College Vision and Mission

SDMCET –Vision

To be a School of Dynamic Mindset focusing on Research, Innovation and Development and emerge as Central hub of Engineering Talents.

SDMCET – Mission

- Committed towards continuous improvement in teaching and learning, Research in engineering and technology.
- Encouraging intellectual, quality, ethical and creative pursuits amongst teaching and students fraternity.
- Striving to be an enabler for reaching the unreached.

SDMCET- Quality Policy

❖ In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

The department shall strive towards globally recognized undergraduate Chemical Engineering program coupled with quality technical education in the field of chemical engineering, and research strength contributing to the needs of industry and society at large.

Mission

1. To offer firm foundation in both theoretical and applied aspects of Chemical Engineering
2. Enabling to discover and disseminate knowledge through creative activity in research using state of the art laboratories and infrastructure by collaborating with industries and academic institutes.
3. To offer program that inculcates commitment, team work, leadership qualities and lifelong learning skills with societal and ethical values.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

I. Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.

II. Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.

III. Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.

IV. Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes and Program Specific outcomes

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for III Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UMAC300	Engineering Mathematics – III	4-0-0	4	50	100	3		
15UCHC300	Technical Chemistry**	3-0-0	3	50	100	3		
15UCHC301	Chemical Process Calculations	3-2-0	4	50	100	3		
15UCHC302	Fluid Mechanics	4-0-0	4	50	100	3		
15UCHC303	Particulate Technology	4-0-0	4	50	100	3		
15UCHC304	Chemical Engineering Drawing	0-0-4	2	50	100	3		
15UCHL305	Particulate Technology Laboratory	0-0-3	1.5	50			50	3
15UCHL306	Basic Analysis Laboratory	0-0-3	1.5	50			50	3
	Total	**18-2-10**	**24**					

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

** To be handled by the Chemistry department faculty

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Scheme for IV Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UMAC400	Engineering Mathematics – IV	4-0-0	4	50	100	3		
15UCHC400	Process Heat Transfer	4-0-0	4	50	100	3		
15UCHC401	Chemical Engineering Thermodynamics	4-0-0	4	50	100	3		
15UCHC402	Chemical Reaction Engineering – I	4-0-0	4	50	100	3		
15UCHC403	Mass Transfer – I	3-2-0	4	50	100	3		
15UCHC404	Pollution Control Engineering	3-0-0	3	50	100	3		
15UCHL405	Computational methods in chemical Engineering Laboratory	0-0-3	1.5	50			50	3
15UCHL406	Fluid mechanics Laboratory	0-0-3	1.5	50			50	3
	Total	**22-2-6**	**26**					

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the Second year: 50

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III Semester

15UMAC300	Engineering Mathematics - III	(4-0-0)4: 52 Hrs.

Course Learning Objective:

1. Learn to represent a periodic function in terms of sine and cosine. Learn the concepts of a continuous and discrete integral transform in the form of Fourier and Z-transforms. Learn the concepts of calculus of functions of complex variables. Learn the concept of consistency, method of solution for linear system of equations and Eigen value problems. Understand the concepts of PDE and its applications to engineering.

Course outcome:

COs	Description: At the end of course the student will able to	**Mapping to POs (1-12)**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Express periodic function as a Fourier series.		1	
CO2	Describe Fourier transform and its properties.		1	
CO3	Define and describe Z transforms and properties and solve difference equations using Z transform.		1	
CO4	Explore analytical functions and properties and describe Bilinear transformations.	13	1	
CO5	Solve set of linear equations. Estimate rank, eigen value and eigen vectors as applied to engineering problems.		1, 2	
CO6	Construct and solve partial differential equation resulting from one dimensional heat equation and wave equation.		1, 2	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	2											1		

Contents:

1. **Fourier Series and Fourier Transform:** Fourier series, Fourier series of Even and Odd functions, exponential form of the Fourier series, half range

Fourier series, practical harmonic analysis. Infinite Fourier transform, Infinite Fourier sine and cosine transforms, properties of Inverse transform, Convolution theorem, Parseval's identity for Fourier transform, Fourier Sine and Cosine transform. **14 Hrs.**

2. **Z–Transform**
   Basic definitions of z-transform, transform of standard forms, linearity property, damping rule, shifting rule, initial and final value theorems, Inverse z-transforms (Partial Fraction method), convolution theorem, applications of z-transforms to solve difference equations. **6 Hrs.**
3. **Complex variables:** Functions of complex variables, Analytic function, Cauchy-Riemann equations in cartesian and polar coordinates, Consequences of Cauchy-Riemann equations, Construction of analytic functions. Conformal Transformations: Standard transformation $w = z^2$, $w = e^z$, $w = z + \frac{a^2}{z}$(only theoretical discussions). Bilinear Transformation.**10 Hrs.**

4. **Linear Algebra:** Rank of a matrix by elementary transformations, solution of system of linear equations - Gauss-Elimination method, Gauss-Seidel method and L-U decomposition method. Eigen values and Eigen vectors. Rayleigh's power method to find the largest Eigen value and the corresponding Eigen vector. Application to Electric circuits, spring mass system, parachutist problem. **12 Hrs.**
5. **Partial Differential equations:** Formulation of PDE by elimination of arbitrary constants/functions, Solution of Lagrange's equations. Solution of non-homogeneous PDE by direct integration, solution of homogeneous PDE involving derivative with respect to one independent variable only. Solution of First and Second order PDE by method of separation of variables. Derivation of one dimensional heat and wave equations, solutions by variable separable method, as applied to engineering problems. **10 Hrs.**

Reference Books:

1. Kreyszig E., "Advanced Engineering Mathematics", 8/e John Wiley and sons, 2003.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 40/e, 2007.
3. Lathi B. P, "Modern Digital and Analog Communication System", 2/e, pp. 29-63.
4. Chapra S C and Canale R P, "Numerical methods for Engineers", 5/e, TATA McGraw-Hill, 2007.

15UCHC300	Technical Chemistry	(3-0-0) 3: 39 Hrs.

Course Learning Objectives:

1. Acquisition of knowledge and development of scientific attitude among the learners.
2. Development of intellectual abilities and skills.
3. To inculcate social virtues among students so as to contribute significantly towards the progress of society.

Course Outcomes:

Cos	Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	To interpret the complex problems with an approach to its chemical nature and chemical bonding.	3	7	4
CO2	Apply the knowledge of inorganic polymers and applicability in material use, optimization and in various engineering applications.	6	8	1
CO3	Implement the reaction mechanisms and the rate of chemical reactions, factors affecting for designing of various industrial processes.	4	5	2 , 13
CO4	To emphasize on modern technologies and the use of Nanotechnological tools for synthesis and engineering activities.	1	4	5
CO5	To converge and design the vibrant mechanisms and correlate the reactions generating critical thinking for specified products for the benefit of society with environmental considerations.	8	2	3 , 13
CO6	To demonstrate the parameters, theory and mathematical approach of catalysts to formulate the process and product formation in chemical engineering processes.	1	3	2 , 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.67	2.67	2	1.67	1.67	1	2	1.5	-	-	-	-	3	-	-

Prerequisites: Nil

Course Content:

1. **Chemical Bonding:** Introduction, Ionic bond – Definition, steps involved in the formation of ionic bond, conditions and factors affecting the formation of ionic bond; Ionic solids- lattice energy, Barn-Haber cycle, lattice defects; semiconductors. Covalent bond - Definition, Lewis concept; Types of covalent bonds – sigma, pi, polar and non-polar. Valence bond theory (VBT) – postulates and explanation, Limitations of VBT; Molecular orbital theory – comparison between atomic orbitals and molecular orbitals, Linear combination of atomic orbitals (LCAO), conditions for effective combination of atomic orbitals. Molecular orbital configuration of simple molecules (H2 and He); Comparison between valence bond theory and molecular orbital theory. Hydrogen bond- consequences of hydrogen bonding, boiling points of binary hydrogen compounds, solubility; unique properties of water. Hybridization- geometry of molecules- VSEPR theory; geometry of molecules of bonding pairs (BF3, CH4), geometry of molecules of nonbonding pairs (H2O, NH3). **8 Hrs.**
2. **Inorganic Polymers:** Introduction, preparation, properties and applications of Phosphorous-based polymers-polyphosphonitrilic chlorides and ultraphosphate glasses. Sulphur-based polymers-polymeric sulphur nitride and chalcogenide glasses. Boron-based polymers-polycarboranes and polymeric boron nitride. **5 Hrs.**
3. **Nano-Technology:** Introduction, Nanoscale; Nanomaterials-Introduction, properties and applications of-one dimensional nanomaterials-Thin films, two dimensional nanomaterials-Carbon Nanotubes and Nonowires, three dimensional nanomaterials- Fullerens, Dendrimers; Construction of Nanomaterials-Top down and Bottom up methods. **6 Hrs.**
4. **Catalysis:** Introduction, General Characteristics, Types of catalysis with examples, Homogeneous catalysis-acid-base catalysis with mechanism, Enzyme catalysis with mechanism and kinetics; effect of temperature on Enzyme catalysis; Heterogeneous catalysis - explanation with examples; effect of temperature; Autocatalysis. **6 Hrs.**
5. **Organic Reactions and their Mechanisms:** Electron displacement effects inductive; electromeric; mesomeric and hyper conjugative; Bond fission – homolytic and heterolytic, carbanions, carbocations; Types of reagents – electrophilic and nucleophilic; Types of reactions – (a) Substitution – free

radical; nucleophilic - S_{N1} and S_{N2}, Electrophilic – halogenation; nitration; sulphonation; Friedel-Craft's alkylation and acylation, Electronic interpretation of orienting influences of substituents in aromatic electrophilic substitution of toluene, chlorobenzene, benzoic acid and nitrobenzene, (b) Addition – free radical; electrophilic and nucleophilic, (c) Elimination – unimolecular and bimolecular, (d) Rearrangement – intra and inter molecular. **14 Hrs.**

Reference Books:

1. J.D. Lee "Inorganic Chemistry".
2. Madan, "Selected Topics in Inorganic Chemistry" Tuli and Mallick.
3. B.R. Puri, L.R. Sharma and M.S. Pathania, "Physical chemistry", S. Chand and
   Co., New Delhi.
4. Samuel Glasstone "Text book of Physical chemistry".
5. Er. Rakesh Rathi S, "Nanotechnology", Chand & Company Ltd., Ram Nagar, New Delhi.
6. Peter Sykes, "Organic Reactions Mechanism", ULBS Publishers, New Delhi.
7. I. L. Finar "Organic Chemistry" Vol I & II.

15UCHC301	Chemical Process Calculations	(3-2-0) 4: 52 Hrs

Course Learning Objectives:

1. To study the analysis of chemical processes through calculations and also to develop systematic problem-solving skills.
2. To formulate and solve material and energy balances in processes with and without chemical reactions.

Course Outcomes:

Cos	Description: Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the fundamentals of units and dimensions and Psychrometry.	13	2, 3	
CO2	Categorize methods of expressing chemical compositions.	1	2, 3	13
CO3	Evaluate problems on steady state material balance with and without chemical reactions.	1	2, 3	13
CO4	Compute ultimate and proximate	1	2, 3	13

	analysis of solid, liquid and gaseous fuels.			
CO5	Perform calculations on energy balances.	1, 2	3	13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.0	1.8	2.0										2.6		

Prerequisites: Nil

Course content:

1. **Units and dimensions:** Fundamental and derived units, Conversion. Dimensional consistency of equations. Dimensionless groups and constants. Conversion of equations. Psychrometry: absolute humidity, molal humidity, dry bulb and wet bulb thermometry, humidity chart, humidification and dehumidification , air conditioning. **8 Hrs**
2. **Basic chemical calculations:** Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases. Concept of normality, molarity, molality, ppm. Ideal gas law calculations. **8 Hrs.**
3. **Material balance without reaction:** General material balance equation for steady and unsteady state. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying, mixing and evaporation. Elementary treatment of material balances involving bypass, recycle and purging. **12 Hrs.**
4. **Steady state material balance with reaction:** Principles of stoichiometry, Concept of limiting and excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, related problems. Ultimate and proximate analyses of fuels, Calculations involving burning of solid, liquid and gaseous fuels, excess air, air-fuel ratio calculations. **12 Hrs.**
5. **Energy Balance:** General steady state energy balance equation, Heat capacity. Enthalpy, Heat of formation, Heat of reaction, Heat of combustion. Heat of mixing. Determination of Heat of formation at Standard and Elevated temperatures, Theoretical flame temperature and adiabatic flame temperature. **12 Hrs.**

Reference Books:

1. Hougen, O.A., Waston, K.M. and Ragatz, R.A., “Chemical Process Principles Part – I, Material and Energy Balances”, 2/e, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau, D.M., “Basic Principles and Calculations in Chemical Engineering”, 6/e, Prentice Hall Of India, New Delhi, 1997.

3. Bhatt, B.L. and Vora, S.M., “Stoichiometry”, SI Units, 3/e, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
4. K.V. Narayanama B. Lakshmikutty, “Stoichiometry and Process calculations” Prentice Hall India Limited, New Delhi, 2006. ISBN: 978-81-203-2992-8

15UCHC302 Fluid Mechanics (4-0-0) 4 : 52 Hrs.

Course Learning Objectives:

1. To introduce the concepts, principles, laws, observations and models of fluids at rest and in motion.
2. To provide the basis for understanding the fluid behaviour, engineering design and control of fluid systems.

Course Outcomes:

Cos	Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify the nature of fluids along with the properties and its measuring devices.		3	
CO2	Interpret and analyze the parameters of fluid flow for different fluids.	1	2	3, 13
CO3	Derive the equations of fluid flow for different fluids.	1	2	3, 13
CO4	Explain and characterize the different pipe fittings, pumps and flow measuring devices.	1	2	3, 13
CO5	Interpret and solve the fluid flow problems using dimensional analysis.	1	3	5

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	2.6		3								3		

Prerequisites: Nil

Course Content:

1. **Fluid Statics and Applications:** Introduction to momentum transfer and unit operations. Nature of fluids, pressure and its measurements. Hydrostatic equilibrium, barometric equation, measurement of fluid pressure-manometers (U tube manometer, Inverted manometer, differential manometer), continuous gravity decanter, centrifugal decanter. **8 Hrs.**

2. **Fluid Flow Phenomena:** Newtonian and Non-Newtonian fluids, types of flows, Shear rate, Shear stress, Rheological properties of fluids. Flow in boundary layer-Boundary layer separation and wake formation. Basic Equations of Fluid Flow: Macroscopic momentum balances, Mechanical energy equations. **10 Hrs.**
3. **Incompressible Fluids:** Laminar flow of incompressible fluids in pipes and conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy equation. Turbulent flow of incompressible fluids in pipes and conduits-Universal velocity distribution equation. Friction factor and Reynolds number relationship and friction factor chart. Nikuradse and Karman equation-Blasius equation, Prandtl one seventh power law. Changes in velocity or direction-Sudden expansion and contraction. **10 Hrs.**
4. **Compressible Fluids:** Continuity equation, Mach number, total energy balance, velocity of sound, Ideal gas equation, adiabatic and isothermal flow equations, Flow through convergent-divergent sections. **8 Hrs.**
5. **Transportation and Metering of Fluids:** Pipes, fittings and valves. Performance characteristics of Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors, Measurement of flowing fluids - full bore meters, area meter, insertion meters with flow rate equations. **10 Hrs.**
6. **Dimensional Analysis:** Dimensional homogeneity, Rayleigh's and Buckingham-Pi methods, dimensionless numbers, models and prototypes. **6 Hrs.**

Reference Books:

1. McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGraw Hill chemical engineering series. ISBN-10: 0072848235
2. Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1 and 2, 5/e. Butterworth publications. ISBN-10: 0750644451
3. Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4. R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

15UCHC303	Particulate Technology	(4-0-0) 4:52 Hrs.

Course Learning Objective:

1. To study the basic principles of the unit operations and to study the construction, working and applications of the equipments involved in each of the unit operations.

Course Outcomes:

COs	Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain the characteristics of particulate solids and equipments dealing with them.	3	13	1,2
CO2	Explain and evaluate drag and pressure drop through a bed of solids immersed in fluid.	4	13	1,2
CO3	Evaluate the terminal velocity of particles moving in a fluid under different regimes.	4	13	1,2
CO4	Comprehend and analyse gravity and centrifugal sedimentation.	13	2	1
CO5	Categorize and explain the industrial filters.	13	2	1
CO6	Describe the types of impellers, mixers and calculate the power consumption in different agitation systems.	13	2	1

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	2.5	1	1									1.5		

Prerequisites: Nil

Course Content:

1. **Particle Technology:** Particle shape, particle size, different ways of expression of particle size, shape factor, sphericity, mixed particles size analysis. Screens – ideal and actual screens, standard screens, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture. Industrial screening equipments, motion of screen, grizzly, gyratory screen, vibrating screen, trommels. Sub sieve analysis – Air permeability method, sedimentation and elutriation methods.

   Size Reduction: Introduction, types of forces used for communition, criteria for communition, characteristics of communited products, laws of size reduction, work index, energy utilization, open circuit grinding, closed circuit grinding, wet and dry grinding. Equipments for size reduction – jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, impactors, attrition mill, ball mill, critical speed of ball mill, fluid energy mill, knife cutter. **15 Hrs.**

2. **Flow of Fluids Past Immersed Bodies:** Drag, drag coefficient. Pressure drop – Ergun's, Kozeny – Carman and Burke – Plummer equations. Fluidization - conditions for fluidization, minimum fluidization velocity, types of fluidization, applications of fluidization, pneumatic conveying. **8 Hrs.**
3. **Motion of Particles Through Fluids**: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, motion of spherical particles in Stoke's region, Newton's region and intermediate region. Criterion for settling regime, hindered settling, modification of equation for hindered settling, centrifugal separators, cyclones and hydro cyclones. **8 Hrs.**
4. **Sedimentation:** Batch settling test, application of batch settling test to design of continuous thickener. Coe and Clevenger theory, Kynch theory. Thickener design, determination of thickener area. **6 Hrs.**
5. **Filtration:** Introduction, classification of filtration, cake filtration, batch and continuous filtration, pressure and vacuum filtration, constant pressure filtration, characteristics of filter media. Industrial filters - sand filter, filter press, leaf filter, rotary drum filter, horizontal belt filter. Filter aids, application of filter aids. Principles of cake filtration, modification of Kozeny – Carman equation for filtration. **8 Hrs.**
6. **Agitation and Mixing:** Application of agitation, agitation equipment, types of impellers – propellers, paddles and turbines, flow patterns in agitated vessels, prevention of swirling, standard turbine design, power correlation and power calculation. Mixing of solids, types of mixers- change can mixer, Muller mixer, mixing index, ribbon blender, internal screw mixer, tumbling mixer.

   Sampling, Storage and Conveying of Solids: Sampling of solids, storage of solids, open and closed storage, bulk and bin storage. Conveyors – belt conveyor, chain conveyor, apron conveyor, bucket conveyor, bucket elevators, screw conveyor. **7 Hrs.**

Reference Books:

1. McCabe and Smith, "Unit Operation of Chemical Engineering", 4/e, McGraw Hill International, Singapore, 2001.
2. Badger, W.L. and Banchero J.T., "Introduction to Chemical Engineering", 3/e, McGraw Hill International, Singapore, 1999.
3. Coulson, J.M. and Richardson, J.F., "Chemical Engineering Vol.2", 5/e, Particle Technology and Separation Processes, 1998.
4. Foust, A.S. et.al, "Principles of Unit Operation", 3/e, John Wiley and Sons, New York, 1997.

15UCHC304	Chemical Engineering Drawing	(0-0-4) 2: 52 Hrs.

Course Learning Objective:

1. To increase competency in drawing through the development of sound observational skills.

Course Outcomes:

Cos	Description: Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Demonstrate symbols for different applications	11	10	
CO2	Translate sketches to engineered drawings.	10,11		
CO3	Analyze sectional views and assembly drawing.	10		

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO 15
Mapping Level										2.66	1				

Prerequisites: Nil

Course Content:

1. **Conventions:** Equipment and piping, colour codes, materials, nuts and bolts. **4 Hrs.**
2. **Proportionate Drawing of Process Equipment**: Jackets-types, Vessel Supports, Storage vessel, Reaction vessel, Heat Exchanger, Evaporator, Distillation column. **4 Hrs.**
3. **Sectional views:** Representation of the sectional planes, Sectional lines and hatching, Selection of section planes and types of sectional views. **6 Hrs.**
4. **Assembly Drawings:**
   i. Shaft Joints: Cotter joint with sleeve, Gib and Cotter joint, Socket and Spigot joint. **8 Hrs.**
   ii. Pipe joint: Flanged type, Union Joint, Expansion joint **8 Hrs.**
   iii. Valves: Stop valve, Lever safety valve, Rams Bottom safety valve, Non-return valve, Plug valve **17 Hrs.**
5. **Process Flow Diagram**: with conventions and blocks, P&ID. **5 Hrs.**

Note:

- First angle projection to be followed.
- Drafter to be used for all drawings.

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Reference Books:

1. Gopal Krishna, K.R., "Machine Drawing," 2/e. Subhash Publication
2. Joshi, M.V., "Process Equipment Design" 3/e, Macmillan India publication.
3. Bhat N.D., "Machine Drawing". Charotar Publishing, 50/e, 2011
4. Vilbrant and Dryden., "Chemical Engineering Plant Design" Publisher: New York, McGraw-Hill, 1959.

15UCHL305	Particulate Technology Laboratory	(0-0-3) 1.5

Course Learning Objectives:

1. To get hands on experience on various unit operations by conducting experiments on size separation, size reduction, filtration etc.
2. To analyze experimental data and project in the form of a report and oral presentation.

Course Outcomes:

Cos	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Determine the average particle diameter by sieve and sub-sieve analysis experiments.	9	10	4, 15
CO2	Evaluate the energy consumed for the size reduction of solid samples by applying size reduction laws.	9	10	4, 15
CO3	Calculate the medium and cake resistance in filtration equipments.	9	10	4, 15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3					1.25	2.25					3

List of Experiments:

1. Ball mill
2. ICI sedimentation
3. Beaker decantation

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4. Cyclone separator
5. Drop weight crusher
6. Jaw crusher
7. Leaf filter
8. Plate and frame filter
9. Screen effectiveness
10. Sieve analysis
11. Thickener
12. Batch sedimentation
13. Air elutriation

Note: Atleast 10 experiments to be conducted

Reference Books:

1. McCabe and Smith, "Unit Operations of Chemical Engineering" 6/e, McGraw Hill International
2. Foust A.S. et al., "Principles of Unit Operations", John Wiley and Sons.

15UCHL306 Basic Analysis Laboratory (0-0-3)1.5

Course Learning Objectives:

1. To get hands on experience on various analysis of materials
2. To analyze experimental data and understand the importance of Chemical analysis

Course Outcomes:

Cos	Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Determine the various properties of the fluids and solids given.	9	10	4, 15
CO2	Estimation and characterization of the given material.	9	10	4, 15
CO3	Analysis of various fluids with the measuring techniques used.	9	10	4, 15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3					1.25	2.25					3

Prerequistes: Nil

List of Experiments:

1. Conductometric titration an Acid vs Base.
2. Standardization of potassium permanganate.
3. Determination of percentage of available chlorine present in bleaching powder sample.
4. Estimation of total hardness of water.
5. Estimation of chlorides in given water sample.
6. Determination of moisture content and ash content of coal.
7. Estimation of calcium hardness of water.
8. Determination of dissolved oxygen in water sample.
9. Determination of optimum dosage of alum of raw water.
10. Determination of bulk density, porosity and specific surface area of a sample.
11. Estimation of oil in seeds by solvent extraction method.
12. Estimation of total loss of ignition for cement sample.

Note: Atleast 10 experiments to be conducted.

Reference Books:

1. Jaffery, G.H., Basset, J., et al., "Vogel's Text book of Quantitative Inorganic Analysis" 5/e, ELBX. 1998
2. Skoog, D.A., "Principles of Instrumental Analysis" 3/e, Saunders College publishing 1985.

IV Semester

15UMAC400	Engineering Mathematics - IV	(4-0-0) 4: 52 Hrs.

Course Learning Objective:

1. Learn to solve algebraic and transcendental equations numerically. Learn the concepts of finite differences and its applications. Learn the concept of special functions. Learn fitting of a curve, correlation, regression for a statistical data. Learn the basic concepts of probability, random variables and probability distributions. Learn the concepts of stochastic process and Markov chain.

Course outcome:

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12)		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO-1	Solve the problems of algebraic and transcendental equations using numerical methods.		1	
CO-2	Use numerical methods to solve first order differential equations.	13	1	
CO-3	Derive the solution of Bessel's differential equation, Legendre's differential equation.	1		
CO-4	Analysis the bivariate statistical data and calculate correlation and regression. Apply concepts of probability to solve engineering problems.	1	15	
CO-5	Recite Markov chains and describe stochastic process.	1,2	15	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.4	1											1		2

Course Content:

1. **Numerical Methods**: Roots of equations: Regula Falsi method, Newton-Raphson Method, Finite differences: Forward, Backward and central differences. Newton Gregory forward and backward interpolation formulae. Striling's and Bessel's interpolation formulae. Lagrange's interpolation formulae. Numerical integration: Simpson's 1/3rd rule and Weddle's rule, Solutions to Engineering problems. **10 Hrs**

2. **Numerical solution of O.D.E:** Numerical solution of ordinary differential equations of first order and first degree, Picards method. Taylor's series method, modified Euler's method, Runge-Kutta method of fourth order. Milne's predictor and corrector methods (no derivations of formulae). Numerical solution of simultaneous first order ordinary differential equations: Picards method, Runge-Kutta method of fourth- order. **10 Hrs**
3. **Special functions:** Introduction to series solution, Series solution of Bessel's differential equation leading to Bessel function of first kind, orthogonal property of Bessel function, Series solution of Legendre's leading to Legendre's polynomial, Rodrigues formula. **8 Hrs**
4. **Statistics and probability**: Curve fitting by the method of least squares: $y = a+bx$, $y = a+bx+cx^2$, $y = ab^x$, Correlation and regression. Random Variables: Discrete and continuous random variables-PDF-CDF- Binomial, Poisson, exponential and Normal distribution. Joint probability distribution of two discrete random variables. **Sampling**: Sampling distribution, standard error, test of hypothesis for means and population, confidence limits for means. *t*-Students distribution as a test of goodness of fit. **14 Hrs.**
5. **Markov Chains:** Introduction, probability vectors, Stochastic Matrices, Fixed points and Regular stochastic matrices, Markov chains, higher transition probabilities, stationary distribution of regular Markov chains and absorbing states. **10 Hrs.**

Reference Books:

1. Jain, Iyengar and Jain, Numerical Methods for Engg. & Scientist, PHI, 3rd Edn., 2005.
2. Gupta S C and Kapoor V K, Fundamentals of Mathematical Statistics, 9th Edn, Sultan Chand & Sons, New Delhi, 2002.
3. B. S. Grewal, Higher Engineering Mathematics – Khanna Publishers – 40th edition – 2007.
4. Kreyszig E., Advanced Engineering Mathematics, 8th Edn, John Wiley & sons, 2007.

15UCHC400	Process Heat Transfer	(4-0-0) 4: 52 Hrs.

Course Learning Objective:

1. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Define the mechanism of heat transfer and apply concepts to engineering applications.	2,13	1	
CO2	Evaluate steady state heat conduction, radiation and convective heat transfer processes.	13	2,7	
CO3	Apply the thermal insulation for engineering systems.		6,13	
CO4	Select appropriate extended surfaces to enhance overall heat transfer coefficient.	2,3,13		
CO5	Design and assess the performance of heat exchangers, condensers and evaporators.	13	2,3	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	1.5	1			2	2						1.2		

Prerequisites: Nil

Course Content:

1. **Modes of Heat Transfer:** Mechanism of thermal conduction in solids, liquids and gases, thermal conductivity, steady state unidirectional heat conduction. Fourier's law, Heat transfer through composite walls and cylinders. Analogy with Ohm's law. **8 Hrs.**
2. **Insulation and Extended Surfaces:** Types of insulating materials, general properties and application of insulators, Critical and optimum thickness of insulation. Extended Surfaces: Fins – types of fins, fin efficiency for longitudinal fins, Fin effectiveness. **8 Hrs.**
3. **Convection:** Individual and overall heat transfer coefficient, Forced convection: In laminar flow - Heat transfer in plate and in tubes. In turbulent flow - Empirical equations for individual coefficients: inside tubes, outside tubes, outside bundle of tubes, flow past spheres. Dimensional Numbers: Dimensional analysis, Empirical correlation for forced and natural convection. Analogy between momentum and heat transfer – Reynolds, and Coulburn analogies Significance of Prandtl No., Nusselt No., Correction for heating and

cooling. Natural convection from vertical plates and horizontal cylinders. Grashof No., Rayleigh No. **10 Hrs.**

4. **Heat Transfer with Phase Change:** condensation of vapor, Film wise and drop wise condensation. Condensation – Film and Drop wise condensation, Nusselt's equation for vertical, horizontal and inclined plate. Condensation outside horizontal tube or bank of tube. Evaporator: Natural circulation, Forced circulation, Falling film evaporator, Performance of steam heated tubular evaporators-capacity and economy, single effect evaporator and multiple effect evaporators. **8 Hrs.**
5. **Heat Exchangers:** Classification of HE, Individual and overall heat transfer coefficient. DPHE, STHE, PTHE-general constructions, temperature profiles in heat exchangers. LMTD and LMTD correction factor. Fouling and types of fouling, fouling factor (R_d). Analysis of HE's - LMTD, ε-NTU method **10 Hrs.**
6. **Radiation:** Radiation laws - Stefan Boltzman's law, Kirchoff's law, Wien's law, Plank"s law. Black body, Grey body. Transmittivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces, radiation shields. **8 Hrs.**

Reference Books:

1. J.P.Holman," Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2. Rao Y.V.C., "Heat Transfer", Edition illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3. McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4. Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1.6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

15UCHC401 Chemical Engineering Thermodynamics (4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To relate state changes in a system to the quantity of energy in the form of heat and work transferred across its boundaries.
2. Understanding of the laws of thermodynamics and their application in the analysis of chemical and engineering problems.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Mastering 3**
CO1	State thermodynamic laws, Identify and distinguish the types of properties, systems and processes	1		
CO2	Apply and evaluate heat and work interactions for the flow and nonflow processes	13, 2		1
CO3	Analyze and evaluate pressure, volume and temperature with equations of state for gases	3	13, 2	1
CO4	Explain and estimate the enthalpy changes in chemical reactions	2, 13		1
CO5	Determine the entropy changes associated with processes	3	13, 2	1
CO6	Apply the laws of thermodynamics to important fluid flow processes	2	1	

POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PO1 3	PO1 4	PO1 5
Mapping level	2.5	1.4	1										1.5		

Course Content:

1. **Basic Concepts:** System, surrounding, state and properties, state and Path functions, Equilibrium state, phase rule, Zeroth law, reservoirs and heat engines. **8 Hrs.**
2. **First law of thermodynamics:** Statement, cyclic process and nonflow processes, Heat capacity. **8 Hrs.**
3. **P-V-T behavior:** Pure fluids, Equations of state, Processes involving ideal gas law: Constant volume, constant pressure, constant temperature adiabatic and polytrophic processes, cubic equations of state, Compressibility charts, principles of corresponding states. **10 Hrs.**
4. **Heat effects accompanying chemical reactions:** Standard heat of reaction, formation, combustion. Hess's law of constant heat summation, effect of temperature. **8 Hrs.**
5. **Second law of thermodynamics:** Statements of second law, entropy, the Carnot principle, entropy changes, Clausius inequality, irreversibility, third law. **8 Hrs.**

6. **Applications of thermodynamics to flow processes:** Duct flow of compressible fluids, Turbines (expanders), compression processes. **10 Hrs.**

Reference Books:

1. Smith J.M and Vanness H.C. and Abbot, "Introduction to Chemical Engineering Thermodynamics", 5/e & 6/e, McGraw Hill, New York, 1996.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" New Age International Publication, Nagpur, 2000.
3. Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.

15UCHC402 Chemical Reaction Engineering- I (4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To provide basic understanding of kinetic models and mechanisms for homogeneous chemical reactions.
2. To understand the interpretation of reactor data and thereby exploring the rate law for chemical reactions.
3. To provide an understanding and application of rate law in design of Ideal reactors and to assess their performances based on temperature effects.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Mastering 3**
CO1	List the classification of reactions and explain the effect of temperature on rate of reaction		1	
CO2	Interpret reaction data and determine the rate equation	1		2
CO3	Formulate performance equations for ideal batch and flow reactors		2	3
CO4	Design ideal batch and flow reactors for single and multiple reactions under isothermal and non-isothermal conditions.		2,13	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO 14	PO 15
Mapping Level	1.5	2.3	3										2		

Prerequisites: Nil

Course Content:

1. **Introduction:** Scope of Chemical Reaction Engineering, classification of reactions, Rate equation and rate of reaction. Factors affecting the rate of reaction. Chemical kinetics, thermodynamics and Equilibrium. Temperature dependency of rate constant from Arrhenius, collision and Transition state theories. Molecularity and order of reaction. Elementary and non-elementary reactions. Kinetic models for non- elementary reactions. **8 Hrs.**
2. **Homogenous reactions**: Interpretation of batch reactor data. Constant volume batch reactor. Analysis of total pressure data in a constant volume system. Integral method of analysis for Irreversible zero, first, second and n^{th} order reactions. Reversible first and second order reactions, series, parallel and autocatalytic reactions. Variable volume reactions. Differential method of analysis. Over all order from half-life method. **12 Hrs.**
3. **Design of Ideal Reactors:** Formulations of performance equations for Ideal batch, Plug and mixed flow reactors for both constant and variable volume reactions. Rate equation from data obtained from ideal reactors. Comparison of Ideal reactors. Multiple reactor systems. Series and parallel combinations. Recycle reactors, introduction and qualitative treatment for single reactions only. **12 Hrs.**
4. **Multiple reactions:** Batch, plug and mixed flow reactors for parallel, series reactions. Yield and selectivity. **10 Hrs.**
5. **Thermal characteristics of reactors:** Heat of reactions, equilibrium constant, optimum temperature progression. Conversion in reactors operated under adiabatic and nonadiabatic conditions. Reactor design by solving material and energy balance equations simultaneously. **10 Hrs.**

Reference Books:

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, McGraw Hill, 1981.ISBN:0-07-066574-5
3. H. Scott Fogler, “Elements of Chemical Reaction Engineering”, 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

15UCHC403	**Mass Transfer- I**	**(3-2-0) 4:52 Hrs.**

Course Learning Objectives:

1. To understand the fundamentals and principles of diffusion mechanism in all the phases of matter along with equilibrium diffusion between the phases with an insight of interphase mass transfer.
2. To understand and apply analogy between transport processes along with an

insight of interphase mass transfer applied to industrial diffusional separations, obtain transfer coefficients to propose and evaluate experimental investigations on mass transfer.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Interpret mechanisms of molecular and turbulent diffusion both in fluids and solids, develop mathematical expressions for one dimensional steady state diffusion and analyze interphase mass transfer.	10	1,3,7,13	12
CO2	Apply interphase concept to crystallization along with stoichiometric calculations to evaluate performance of crystallizers.	10	1,3,12,13	
CO3	Analyze humidification process, configurations and design of cooling tower for air-water system.	10	1,3,7,12,13	
CO4	Apply interphase concept to drying along with stoichiometric computations for assessing the performance of dryers.	7,10	1,13	12
CO5	Interpret adsorption, types with industrial adsorbents and analyze stage wise operations.	10,13	1,3,7,14	12

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2		2				1.7			1		2.6	1.8	2	

Prerequisites: Nil

Course content

1. **Diffusion**: Types of diffusion, importance, molecular versus turbulent diffusion. Illustration, molecular diffusion in fluids, rates of diffusion, Fick's I-law. Diffusion in a binary system, steady state unidirectional diffusion in the fluids at rest and laminar flow. Cases with examples: 1. Unicomponent diffusion and 2. Equimolal counter diffusion. Pseudo steady state diffusion. Diffusivity of gases, empirical treatment. Convective mass transfer, mass transfer coefficients, Local and Overall mass transfer coefficients and

correlations. Analogies; Reynold's, Prandtl's, Von Karman's, and Chilton and Colburn J-factor. Theories of convective mass transfer; Film theory. Penetration theory, Surface renewal, Surface stretch, Combination of film and surface renewal theory. Diffusion in solids, importance, types with different geometrical shapes. **15 Hrs.**

2. **Interphase Mass Transfer:** Introduction, concentration profile. Use of Film Transfer Coefficients in unicomponent diffusion and equimolal counter diffusion. Use of Overall Transfer Coefficients. Graphical approach, equilibrium diffusion between the phases, types of operations. Material balance in each process. Stages, efficiencies. **9 Hrs**.
3. **Crystallization:** Introduction, importance with examples, solubility concept, equilibrium solubility etc. Saturation/equilibrium, super saturation, mechanism of crystallization etc. Myer's theory of super saturation, Methods of generating super saturation. Nucleation types, crystal breeding, growth regimes. Ostwald's ripening, crystal growth and coefficients, crystal size and shape factors. Material balance calculations, ΔL law of crystal growth, caking of crystals. **7 Hrs.**
4. **Humidification:** Introduction, importance and terminology in humidification. Psychrometric chart for air-water system and its use. Measurement of Wet Bulb Temperature, Adiabatic Saturation Temperature, Lewis relation. Cooling towers, Theory of cooling towers. Types, construction and working. Design of cooling towers, NTU and HTU concept. **7 Hrs.**
5. **Drying:** Introduction, importance with examples. Terminology in drying. Graphical representations of various terms. Typical rate of drying curve. Drying time calculations both in Constant rate period and Falling rate period and total drying time. Mechanism of drying, use of heat transfer and mass transfer coefficients. Theories of moisture movement. Construction and working of various types of dryers. **7 Hrs.**
6. **Adsorptio**n: Introduction, importance with examples, applications. Types of adsorption; nature of adsorbents, chemisorption and vander waal's adsorption. Adsorption equilibria; isotherms, isobars and isosteres. Adsorption calculations, Freundlich and Langmuir adsorption isotherms. Stage wise calculations and graphical representation. Adsorption equipments **7 Hrs.**

Reference Books:

1. Robert E. Treybal, "Mass Transfer Operations", 3/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 1981 ISBN: 0-07-066615-6.

2. Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 6/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 2001; ISBN: 0-07-118173-3.
3. Christie J. Geankoplis, "Transport Processes and Unit Operations", 3/e., Prentice Hall of India, New Delhi; 1993; ISBN: 13: 978-0139304392.
4. Binay K. Dutta, "Principles of Mass Transfer and Separation Processes", PHI Learning, New Delhi; 2009; ISBN-13-9788120329904.

15UCHC404 Pollution Control Engineering (3-0-0)3: 39 Hrs.

Course Learning Objective:

1. To create awareness on the various environmental pollution aspects and issues and give a comprehensive insight into natural resources, ecosystem, and biodiversity.
2. To understand the different parameters, treatment methods and control techniques of various environmental pollution.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the importance of the environment on mankind, regulatory bodies and guidelines.	3,6,7	14	
CO2	Interpret various parameters of waste water and explain different methods of treatment.		14,15	3,6,7
CO3	Identify the sources and effects of different types of pollution, their prevention and control techniques.		3,6,7	14
CO4	Apply different methods for handling and disposal of solid waste.		3,6,7	14
CO5	Explain the pollution problems of specific industries and control techniques.	3,6,7	14,15	4

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			1.8	3.0		1.8	1.8							2.4	2.0

Prerequisites: Nil

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Course content:

1. **Introduction:** Importance of Environment for Mankind. Engineering, ethics and environment. Ecological systems and pollution, hydrological cycle and nutrient cycle. Damages from environmental pollution. Fundamental definition of pollution parameters- air, water and soil quality criteria, standards and legislation and acts, EIA, EIS and EMP. Air, water and soil pollution management through waste minimization. **6 Hrs.**
2. **Water Pollution:** Water Resources. Wastewater Classification. Types of Water Pollutants. Waste Water Sampling, Methods of Analysis: DO, BOD, COD, TOC, Nitrogen, Phosphorus, Trace Elements and Alkalinity. Wastewater Treatment: Preliminary, Primary, Secondary and Tertiary. Advanced wastewater Treatment: Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electrodialysis cell. Design of sedimentation tanks and biological treatment processes. Applications to Industries: Petroleum refinery, distillery, Fertilizer and Textile processing. **14 Hrs.**
3. **Air Pollution:** Definition, Sources, Classification, Properties of air pollutants, Effects of air pollution on health vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling. Analysis of air pollutants. Air pollution meteorology (generation transportation and dispersion of air pollutants). Control methods and Equipments for particulates and gaseous pollutants. Selection design and performance analysis of air pollution control equipment : gravity settling chambers, air cyclones, ESPs, filters and wet scrubbers. Applications to Industries: Thermal power plants, Metallurgical and Cement industries. **12 Hrs.**
4. **Solid Waste Treatment:** Sources and Classification, Effect on public health, Methods of Collection, onsite handling, storage and processing techniques, Disposal Methods, Reuse, Recovery and Recycling of Solid Waste. Solids waste disposal – compositing, landfill, briquetting/gasification and incineration. **5 Hrs.**
5. **Noise Pollution:** Definition, Sources, Effects of Noise, Equipments Used for Noise Measurement, Approaches for Noise Control. **2 Hrs.**

Reference Books:

1. C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2. S .P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill.
3. Metcalf and Eddy, "Waste Water Engineering Treatment Disposal Reuse" Tata McGraw Hill, 4/e, 2003.
4. Frank Kreith and George Tchobanoglous- "Hand book of Solid waste Management", Tata Mc-Graw Hill, 2/e.

15UCHL405 Computational methods in Chemical Engineering Laboratory (0-0-3) 1.5

Course Learning Objective:

1. To understand the application of mathematics using computer to solve the simple Chemical Engineering problems.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Solve Chemical Engineering problems using the analytical methods and programming.	9	10	4,15
CO2	Compute the chemical engineering problems with nonlinear-algebraic equations.	9	10	4,15
CO3	Compute the chemical engineering problems with Numerical Integration	9	10	4,15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	-	8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3					1.25	2.25					3

Prerequisites: C Programming

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – simpson's 1/3 rule.
6. Estimation of power requirement of centrifugal pump and annual cost.
7. Calculate average particle size of material from sieve analysis data.
8. Power requirement of mixing tank agitator.
9. Pressure drop in a pipe.
10. Heat dissipated by fin.

11. Curve fitting – List square method
12. Double pipe heat exchanger (Area, Length)
13. Bubble and dew point calculation.

Note: Atleast 10 experiments to be conducted.

Reference Books:

1. Jenson, V.J. and Jeffereys, G.V., “Mathematical Methods in Chemical Engineering”, Academic Press, London and New York, 1977.
2. Mickley, H.S., Thomas. K. Sherwood and Road, C.E., “Applied Mathematics in Chemical Engineering”, Tata McGraw-Hill Publications, 1957.
3. S. Pushpavanam, “Mathematical Methods in Chemical Engineering”, PHI
4. E. Balagurusamy, “Programming in ANSI C”, 6/e, TMH 2012.

15UCHL406	Fluid Mechanics Laboratory	(0-0-3) 1.5

Course Learning Objective:

1. To understand the principle, construction, working and analysis of different equipment’s in the fluid flow phenomena.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Calculate the discharge rate for flow measuring devices and pumps	9	10	4,15
CO2	Distinguish the types of pipe fitting and identify their applications	9	10	4,15
CO3	Identify the flow pattern of the fluid and evaluate the friction factor of the spiral coil	9	10	4,15
CO4	Calculate the minimum fluidization velocity	9	10	4,15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	-	8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3				2	1.2	2.2					3

Prerequisites: Fluid Mechanics Theory

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List of Experiments:

1. Fluidized bed.
2. Study and development of characteristics for centrifugal pump
3. Local velocity measurement using Pitot tube.
4. Positive Displacement Pump Characteristics
5. Packed Bed
6. Reynolds Experiment
7. Flow through spiral coil
8. Orifice meter and venturimeter characteristics
9. Friction in circular pipes
10. Pipe fittings
11. Weir characteristics

Note: Atleast 10 experiments to be conducted.

Reference Books:

1. McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, Mc Graw Hill.
2. Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1, 5/e. Butterworth publications.
3. Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4. R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

College Vision and Mission

SDMCET –Vision

To be a School of Dynamic Mindset focusing on Research, Innovation and Development and emerge as Central hub of Engineering Talents.

SDMCET – Mission

- Committed towards continuous improvement in teaching and learning, Research in engineering and technology.
- Encouraging intellectual, quality, ethical and creative pursuits amongst teaching and students fraternity.
- Striving to be an enabler for reaching the unreached.

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

Vision and mission of Department

Vision

The department shall strive towards globally recognized undergraduate Chemical Engineering program coupled with quality technical education in the field of chemical engineering, and research strength contributing to the needs of industry and society at large.

Mission

1. To offer firm foundation in both theoretical and applied aspects of Chemical Engineering

2. Enabling to discover and disseminate knowledge through creative activity in research using state of the art laboratories and infrastructure by collaborating with industries and academic institutes.

3. To offer program that inculcates commitment, team work, leadership qualities and lifelong learning skills with societal and ethical values.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

I. Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.

II. Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.

III. Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.

IV. Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

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Program Outcomes and Program Specific outcomes

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for V Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC500	Chemical Reaction Engineering – II	4-0-0	4	50	100	3		
15UCHC501	Mass Transfer – II	4-0-0	4	50	100	3		
15UCHC502	Chemical Equipment Design	4-0-0	4	50	100	3		
15UCHC503	Chemical Plant Utilities and Safety	4-0-0	4	50	100	3		
15UCHL504	Heat Transfer Laboratory	0-0-3	1.5	50			50	3
15UCHL505	Environmental Engineering Laboratory	0-0-3	1.5	50			50	3
15UCHE50X	Elective-1	4-0-0	4	50	100	3		
15UCHE50X	Elective-2	4-0-0	4	50	100	3		
	Total	**24-0-6**	**27**					
15UCHE506	Process Instrumentation	4-0-0	4	50	100	3		
15UCHE507	Energy Technology and Management	4-0-0	4	50	100	3		
15UCHE508	Solution Thermodynamics	4-0-0	4	50	100	3		
15UCHE509	Food Technology	4-0-0	4	50	100	3		
15UCHE510	Fertilizer Technology	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study *SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Scheme for VI Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC600	Management, Entrepreneurship and Protection of Intellectual Property Rights	4-0-0	4	50	100	3		
15UCHC601	Chemical Process Integration	4-0-0	4	50	100	3		
15UCHC602	Process Equipment Design and Drawing	3-0-2	4	50	100	4		
15UCHL603	Mass Transfer Laboratory	0-0-3	1.5	50			50	3
15UCHL604	Chemical Reaction Engineering Laboratory	0-0-3	1.5	50			50	3
15UCHL605	Mini Project	0-0-8	4	50			50	3
15UCHE60X	Elective – 3	4-0-0	4	50	100	3		
15UCHE60X	Elective – 4	4-0-0	4	50	100	3		
	Total	**18-2-16**	**27**					
15UCHE606	Petroleum and Petrochemicals	4-0-0	4	50	100	3		
15UCHE607	Catalyst Technology	4-0-0	4	50	100	3		
15UCHE608	Applied Mathematics in Chemical Engineering	4-0-0	4	50	100	3		
15UCHE609	Polymer Science and Technology	4-0-0	4	50	100	3		
15UCHE610	Composite Materials	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study *SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the third year: 54

Detailed Syllabus
V Semester

15UCHC500	Chemical Reaction Engineering-II	(4-0-0)4: 52 Hrs.

Course Learning Objectives:

1. To understand Non-Ideal flow behavior in Chemical reactors.
2. To provide the forum to understand the Principles and concepts involved in Catalytic reactions.
3. To understand kinetics of heterogeneous reactions (Non-Catalytic) and apply the same for reactor design.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Define residence time distribution and determine conversion using single parameter models for real reactors.	1		2
CO2	Explain various methods to estimate properties of a given catalyst and evaluate its performance.		1	4
CO3	Develop performance equations for reactors containing porous catalyst and apply the same for reactor design.		4	3,13
CO4	Develop the mechanism and determine the deactivation and regeneration rates in various reactors.		4	3
CO5	Interpret various kinetic regimes for heterogeneous non- catalytic reactions and apply the same for reactor design.	4	2	3,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2.5	3	2									3		

Prerequisites: Chemical Reaction Engineering-I

Course Content:

1. **Basics of non-ideal flow:** Causes for non-ideal flow, the residence time distribution (RTD), E, C and F. Curves, Experimental methods for finding extent of non-ideal behavior, Micro and macro mixing, conversion in non-ideal flow reactors from tracer information, dispersion model and tanks-in-series model. **10 Hrs.**

2. **Fluid-Particle reactions:** Introduction to heterogeneous non-catalytic reactions, industrial examples, overall rate expression, Ideal contacting patterns, progressive conversion and shrinking core model, overall rate expression for various controlling mechanisms from shrinking core model, conversion – time expressions, Design of reactors for particles of single size and different sizes under ideal flow patterns. **10 Hrs.**
3. **Fluid – Fluid reactions:** Industrial examples, Rate equations for straight mass transfer and mass transfer with chemical reaction, various kinetic regimes, liquid film enhancement factor, Role of Hatta number, Design of reactors for fluid-fluid reactions under co current and counter current operations based on ideal flow patterns. **10 Hrs.**
4. **Fluid – Solid Catalytic reactions:** The nature and mechanism of catalytic reactions, Adsorption isotherms, physical, chemical dynamic and mechanical properties of solid catalyst and their determination, catalyst preparation, overall rate expressions for various controlling mechanisms. **10 Hrs.**
5. **Catalyst deactivation:** Causes for deactivation, mechanisms of deactivation, Experimental methods to find deactivation kinetics using Batch- solids and Batch-fluids, Batch solids and Mixed constant and variable flow of fluid, Batch solids and plug constant and variable flow of fluid. **10 Hrs.**

Reference Books:

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, McGraw Hill, 1981. ISBN:0-07-066574-5
3. H. Scott Fogler, “Elements of Chemical Reaction Engineering”, 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

15UCHC501	Mass Transfer - II	(4-0-0) 4: 52 Hrs.

Course Learning Objectives:

1. To understand the principles and mechanism of diffusion mass transfer in applying to various separation processes viz. distillation, absorption, extraction and leaching.
2. To propose and evaluate the performance of the related equipment’s for separations involving diffusion.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the principles of different mass transfer equipment's.	13	-	1,2
CO2	Interpret and analyze the concept of absorption towers for accessing the performance of the tower.	1	2	3, 13
CO3	Design and evaluate the performance of distillation tower with different methods	1	2	3, 13
CO4	Explain the extraction and leaching process with different approaches and to determine the no of stages required.	1	2	3, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	1.5	2.25	3										2.5		

Prerequisites: Mass Transfer-I

Course Content:

1. **Gas liquid contacting systems:** Plate and Packed Towers: Types, construction and working for Distillation and Gas Absorption. **4 Hrs.**
2. **Distillation:** Vapor-liquid equilibria, Relative volatility, Ideal Solutions, Relative volatility, Azeotropic mixtures, Raoult's law and deviations from ideality, methods of distillation; fractionation of binary and multicomponent system, Principle of distillation - flash distillation, differential or simple distillation, steam distillation, multistage continuous rectification, Total reflux, minimum reflux ratio, optimum reflux ratio. Design calculations by McCabe-Thiele and Ponchon-Savarit methods; extractive and azeotropic distillation, low-pressure distillation; steam distillation, effect of operating conditions on the number of ideal stages, Murphree stage and overall efficiency, calculation of actual number of stages, Introduction to Multicomponent distillation **18 Hrs.**
3. **Gas Absorption:** Mechanism of gas absorption, equilibrium in gas absorption, Choice of solvent, Equilibrium and operating line concept in absorption calculations, application of mass transfer theories to absorption, calculation of HETP, HTU, NTU, calculation of height of packed. Absorption and stripping factors, tray efficiencies, absorption with chemical reaction.

16 Hrs.

4. **Liquid-Liquid Extraction and Leaching operation:** Liquid-Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Different types of extractors: Selection construction, sizing and operation, Solid-liquid extraction (Leaching), various types with application, method of calculations, leaching equipment.

14 Hrs.

Reference Books:

1. Robert. E. Treybal, "Mass Transfer Operation", 3/e, McGraw Hill, 1981.
2. McCabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/ e, Mc Graw Hill, 2001.
3. Coulson and Richardson, "Chemical Engg Vol. 1 and Vol 2", 4/e. Pergamon press, 1998.
4. Geankoplis, C.J., "Transport Processes and Unit Operations", 3/e, Prentice Hall (I).

15UCHC502	**Chemical Equipment Design**	**(4-0-0) 4: 52 Hrs.**

Course Learning Objective:

1. To develop key concepts and techniques with relevant codes and standard procedures of different equipments.
2. To study the detailed design considerations of different types of equipments used in chemical industries.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Congregate the data from relevant codes and identify the standard procedures for the design of chemical plant equipment's.	3		14
CO2	Design and evaluate the components of the reaction and pressure vessels.	1	2	3,13
CO3	Design and evaluate the components of the storage and tall vertical vessels.	1	2	3,13
CO4	Analyze and characterize the pipe line design.		3	13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	1	2	2.25										3	3	

Prerequisites: Nil

Course Content:

1. **Introduction:** Design procedure, equipment classification and components, design parameters, pressure vessel codes. Design considerations: Material selection, factors affecting design, stresses due to static and dynamic loads (Internal and External), temperature effects, and economic considerations. **10 Hrs.**
2. **Design of Pressure Vessels:** Design parameters, conditions and stresses. Design of shell and other vessel components. Vessel at low and high operating temperatures. Design of components, supports and selection of vessels accessories and mountings. Numerical problems. **12 Hrs.**
3. **Design of Reaction Vessels:** Design of reaction tanks-agitators, baffles, jackets, tank dimensions. Power calculations. Drive calculations and accessories. Support calculations for the system. Numerical problems. **12 Hrs.**
4. **Design of Tall Vertical Vessels:** Vessels subjected to wind loads. Multi shell constructions. Determination of shell thickness. Supports for columns. Numerical problems **8 Hrs.**
5. **Pipe Line Design:** Pipe thickness, pipe diameter. Optimum size of delivery line in pumping operations. Pump rating. Numerical problems. **4 Hrs.**
6. **Introduction to Design of Storage Vessels:** Process conditions and design parameters for storage of volatile, nonvolatile fluids and gases. Design of components, supports and selection of vessels accessories and mountings. Roofs for vessel. Numerical problems. **6 Hrs.**

Note: IS code book 2825 for pressure vessel design is permitted in the exams for reference.

Reference Books:

1. M.V.Joshi "Process Equipment Design", 3/e, reprint Macmillan & Co. India, Delhi, 1998.
2. S.D.Dawande, "Process Design of Equipment - Vol 1", 3/e Central Techno Publications.
3. Brownwell and Young “Process equipment Design”, vessel design John Wiley 1951.
4. Perry and Green; “Chemical Engineers Handbook”, McGraw Hill Publications.

15UCHC503 Chemical Plant Utilities and Safety (4-0-0)4: 52 Hrs.

Course Learning Objectives:

1. To understand the utilities in a chemical process plant, types, role and their selection.
2. To understand the principles of safety with insight of safety analysis techniques and application of safety devices.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	List and comprehend the selection and role of utilities in a chemical plant.	-	3,8,9,10,14	6,7
CO2	Appraise the generation, handling and role of water, steam and air in a chemical plant.	-	6,8,9,10	3,14
CO3	Assess refrigerants, evaluate the performance and apply refrigeration.	-	6,8,9,10	3,14
CO4	Prioritize safety aspects, plan and use safety devices in defiant situations in a chemical plant.	-	9	3,6,7,8,10,14
CO5	Interpret safety analysis tools and techniques and translate to hazardous conditions.	-	3,8	6,7,9,10,14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2.6			2.6	3	2.2	2.2	2.4				2.8	

Prerequisites: Nil

Course Content:

1. **Introduction:** Utilities and their Role in Process Plant Operations, Criteria for selection and estimation of suitable Utilities. **4 Hrs.**
2. **Water:** Resources, Cooling water-requirements and treatments, Process water-Ion Exchange, Water softening methods-Ion exchange, Reverse osmosis, Electro dialysis, Water pretreatment, recycle and reuse, various pumps. **8 Hrs.**

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3. **Air:** Compressed air for process and instruments, Blowers and Fans-Characteristics, Compressed- Positive displacement and Centrifugal features, Multistage Compression-features, Vacuum pumps, Air Drying-Pressure swing and Thermal swing. **6 Hrs.**
4. **Steam:** Generators, Boiler ratings, Efficiency, Feed water Treatment and Blow down Calculations, Steam quality, Steam consumption, Various steam flow meters, Steam distribution. Condensate removal, Condensate recovery, Piping ancillaries, Efficient utilization of Steam. **7 Hrs.**
5. **Refrigeration:** Carnot Cycle and Reverse Carnot Cycles, Tonnage, Primary and Secondary refrigerants, Vapor Compression Refrigeration; various refrigerants, Tonnage. Vapor Absorption Refrigeration- Characteristics, Comparison. **7 Hrs.**
6. **Introduction to Safety:** Safety aspect, safe design, Intrinsic and Extrinsic safety, Hazard, Risk, Toxicity, Flammability, Fire, Explosion, TLV, Sources of ignition. **3 Hrs.**
7. **Hazardous Materials and Conditions:** Reactive Chemicals, Combustion and Flammability, Gas explosion, Dust Explosion, UCVCE, Static Electricity, Vacuum Hazards, Inert Gas Hazards, Gas Dispersion. **3 Hrs.**
8. **Safety Devices:** Pressure Relief Systems, Emergency, Relief devices, Flame Arrestors, Storage and handling of hazardous material. **5 Hrs.**
9. **Process safety analysis:** Hazard Analysis (HAZAN), Hazard and Operability studies (HAZOP), Comparison, Risk Analysis and Estimation, Safety check lists. **6 Hrs.**
10. **Case Studies:** Jaipur disaster, Flixborough, Seveso, Piper Alpha, Mexico [LPG Fire] **3 Hrs.**

Reference Books:

1. Perry's "Handbook of Chemical Engineers" 7/e, Mc-Graw Hill Publications.
2. Frank P. Lees, "Loss Prevention", Vol 1 and Vol 2.
3. Jack Broughton, "Process Utilities", I Chem publications.

15UCHL504	Heat Transfer Laboratory	(0-0-3)1.5

Course Learning Objective

1. To study the phenomena of conduction, convection and radiation effects in different equipments and know the rate of heat transfer.
2. To study the working, construction and analyse the efficiency and performance of heat exchangers.

Course Outcomes:

COs	Description: At the end of the	Mapping to POs and PSOs

	course student will be able to	Introductory 1	Moderate 2	Substantial 3
CO1	Identify the different modes of heat transfer and evaluate the rate of heat transfer coefficient.	9	10	4,15
CO2	Determine the thermal conductivity of solids and liquids.	9	10	4,15
CO3	Distinguish the different types of heat exchangers and identify their applications.	9	10	4,15
CO4	Evaluate the performance and efficiency of the heat exchangers using the steam and recognize the boiler characteristics.	9	10	4, 15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report.		8, 10	9

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level				3				2	1.4	2					3

Prerequisites: Process heat transfer theory.

List of Experiments:

1. Double pipe heat exchanger
2. Cross flow heat exchanger
3. Thermal conductivity of liquids
4. Heat transfer through lagged pipe
5. Emissivity determination
6. Stefan - Boltzmann apparatus
7. Extended surfaces
8. Packed bed vertical condenser
9. Heat transfer through helical coil
10. Unsteady state heat transfer
11. Natural and forced convection in a jacketed vessel
12. Evaporator
13. Solar heater
14. Heat transfer through fluidized bed

Note: Atleast 10 experiments to be conducted

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Reference Books

1. J.P.Holman, "Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2. Rao Y.V.C., "Heat Transfer", Edition illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3. McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4. Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1. 6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

15UCHL505 Environmental Engineering Laboratory (0-0-3)1.5

Course Learning Objectives:

1. To understand the employability of instruments in determining various parameters of solid, liquid and gas samples to analyze completely and present a good technical report.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Reproduce theory and apply into practice for using high precision instruments for analysis.	9	10	4,15
CO2	Characterize the samples through the use of pollution indicators and report the results.	9	10	4,15
CO3	Comprehend the use of instruments in projects.	9	10	4, 15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report.		8, 10	9

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3				2	1.5	2					3

Prerequisites: Instrumental method of analysis
Pollution Control theory.

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List of Experiments:

1. Analysis of effluents for pH, alkalinity and turbidity
2. Determination of COD and BOD
3. Volatile, Fixed, Filterable and Dissolved solid analysis
4. Analysis by ion selective electrode (any two anions)
5. Measurements of particulate matter in Air
6. Analysis of exhaust by Orsat Apparatus.
7. Dissolved Oxygen Measurement
8. KF Auto Titrator
9. Flame Photometer
10. Turbidometer
11. Bomb calorimeter
12. Viscometer
13. mV Titrator

Note: Atleast 10 experiments to be conducted

Reference Books

1. C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2. Metcalf and Eddy - "Waste Water Engineering Treatment Disposal Reuse" 4/e, Tata McGraw Hill, 2003.
3. Jaffery, G.H., Basset, J., et. al., " Vogel's Text book of Quantitative Inorganic Analysis" 5/e, ELBX, 1998
4. Skoog, D.A., "Principles of Instrumental Analysis" 3/e, Saunders College publishing 1985.

15UCHE506	**Process Instrumentation**	**(4-0-0)4: 52 Hrs.**

Course Learning Objectives:

1. To make students understand the Identification, classification construction, working principle and application of various transducers used for Displacement, Temperature, Level, flow and Miscellaneous measurement.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Comprehend the fundamentals of instrumentation to control chemical processes.	3	1,13	

CO2	Explain process control instrumentation with principles and theory	3,13	1	
CO3	Apply correct practice to installation, calibration of instrument and analyze limitations of each measuring instruments.	1,13	3	
CO4	Troubleshoot, isolate and fix electronic instrumentation problems.		1,3,13	
CO5	Design a simple instrumentation system.	13	1	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.8	1.8											1.4		

Prerequisites: Nil

Course content:

1. **Introduction:** classification, characteristics of instruments- static and dynamic. Sensor and Transducer: Definition, classification (active, passive, primary, secondary, mechanical, electrical, analog, digital).Transducer specifications. Transmitters, Converters, Control panel, Recorders and monitors. Error: definition, classification. **5 Hrs.**

2. **Flow Measurement:** Head Type: orifice, venturi, nozzle, pitot tube. Variable Area Type: Rotameter type. Other flow meters: Turbine, electromagnetic, ultrasonic, positive displacement, anemometers, solid flow measurements. **7 Hrs.**
3. **Pressure Measurement:** Pressure scales, units and relations, classification, U-tube types, well type, inclined type manometer, micro manometer, bellows, diaphragm, bourdon tube,. Vacuum Measurement Units and relations, McLeod gauge, Pirani gauge, thermocouple gauge, hot cathode ionization gauge, Knudsen gauge. **5 Hrs.**
4. **Level Measurement:** Need for Level Measurement, Classification of Level Measurement Techniques. Construction and working of Dipstick, displacer, float system, bubbler, capacitive devices for level measurement, ultrasonic level gauge, DP cell, vibrating type, radar, radioactive type level gauges, LASER type transducers, fiber optic level sensors. **6 Hrs.**

5. **Temperature Measurement:** Temperature scales, classification of Temperature Sensors, a) Thermometers: Classification, Construction and working of glass thermometers, liquid expansion thermometer, gas thermometer (filled system thermometer), bimetallic thermometer, Specifications. b)Resistance temperature detector (RTD):Principle, types,

Configurations, construction and working of RTD, Material for RTD, Lead wire Compensation in RTD, Specifications, advantages, disadvantages and applications of RTD. c) Thermistors: Principle, types (NTC and PTC), characteristics, Construction and working, materials, specifications of Thermistor, applications. **10 Hrs.**

6. **Thermocouples:** Principle, thermoelectric effect, See beck effect, Peltier effect, laws of thermocouple, types of thermocouple with characteristic curve, thermocouple table, Sensitivity, constructional features of Thermocouples, Thermo couple specifications, cold junction Compensation method, thermopile, thermocouple emf measurement method, Thermo well. Pyrometers: Principle, Construction and working of Radiation and optical pyrometers and its Applications. **6 Hrs.**
7. **Displacement Measurement:** a) Resistance potentiometer: piezo-resistive effect, ultrasonic transducer. LVDT, RVDT. Selection and properties of materials for LVDT, and general electromagnetic sensors. b) Capacitance type transducers: with applications, materials for capacitive, ultrasonic and elastic transducers. c) Digital transducer: translational and rotary encoders, Optical and magnetic pickups. d) Pneumatic transducer: flapper- nozzle transducer. **6 Hrs.**
8. **Miscellaneous Transducers:** Transducers for Position, speed, acceleration, humidity, and moisture measurement. Electronic measuring instruments, Electronic voltmeters, Principle of A/D and D/A converters. **7 Hrs.**

Reference Books:

1. Donald Eckman, “Automatic Process Control”, Wiley Eastern Limited
2. John P. Bentley, “Principles of Measurement Systems”, 3/e, Addison Wesley Longman Ltd., UK, 2000.
3. Doebelin E.O, “Measurement Systems - Application and Design”, 4/e, McGraw-Hill International Edition, New York, 1992.
4. Stephanopoulos George, “Chemical Process Control”.

15UCHE507	**Energy Technology and Management**	**(4-0-0) 4: 52 Hrs.**

Course Learning Objective:

1. Understand the utilization of conventional and non – conventional energy sources and the principle of working of related equipments.
2. Recognize the effects of current energy systems on the environment and society.
3. Study energy costs/waste minimization without affecting production and quality.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and comprehend the effects of current energy systems based on solid and gaseous fuels.	3	2,13	1
CO2	Analyze the principles and concepts involved in non – conventional energy sources such as solar, geothermal, wind, biomass, ocean and tidal energy.	3, 14	2, 13	1
CO3	Describe the challenges and problems associated with solar, geothermal, wind, biomass, ocean and tidal energy sources with regards to future energy supply and environmental concern.	1	2,13	3, 14
CO4	Discuss the principles and need of energy audit and management programs.		2,13	1

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.5	2	1.7										2	2	

Prerequisites: Nil

Course Content:

1. **Fuels:** Classification, properties, tests and analysis. Solid fuels – coal, origin, classification, storage and handling, carbonization and briquetting, chemistry, gasifiers. Gaseous fuels - Water gas, carbureted water gas, producer gas, coal gas & natural gas. Furnaces – types and classification. **08 Hrs.**
2. **Solar Energy:** Solar constant, Solar radiation at earth's surface, Solar radiation geometry, Solar radiation measurement. Solar water heating, space cooling, Solar distillation, pumping and Solar cooking- Basic principles, methods, applications, advantages and limitations. **10 Hrs.**
3. **Geothermal Energy**: Resources of geothermal energy, thermodynamics of geo-thermal energy, electrical and non-electrical conversion, environmental considerations. **04 Hrs.**
4. **Wind Energy:** Introduction, Basic components of WECS (wind energy conversion system). Classification of WEC Systems. Types of wind energy

machines- (wind energy collectors) horizontal axis, vertical axis machines. **06 Hrs.**

5. **Bio – Energy (Thermal Conversion):** Introduction, Biomass conversion technology, Wet and Dry process, Factors affecting Bio digestion or Generation of gases, Classification of Bio gas plants, Floating Drum, Fixed Dome plants -Basic principles, Construction and Working principles, Advantages and disadvantages, Thermal gasification of biomass. Classification of Bio gasifiers. **10 Hrs.**
6. **Energy from oceans:** Introduction to Ocean thermal energy conversion (OTEC). Methods of ocean thermal electric power generation. Open and closed OTEC cycle. Hybrid cycle **Energy from tides:** Basic principles of tidal power, Components of tidal power plants. Operation methods of utilization of tidal energy. Advantages and limitations of tidal power generation. Applications of tidal energy. **08 Hrs.**
7. **Energy management:** Principles and needs initiating and managing an energy management programs, Energy Audit – Elements and concepts, Types of Energy Audits, Energy Audit of any one chemical industries. **06 Hrs.**

Reference Books:

1. G.D. Rai, "Non-Conventional Energy Sources", 4/e Second Reprint, Khanna Publications", 1997.
2. P.C. Jain and M. Jain, "Engineering Chemistry", 10/e, 3rd Reprint, Dhanpat Rai and Sons, 1995.
3. S.P. Sukhatme, "Solar Energy", 2/e, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.
4. G.D. Rai, "Solar Energy Utilization", 4/e, Khanna Publications.

15UCHE508	Solution Thermodynamics	(4-0-0) 4: 52 Hrs.

Course Learning Objectives:

1. To calculate thermodynamic properties of fluids and fluid mixtures using equations of state.
2. To determine the equilibrium compositions of chemical reactions and two-phase Liquid /vapor mixtures.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**

CO1	Classify thermodynamic properties of pure fluids and derive equations which relate them to non measurables.			1,2,3,13
CO2	Differentiate between ideal and non- ideal solutions and calculate the partial molar properties.			1,2,3,13
CO3	Generate VLE data for solution using various correlations and interpret their consistency.		4	1,2,3,13
CO4	Determine the conversion at equilibrium and predict the effect of controllable variables on conversion.		4	1,2,3,13
CO5	Explain the important refrigeration cycles and list the properties of refrigerants.	3,13,15		1,2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	3	2.6	2									2.6		1

Prerequisites: Chemical Engineering Thermodynamics

Course Content:

1. **Thermodynamic Properties of Pure Liquids:** Reference Properties, Energy properties, Derived properties, Work function, Gibbs free energy, Relationships among thermodynamic Properties: Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, Modified equations for U and H, Effect of temperature on U, H and S, Relationships between C_p and C_v, Gibbs-Helmholtz equation, Fugacity: Fugacity, Fugacity coefficient, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: effect of temperature and pressure, Thermodynamic diagrams. **10 Hrs**.
2. **Properties of Solutions:** Partial molar properties, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, Activity and Activity coefficients, Gibbs-Duhem equation, Property changes of mixing, excess properties. **10 Hrs.**
3. **Phase Equilibria:** Criteria of phase Equilibria, and stability, Duhem's theorem, Vapor-Liquid Equilibria, ideal and nonideal solutions, Consistency test for VLE data, Calculation of Activity coefficients using Gibbs-Duhem equation, Liquid-Liquid Equilibrium diagrams. **10 Hrs.**
4. **Chemical Reaction Equilibrium:** Reaction stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant-temperature and pressure effect,

standard free energy change, factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous reaction Equilibria, phase rule. **12 Hrs.**

5. **Refrigeration:** Carnot Refrigerator, Vapor compression cycle, choice of refrigerants. **10 Hrs**.

Reference Books:

1. Smith J.M and Vanness H.C. and Abbot, "Introduction to Chemical Engineering Thermodynamics", 5/e & 6/e, McGraw Hill, New York, 1996.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" New Age International Publication, Nagpur, 2000.
3. Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.

15UCHE509	**Food Technology**	**(4-0-0) 4: 52 Hrs.**

Course Learning Objective

1. To understand the basic principles of Food Science and Technology and applying this understanding to the growing and dynamic needs of the Food Industries.
2. To study the application of unit operations and modern trends in food processing industries.

Course Out comes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Understand the quality attributes and the chemistry of food	2		14
CO2	Apply unit operations and modern techniques for food processing	1	5	3
CO3	Identify and analyse the different food preservative, enzymes and additives required	14	2	6,7
CO4	Assess the impact of environmental concern and food safety	14	8	6, 7

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	1.5	3		2	3	3							1.6	

Prerequisites: Nil

Course Content:

1. **Introduction and Quality Attributes of Food:** Function of foods. Food in relation to health. Aim of food science and technology. Quality attributes – Appearance factors, Textural factors, Flavour factors. Visual and objectively measurable attributes. Aroma of foods –introductory ideas, formation, chemistry and analysis. Taste – introductory ideas, formation and chemistry. Additional quality; quality standards, quality control. Introduction to sensory evaluation of foods and beverages. **6 Hrs**
2. **Formation and Chemistry of Food:** Carbohydrates. Proteins. Lipids. Vitamins. Minerals. Water. Biotin. Choline. Phytochemicals. **4 Hrs**
3. **Food Processing and Preservation:** Food deterioration – Causes. Aims and objectives of preservation and processing. Unit operations in processing. Different methods of food preservation – low temperature, high temperature, preservatives, osmotic pressure, dehydrations. Food irradiation; processing and preservations of milk and dairy, vegetables and fruits, cereals, legumes and nuts, meat and meat products, fats and oils, beverages, sugars, sweeteners, honey and confectionary, salt and spices. **8 Hrs**
4. **Enzymatic and Non-Enzymztic reactions during storages:** Introduction to enzymes. Nature and function of enzymes. Classification of enzymes. Hydrolases – Esteraus, amylases, pectic enzymes. Proteases. Oxidoreductases – phenolases, glucose oxidase, catalose, peroxidase, lipoxygenase, xantine oxidase. Immobilized enzymes. Uses and suggested uses of enzyme in food processing. Non-enzymatic reactions. **8 Hrs**
5. **Food Additives:** Introduction and need for food additives. Types of additives –antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and antichoking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety. **9 Hrs**
6. **Food Contamination and Adultration:** Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. **9 Hrs**
7. **Environmental Concerns and Food Safety:** Water in food production. Properties and requirements of processing water. Environmental concerns – solid waste disposal, waste water properties, wastewater treatment. Safety hazards and risks. Food related hazards. Processing and handling. Cleaning and sanitizing. **4 Hrs**
8. **Modern Trends in Food Science:** Biotechnology in food. Biofortification. Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition label in. Careers in food science and food industries. **4 Hrs**

Reference Books:

1. N. Shakuntala Manay and M. Shadaksharamurthy, “Foods (facts and principles)”, 3/e, New Age International, 2016.
2. Heid, J.L. and Joslyn, M.A., Fundamentals of Food Processing Operation, The AVI Publishing Co., Westport, 1967.
3. Heldman, D.R., Food Process Engineering, The AVI Publishing Co., Westport, 1975.
4. Hall, C.W., Farall, A.W. and Rippen, A.L., Encyclopedia of Food Engineering, Van Nostrand, Reinhold, 1972.

15UCHE510	Fertilizer Technology	(4-0-0) 4 : 52 Hrs.

Course Learning Objective:

1. It is needed to provide comprehensive and balanced understanding of essential link between chemistry and the synthetic fertilizer industry. It is therefore vital for chemical engineers to understand the fertilizer production and technology.
2. To study the different reaction and separation steps of the different fertilizers and application of unit operations in fertilizer industries.

Course Out comes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Use reactions and unit operations steps in manufacturing of various fertilizers	1	2	13
CO2	Characterize fertilizers on the basis of different properties		3	14
CO3	Identify engineering problems in fertilizer manufacturing	3	13	6,7
CO4	Handle the fertilizers	7,8	14	
CO5	Select appropriate synthesis fertilizer	7,8		14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	1.5			3	1.6	1						3	

Prerequisites: Nil

Course Content:

1. **Overview of Fertilizer:** Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crop. Development of fertilizer industry; Fertilizer production and consumption in

India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers. **8 Hrs**

2. **Nitrogenous Fertilizers:** Introduction to Ammonia: Physical &chemical properties, applications, Synthesis gas by Catalytic partial oxidation Steam Hydrocarbon reforming, Ammonia converters: Design aspect of Single bed and multi-bed converter, Kellogg process and Haldor Topsoe process, Storage and Transportation of Ammonia. Introduction to Nitric acid: Chemical, physical properties and applications, Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process, Concentration of Nitric acid by $Mg(NO_3)_2$. Physical, chemical properties of Urea. Manufacturing of Urea by Stamicarbon's CO2 stripping process, Montecatini Solution recycle process Toyo-Koatsu total recycle process **16 Hrs**
3. **Phosphate Fertilizers:** Physical, chemical properties and applications of Phosphorus and Phosphoric acid. Manufacturing of elemental phosphorous by Electric furnace method. Manufacturing phosphoric acid by Wet Process. Strong Sulphuric Acid Leaching Hydrochloric Acid Leaching Electric Furnace Process. **08 Hrs**
4. **Potassium Fertilizers:** Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate, Manufacturing of potassium chloride from sylvinite, Preparation of Potassium nitrate, Potassium sulphate. **10 Hrs**
5. **Miscellaneous Fertilizer and Bio Fertilizers:** Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate(CAN), Biofertilizers, Types of Biofertilizers, Nitrogen fixing biofertilizers, Phosphate-solubilizing biofertilizers, Preparation of a biofertilizers. **10 Hrs**

Reference Books:

1. Collings, G.H., "Commercial Fertilizers", 5/e, Mcgraw Hill, New York, 1955.
2. Editorial board, "Handbook of Fertilizer Technology", The Fertilizer Association of India, New Delhi, 1977.
3. Slacks, A.V., "Chemistry and Technology of Fertilizers", Interscience, New York, 1966.

VI Semester B.E.

15UCHC600 Management, Entrepreneurship and Protection of Intellectual Property Rights (4–0–0)4: 52 Hrs.

Course Learning Objectives:

1. To understand the development and function of management, the concept of entrepreneurship, intellectual property rights and legal issues.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain historical development of management and Engineering; Defend the synthesis of Engineering and Management.	6		
CO2	List and differentiate the functions of management in modern organization structures.		9,10	7,8
CO3	Explain foundation of entrepreneurship, role of entrepreneurs in economic development.		9,10	7,8
CO4	Asses impact of liberalization, privatization and globalization on small scale industries.		9,10	7,8
CO5	Identify Institutional support to small scale industries and prepare project report and its feasibility studies.		9,10,14	8,11
CO6	Explain forms of intellectual property rights and procedure for registration, infringements and penalties.		5,6	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level					2	1.5	3	3	2	2	3			2.5	

Prerequisites: Nil

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Course Content:

Management:

1. **Introduction:** Development and evolution of management thoughts, Modern management approaches, Scope and characteristics of

management, tools of management, management and administration, levels of management, principles of management, roles of management **4 Hrs.**

2. **Planning:** Nature and importance of planning, types of planning, steps of planning, essential of planning, planning process, planning tools and techniques. **5Hrs.**
3. **Organizing and staffing:** Steps and nature of organizing, organization structure, purpose of organization, types and principles of organization, Departmentation, span of control, authority, power and responsibility, delegation, centralization and decentralization, management by objectives, nature and importance staffing, recruitment and selection. **5Hrs.**
4. **Directing and controlling:** Nature of direction, principles of direction, leadership and styles, motivation, communication, types and forms of communication, coordination and cooperation, managerial control, steps in control process, control methods. **4Hrs**

Entrepreneurship:

1. **Entrepreneurship:** Evolution and Meaning of entrepreneur, characteristics of entrepreneur, entrepreneur and manager, functions and types of entrepreneur, Intrapreneur, role of entrepreneurship in economic development, barriers of entrepreneurship. **5 Hrs.**
2. **Small Scale Industry:** Definition, characteristics, objects, role of SSI in economic development, advantages of SSI, steps to start a SSI, impact of liberalization, privatization, and globalization on SSI, impact of WTO/GATT on SSI, definition of ancillary and tiny industry. **5 Hrs.**
3. **Institutional Support:** Nature of support of government, objectives and functions of NSIC, SIDO, SISI, SSIB, SSIDC, SIDBI, DIC, KIADB, KSSIDC, KSFC. **4 Hrs.**
4. **Preparation of Project:** Meaning of project identification, project report, contents and formulation, identification of business opportunities, feasibility studies, types and purpose **4 Hrs.**

Protection of Intellectual Property:

1. Introduction: Meaning and forms of intellectual property right, competing rationale for protection, international conventions, world court. **3 Hrs.**
2. Copyright: Meaning of copyright, content of copy right, ownership and rights, period of copyright, assignment and relinquishment of copyright, license, infringement of copy right, fair use, offenses and penalties. **4 Hrs.**
3. Patents: Concept of patent, patentable inventions, procedure for obtaining patent, rights and obligations of patent holders, infringements and remedies, offenses and penalties. **4Hrs.**

4. Industrial Designs and Trademarks: Definition of design, procedure for registration, rights conferred by registration, infringements. Concept of trademarks, procedure of registration, duration and fees of trademarks **5Hrs.**

Reference Books:

1. Thomas W. Zimmerer, "Essentials of Entrepreneurship", PHI, 2005.
2. Veerabhadrappa Havinal, "Management and Entrepreneurship", 1/e, ISBN (13): 978-81-224-2659-5, New Age International, 2009.
3. Peter Drucker, "The Practice of Management", ISBN-10: 0060878975 Harper Business Reissue edition, 2006
4. N.K. Acharya, "Text book on Intellectual Property Rights", 4/e, Asia Law House.

15UCHC601 Chemical Process Integration (4-0-0) 4 : 52 Hrs.

Course Learning Objectives:

1. To teach students basic principles and methodologies for energy, mass and material integration for sustainable process synthesis and design.
2. It helps in understanding the usage of material, Heat and Mass effectively for the profit of Industry using pinch analysis.
3. It helps in formulating the design and optimizing the process in plant for the integrated approach.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and explain the importance of process integration.	14	3	6,7
CO2	Evaluate and analyze the direct recycle strategy through material balance, graphical and algebraic approach.	1	2,3	13
CO3	Predict and evaluate the visualization strategies of mass integrated system through graphical and algebraic approach	1	2,3	13
CO4	Illustrate and develop heat exchange network by pinch diagram with screening of exchangers along with combined heat and power integration	1	2,3	13

CO5	Formulate and optimize the different process integration networks	1,2		5,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	2		3	3	3						3	1	

Prerequisites: Nil

Course Content:

1. **Introduction to Process Integration:** Categories of process integration. Mass targeting for minimum discharge of waste and minimum purchase of fresh utilities. **6 Hrs.**
2. **Direct recycle strategies.** Source-Sink mapping diagram, Multicomponent source sink mapping. Graphical and algebraic approach for direct recycle strategies. Property based pinch diagram. **14 Hrs.**
3. **Heat Integration**. Design and synthesis of heat exchange network (HENs). Heat exchange pinch diagram and algebraic approach for pinch point. Grand composite curves (GCC). Combined heat and power integration (Heat Pumps and Engines). Cogeneration process targeting. **14 Hrs.**
4. **Mass Integration**. Synthesis of mass exchange network (MEN). Design and cost optimization of mass exchangers. Visualization strategies for the development of mass integrated system. Algebraic and graphical approach to targeting mass exchange (Mass Integration) **14 Hrs.**
5. **Optimization.** Overview of optimization, classification and formulation of optimization programs. Different methods of optimization programming. Approach for direct recycle and synthesis of mass and heat exchange network using a programming language. **4 Hrs.**

Reference Books:

1. Mahmoud Halwagi, “Process Integration”, 1/e, Elsevier, 2006.
2. I. C. Kemp, “Pinch analysis and process Integration” 2/e, Butterworth, 2006.
3. Robin smith, “Chemical Process Design and Integration”, 1/e, Wiley, 2005

15UCHC602	**Process Equipment Design and Drawing**	**(3-0-2)4: 52 Hrs.**

Course Learning Objectives:

1. To develop key concepts and techniques to design process equipment in a process plant.
2. To expose students to the practices followed in the design of chemical equipment’s and their drawing.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Congregate and analyze the data from the hand book, code book and literature.			1,2
CO2	Design and evaluate the heat transfer equipment's like DPHE, STHE and condensers	1	2	3,13
CO3	Design and evaluate mass transfer equipment's like Distillation column and absorption towers.	1	2	3, 13
CO4	Design and evaluate the simultaneous heat and mass transfer equipment's, evaporator and rotary dryer.	1	2	3,13
CO5	Draw the equipment's as per the design.			3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2.25	3										3		

Prerequisites: **Process Heat Transfer, Chemical Engineering Drawing, Mass Transfer I and II**

Course Content:

- Detailed Chemical Engineering Process Design of the following equipment.
- Necessary aspects studied in "Chemical Equipment Design" is to be applied for mechanical design.
- Use of standard code books to be taught.
- The detailed dimensional drawings shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template.

NOTE:

1. The question paper to contain two full design problems (100 Marks each) for the equipment from the above list and student to answer any **One**.
2. Perry's Chemical Engineer's Handbook shall be allowed in the examination as reference. IS Code 4503 for Heat Exchangers (if required) shall be permitted.
3. The answer shall include detailed process design steps using the data given in the problem, mechanical design for component dimensions and drawing (Sectional Front View, Top/Side View and major Component Drawings with Part Template).

1. Double Pipe Heat Exchanger.
2. Shell and Tube Heat Exchanger.
3. Condenser
4. Distillation Column.
5. Evaporator
6. Absorption Column.
7. Rotary Dryer.

Reference Books:

1. R. H. Perry and D. W. Green “Chemical Engg Hand Book”, 7/e, McGraw Hill, 1998.
2. Donald Q. Kern, "Process Heat Transfer”, McGraw Hill, 1997.
3. Robert E. Treybal, "Mass Transfer Operations", 3/e, McGraw Hill, 1981.
4. J. M. Coulson & J. F. Richardson, "Chemical Engineering", Vol. 6 Pergamon Press, 1993.

15UCHL603	Mass Transfer Laboratory	(0-0-3)1.5

Course Learning Objectives:

1. To provide an understanding of extending the theory into practice through various experiments related to diffusion, both molecular and convective; transfer coefficients and other diffusion based separation processes.
2. To analyze experimental data from the experiment conducted and present a good technical report, thereby demonstrating skills in communication through mandatory oral presentations.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Evaluate Rayleigh’s equation, vaporization and thermal efficiencies using distillation principles.	9	10	4, 15
CO2	Estimate the percentage recovery for types of Extraction equipments.	9	10	4, 15
CO3	Calculate the Diffusion coefficient for Diffusion of organic vapour experiment.	9	10	4, 15

CO4	Explain the temperature dependency on ternary phase diagram.	9	10	4, 15
CO5	Evaluate Freundlich equation using adsorption principles	9	10	4, 15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3.0					1.0	2.0					3.0

Prerequisites: Mass Transfer I and II

List of Experiments:

1. Diffusion of organic vapors in Air
2. Steam distillation
3. Packed column/ Plate column distillation
4. Distillation - Simple (Differential) distillation
5. Solid - liquid leaching
6. Surface evaporation
7. Tray dryer
8. Adsorption studies
9. Liquid - Liquid / Vapor - Liquid equilibrium
10. Liquid extraction - (Cross current: single and 2 or 3 Stage)
11. Holdup studies in packed columns
12. Rotary / Vacuum dryers
13. Wetted wall column
14. Cooling tower
15. Solid dissolution

Note: Atleast 10 experiments to be conducted.

Reference Books:

1. Robert E. Treybal, “Mass Transfer Operation” 3/e, Mc Graw Hill.
2. Coulson and Richardson, “Chemical Eng Vol. 1 and Vol. 2”, 4/e.
3. Geankoplis C.J, “Transport Processes and Unit Operations”, 3/e,Prentice Hall (I).
4. Mc Cabe and J.M.Smith, “Unit Operations in Chemical Engineering”, 7/e Mc Graw Hill.

15UCHL604	Chemical Reaction Engineering Laboratory	(0-0-3)1.5

Course Learning Objectives:

1. To study the reaction kinetics for lab scale reactors by applying the knowledge of chemistry and engineering into practice.
2. To analyze and interpret the experimental data to find the rate law and project in the form of a report and oral presentation.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Determine the kinetics of the reaction for batch, semi batch and flow reactors	9	10	4, 15
CO2	Evaluate the activation energy of the reaction	9	10	4, 15
CO3	Characterize the non ideal behavior in the reactors	9	10	4, 15
CO4	Analyse and interpret the data for reactor design	9	10	4, 15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12.	PO13	PO14	PO15
Mapping Level				3				2	1.2	2.2					3

Prerequisites: Chemical Reaction Engineering I and II.

List of Experiments

1. Batch Reactor
2. Isothermal plug flow reactor
3. Semi Batch Reactor
4. Mixed flow reactor
5. Heterogeneous catalytic reactor
6. Segregated flow reactor
7. Adiabatic reactor
8. Packed Bed Reactor
9. RTD Studies in Tubular reactor
10. Effect of temperature on Rate of reaction
11. RTD Studies in mixed flow reactor

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Note: Atleast 10 experiments to be conducted

Books

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley and Sons, 1999.
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, Mc Graw Hill, 1984.

15UCHL605	Mini Project	(0-0-8) 4

Course Learning Objectives:

1. To carry out the experimental/design tasks of relatively minor intensity and scope as compared to the major project and in line with the guidelines formulated by the DUGC.
2. To see that this project could be a prologue for the upcoming major projects in the final year.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify the topic of chemical engineering or integrated problems (allied fields).	7, 14	8, 12	2, 10
CO2	Compare the literature review and select suitable materials and methodologies for selected topic.	7, 10,14	8,11,12	3,4,5,15
CO3	Plan and carry out the experimental work and economic analysis.	9	8,10,12	11,15
CO4	Prepare a precise report on the work done with proper guidelines and references.	9	8,15	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3.0	3.0	3.0	3.0		1.0	2.0	1.0	2.2	2.5	2.0		1.0	2.6

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VI semester. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VI semester. After getting the approval from DUGC, the project work should be carried out in VI semester. The project report should be submitted along with the presentation on the work carried out at the end of VI semester

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

15UCHE606	Petroleum and Petrochemicals	(4-0-0)4 : 52 Hrs.

Course Learning Objective:

1. Studying this subject the students will learn about the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the Indian petroleum industry and world scenario	6		
CO2	Apply the basic procedure and role of all fundamental system used in petroleum and petrochemical industry		15	1
CO3	Identify and characterize the different products of hydrocarbon	3, 14	2	15
CO4	Analyze the measuring parameters to be measured according to the operational conditions	13	1	4
CO5	Analyze the key issues in the	1‘	2, 13, 15	3

	design and optimization of petroleum and petrochemical production system			
CO6	Apply critical thinking and problem solving approaches towards the principles of petroleum and petrochemical engineering	1, 13	2, 12	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.75	2	2	3		1						2	1.33	2	2.33

Prerequisites: Nil

Course Content:

1. **Indian Petroleum Industry:** prospects & future, major companies, world production, markets, offshore & onshore, oil well technology. **4 Hrs.**
2. **Petroleum crude characterization**: Composition and classification, UOP K factor, TBP analysis, EFV Analysis, Average Boiling points, ASTM Curves, Thermal properties, Pour Point. **4 Hrs.**
3. **Product properties and test methods:** Characterization -Flash point, Fire point, Reid vapor pressure Analysis, Octane Numbers, Cetane Index, smoke point, Burning quality, Carbon Residue, Viscosity Index, Softening point, Penetration Index, Oxidation Stability, Volatility, Aniline point, Pour point . Various Petroleum products & Additives for Naphtha, Gasoline, Gas, ATF, LPG, Kerosene, Diesel, Lubricating oils, Bitumen. **12 Hrs.**
4. **Crude pretreatment**: Pumping, dehydration, comparison, petroleum furnaces and comparison, Refining of petroleum – Atmospheric and vacuum distillation. **6 Hrs.**
5. **Treatment techniques**: Removal of sulphur compounds, storage and stability, product treatment using solvent, dewaxing, clay treatment and hydro refining. **5 Hrs.**
6. **Thermal cracking:** Visbreaking, Coking, Catalytic cracking (FCC), Hydro cracking, Air blowing of bitumen. Catalytic reforming, Extraction of Aromatics. **5 Hrs.**
7. **Petrochemicals:** Definition, importance and growth potential of the field, raw materials for petrochemical industries, sources, economics and advantages. Production of petrochemicals like dimethyl terephathalate (DMT), ethylene glycol, synthetic glycerin, LAB, acrylonitrile, methyl methacrylate (MMA), phthalic anhydride, maleic anhydride, phenol acetone, formaldehyde, production of carbon black. **14 Hrs.**

Reference Books:

1. B.K. Bhaskar Rao, “Modern Petroleum Processes”, 3/e, Oxford IBH publisher.
2. Ram Prasad , “Petroleum Refining Technology”, Khanna Publishers, 2000.
3. W.L. Nelson, “Petroleum Refinery Engineering” 4/e, McGraw Hill, 1985.
4. B.K.Bhaskar Rao, “A text book on petrochemicals” 1/e, Khanna Publishers, New Delhi, 1987.

15UCHE607	Catalyst Technology	(4-0-0)4 : 52 Hrs.

Course Learning Objectives:

1. To provide forum to understand the Principles and concepts of Heterogeneous Catalysis, Catalyst Characterization and Chemical analysis.
2. To provide an understanding of catalyst preparation methods, data analysis and reactor design along with deactivation kinetics.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain the various methods to estimate properties of given catalyst and evaluate its performance		1	
CO2	Formulate performance equations for reactors containing porous catalyst and apply the same for reactor design		1,14	2,3
CO3	Describe the various methods and equipments used in the manufacture of industrial catalyst.		1,14	
CO4	List the various mechanisms and determine the deactivation and regeneration rates in catalytic reactors.		1	2,3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	3	3											2	

Prerequisites: Nil

Course Contents:

1. **Introduction:** Brief history of catalyst technology development and its Economic importance. **2 Hrs.**
2. **Fundamentals of catalytic phenomena**: Definitions, structure of supported catalyst, steps in heterogeneous catalytic reaction, adsorption and desorption, reaction and diffusional resistances, kinetics of catalytic surface reaction, effect of surface structure on catalytic activity. **6 Hrs.**
3. **Catalyst materials**: Make up of a typical heterogeneous catalyst, carrier materials, Promoters, active phases, inhibitors, Role and functions of each, molecular sieve and zeolite catalysts. **4 Hrs.**
4. **Catalyst characterization and selection**: Definition and objectives of catalyst characterization, Determination physical properties of catalyst like , surface area, pore size, pore volume, particle size and size distribution, mechanical strength and density**.** **10 Hrs.**
5. **Determination of chemical properties**: Chemical composition chemical structure and morphology, Dispersion and crystallite size of active species, surface acidity and surface reactivity. **5 Hrs.**
6. **Catalyst preparation and forming**: Various methods like precipitation, impregnation, mixing techniques, preparation of finished catalyst by forming methods. **5 Hrs.**
7. **Manufacture of industrial catalysts:** Details of various equipments like reactors, Filters, dryers, calcinators, activators and impregnators. At least 5 different industrial catalysts manufacture to be dealt with. **6 Hrs.**
8. **Testing, evaluation of catalysts and scale up**: Basic approaches to reactor design, collection of data from laboratory reactors, choosing reactors for laboratory, rate data analysis and selection of plant reactors. **6 Hrs.**
9. **Catalyst Deactivation**: Causes and mechanism of deactivation, poisoning, fouling coking, thermal degradation, sintering volatilization and Mechanical failure, Prevention and regenerative treatments, reactor design and operation strategies with deactivation catalysts. **8 Hrs.**

Reference Books:

1. Prof.I.P.Mukhlyonov, “Catalyst Technology”, MIR Publishers.
2. Alvin Stoes and Marcell Decker, “Catalyst Manufacture”.
3. R.P.Farrauto and C.H. Bartholomew, “Fundamentals of Industrial Catalytic Processes”.
4. J. J. Carberry, “Chemical Catalytic Reaction Engineering”, McGraw Hill, New York.
5. Hamid Al-Mergen and Tian Cun Xiao, “Petrochemical Catalyst Materials, Processes and Emerging Technologies”, IGI Global Series Book, 2016, ISBN: 9781466699755.

15UCHE608 Applied Mathematics in Chemical Engineering

(4-0-0) 4:52 Hrs.

Course Learning Objective:

1. To understand the Computational techniques and use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand calculations for application in Chemical Engineering.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and apply mathematical methods to solve chemical engineering problems	3	2	1
CO2	Evaluate and analyse different chemical engineering problems using different mathematical techniques		2	3, 13
CO3	Interpret and develop the relationship in chemical engineering using different techniques		2	3, 13
CO4	Formulate and optimize with different methods to solve chemical engineering problems unit operation and process.	1	2	3, 5, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2	2.5		3								3		

1. **Computation and Error Analysis:** Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation. Linear Systems and Equations Matrix representation, Calculation of Eigen Values and Eigen vectors, Solution by Cramer's rule; Iterative Method-- Jacobi iteration; Gauss-Seidel Method, Chemical Engineering Examples: Material and energy balance problems involving at least 3 simultaneous equations Non-linear Algebraic Equations (single and multivariable) Secant, Multivariate Newtons method Chemical Engineering Examples: Equation of state (van der Waals, Beattie-Bridgeman, etc.), Friction factor equation etc. **14 Hrs**
2. **Regression and Interpolation:** Polynomial regression, Newtons Difference Formulae, Cubic Splines Chemical Engineering Examples: Free settling velocity of particles, Arrhenius Equation, Specific heat w.r.to temperature etc.

8 Hrs

3. **Numerical differentiation:** Numerical differentiation; higher order formulae. Integration and Integral Equations Two and Three point Gaussian quadrature formula Chemical Engineering Examples: Rayleighs equation, Rate equation. **8 Hrs**
4. **ODEs:** Initial Value Problems Runge – Kutta method for second order differential equations, Explicit Adams-Bashforth technique, Implicit Adams-Moulton technique, Predictor-Corrector technique. Stiffness of ODE"s ODEs: Boundary Value Problems: Orthogonal Collocation, shooting techniques. Chemical Engineering Examples: Rate equation, Steady-state material or energy balance equations etc. **10 Hrs**
5. **Solution of partial differential equations:** Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, implicit and explicit methods, Cranks Nicolson Method, Chemical Engineering Examples: unsteady-state one dimensional heat conduction. Use of Matlab with chemical engineering examples. **12 Hrs**

Reference Books

1. Gupta S.K , "Numerical Methods for Engineers", 3/e, ISBN : 978-81-224-3359-3, New Age International, 1995
2. Alkis Constantinides and Navid Mostoufi, "Numerical Methods for Chemical Engineers with MATLAB Applications", ISBN-10: 0130138517, Prentice Hall, 1999.
3. Steven Chapra and Raymond Canale, "Numerical Methods for Engineers.", 6/e, McGrew Hill Publication, 2010.
4. M. K. Jain, S. R. K. Iyengar, and R. K. Jain, "Numerical Methods", 6/e New Age International Publishers, New Delhi, 2012

15UCHE609 Polymer Science and Technology (4-0-0) 4: 52 Hrs.

Course Learning Objective:

1. To provide a broad and fundamental knowledge of the polymers and their chemical, physical and mechanical behavior.

Course Out comes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Classify polymer classification ,chemistry and kinetics	1	2	
CO2	Explain different polymer		1,4	

	processing stages			
CO3	Comprehend polymer properties and their testing	1	3	
CO4	Comprehend manufacturing, processing and properties of polymers	2	1	
CO5	Apply polymers for engineering applications	2	7	

POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
Mapping Level	1.5	1.3	2	2			2								

Prerequisites: Nil

Course Content:

1. **Polymer science:** Introduction, IUPAC names, Classification of polymers (source, occurrence, elemental composition, geometry and tacticity, stereo regularity), Definition of polymerization, characterization, Chain polymerization (free radical, ionic and co-ordination polymerizations), Step (condensation) polymerization, copolymerization. **6 Hrs.**
2. **Polymerization kinetics:** Definition of reaction rate, order, molecularity, kinetics of step reaction polymerization, kinetics of addition polymerization. **5 Hrs.**
3. **Methods of Polymerization*:*** Bulk, solution, Suspension, Emulsion, solid phase, gas phase polymerizations (formulation, mechanism, properties of the polymer produced, advantages and disadvantages). **8 Hrs.**
4. **Polymer properties:** Tensile strength, Impact strength, glass transition temperature, melting temperature, testing : sample preparation, testing standards & methods, analysis of polymer **6 Hrs.**
5. **Processing Technology:** Extrusion, Injection moulding, blow moulding Compression moulding, rotational moulding, thermoforming, Calendering, Compounding. **7 Hrs.**
6. **Polymer manufacturing:** Industrial production methods of PE, PP, PS, PVC, UF,PF, PU, Poly butadiene, Nylon 6 and Nylon 66. **8 Hrs.**
7. **Frontiers of polymer materials:** biodegradable polymers, biomedical polymers, conducting polymers, polymers for space. **5 Hrs.**
8. **Problems of polymer:** Thermoxidative degradation, fire hazards, toxicity, effluent disposal. **4 Hrs.**
9. **Recycle:** Recycle and Reuse of polymers. **3 Hrs.**

Reference Books:

1. R.J.Young and P.A.Lovell, "Introduction to polymers", Chapman and Hall, London.
2. Fred W.Billmeyer, "Text book of Polymer Science", J.R.John Wiley and Sons, New York.
3. F. Rodrignek, "Principles of Polymer Systems", McGraw Hill, N.Y.
4. Gowarikar, "Polymer Science", Wiley Eastern Ltd. New Delhi.

15UCHE610	Composite Materials	(4-0-0)4: 52 Hrs.

Course Learning Objective:

1. To understand the nature, properties, structure and processing of composite materials and their engineering applications.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Characterize and explain the different synthesis of advanced and future materials for industrial application		6	2,14
CO2	Analyse and compile the different techniques for preparing the materials	7	2	14
CO3	Compare and assess the different processing techniques for advanced materials	7	2	14
CO4	Distinguish between mechanical and chemical techniques for fabrication and synthesis of composite materials	7	2	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		2.25				2	1							3	

Prerequisites: Nil

Course Content:

1. **Synthesis and Fabrication of advanced and future material:** emphasis on ceramic, Semi-conducting and Super-conducting materials with superior structural, optical and electrical properties. **10 Hrs.**

2. **Techniques for preparation of ultra-pure, ultrafine powders:** of oxides, nitrides, carbides etc., with very well defined characteristics and superior properties. **12 Hrs.**
3. **Processing Techniques:** Sintering, hot pressing, hot isostatic pressing, tape-casting sol-gel processing for the formation of monolithic ceramics, composites (ceramic, ceramic metal, as well as metal matrix), SiO_2, Glasses from above powders. **10 Hrs.**
4. **Processing Techniques based on reaction methods:** Chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI), self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibers and semi conducting materials such as Si and gallium arsenide. **12 Hrs.**
5. **Synthesis and processing**: mixed ceramic oxides with high temperature super conducting properties. Comparison of properties of such advanced materials with conventional materials such as metals and polymers. **8 Hrs.**

Reference Books:

1. W.D. Kingery “Introduction to Ceramics”.
2. Chawla “Advanced Composites”.
3. James.T.Schockel Ford, “Introduction to Material Science for Engg”, McMillan publications.
4. L.H. Vanvlack, “Material Science and Engineering”.

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College Vision and Mission

SDMCET –Vision

To be a School of Dynamic Mindset focusing on Research, Innovation and Development and emerge as Central hub of Engineering Talents.

SDMCET – Mission

- **Committed towards continuous improvement in teaching and learning, Research in engineering and technology.**
- **Encouraging intellectual, quality, ethical and creative pursuits amongst teaching and students fraternity.**
- **Striving to be an enabler for reaching the unreached.**

SDMCET- Quality Policy

- **In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.**

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

The department shall strive towards globally recognized undergraduate Chemical Engineering program coupled with quality technical education in the field of chemical engineering, and research strength contributing to the needs of industry and society at large.

Mission

1. To offer firm foundation in both theoretical and applied aspects of Chemical Engineering
2. Enabling to discover and disseminate knowledge through creative activity in research using state of the art laboratories and infrastructure by collaborating with industries and academic institutes.
3. To offer program that inculcates commitment, team work, leadership qualities and lifelong learning skills with societal and ethical values.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

I. Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.

II. Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.

III. Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.

IV. Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes and Program Specific outcomes

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

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Scheme for VII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
11UCHC700	Process Dynamics and Control	4-0-0	4	50	100	3		
11UCHC701	Chemical Technology	4-0-0	4	50	100	3		
11UCHC702	Biochemical Engineering	3-0-0	3	50	100	3		
11UCHL703	Major Project-Phase 1	0-0-6	4	50			50	3
11UCHL704	Process Control Laboratory	0-0-3	1.5	50			50	3
11UCHL705	Computer Applications in Chemical Engineering and Simulation Laboratory	0-0-3	1.5	50			50	3
11UCHE70X	Elective – 5	4-0-0	4	50	100	3		
11UCHE70X	Elective – 6	4-0-0	4	50	100	3		
	Total	**19-0-12**	**26**					
11UCHE706	Pilot Plant and Scale up Methods	4-0-0	4	50	100	3		
11UCHE707	Transport Phenomena	4-0-0	4	50	100	3		
11UCHE708	Process Modeling and Simulation in Chemical Engineering	4-0-0	4	50	100	3		
11UCHE709	Novel Separation Techniques	4-0-0	4	50	100	3		

Scheme for VIII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
11UCHC801	Seminar	0-0-3	2	50				
11UCHC800	Process Engineering Economics and Management	4-0-0	4	50	100	3		
11UCHL802	Major Project- Phase 2	0-0-12	10	50			50	3
11UCHE80X	Elective – 7	4-0-0	4	50	100	3		
11UCHL80X	Elective – 8	4-0-0	4	50	100	3		
Total		**12-0-15**	**24**					
11UCHE803	Solid Waste Management	4-0-0	4	50	100	3		
11UCHE804	Instrumental Methods of Analysis*	4-0-0	4	50	100	3		
11UCHE805	Sugar Technology	4-0-0	4	50	100	3		
11UCHE806	Catalyst Technology	4-0-0	4	50	100	3		
11UCHE807	Unit Processes in Organic Synthesis*	4-0-0	4	50	100	3		

***** To be handled by the Chemistry department faculty

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the Fourth year: 50 Hrs

VII Semester B.E.

11UCHC700 Process Dynamics and Control (4-0-0)4:52 Hrs.

Course Learning Objective:

1. The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Comprehend the fundamentals of process controls	13	1,10	
CO2	Derive transfer function models for dynamic processes and study the transient response characteristics.	2	3,4	
CO3	Predict the closed-loop behavior using block diagram and evaluate the stability of the system.	2	4,13	
CO4	Analyse the principles involved in selecting a control value and understand the interaction with other process components.	5	2,13	
CO5	Analyse controllers to achieve desired performance.	2	3,5,13	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	1.25	2	2	1.5					2			1.75		

Prerequisites: Nil

Course Content:

1. **Introduction:** Classification of variables, control configuration, classification of control systems. Laplace Transform, types of inputs- step, impulse, linear and sinusoidal **6 Hrs.**
2. **Process dynamics:** First order systems, transfer functions - mercury in glass thermometer, level, mixing tanks, stirred tank reactors, I order system in Series-interacting and non interacting systems, response equations, linearization of non-linear system. **12 Hrs.**
3. **Second order systems:** U-tube manometer, damped oscillator, response equations, terms of second order under damped system. **7 Hrs.**
4. **Block diagram:** Importance, reduction rules, steps, problems **6 Hrs.**

5. **Final control element:** control valves, types, actuators, positioners, valve plugs, characteristics. **5 Hrs.**
6. **Controllers:** Proportional, Proportional +Integral (P+I), Proportional + Integral + Derivative (P+I+D), On-Off controller, servo and regulator control system. **7 Hrs**
7. **Stability:** Stability of linear control system, Routh –Hurwitz, Root Locus methods. **9 Hrs.**

Reference Books:

1. Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.
3. Coulson and Richardson, "Chemical Engineering" Vol, III, 3/e, Pengeman Press.
4. George Stephanopoules, "Chemical Process Control" An Introduction to Theory and Practical, Prentice Hall, New Delhi, 1998.

11UCHC701	Chemical Technology	(4-0-0)4: 52 Hrs.

Course Learning Objectives:

1. To understand the industry protocols used in the manufacture of chemicals both inorganic and organic with the use of reference flow sheets.
2. Identify major engineering problems associated with manufacturing processes.
3. Overcoming bottlenecks and trouble shooting.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the impetus of Chemical Industry globally	1	12	6,7
CO2	Apply the concepts of unit operations and processes, reaction kinetics, thermodynamics, stoichiometry, transport processes, materials engineering etc. and translate to develop a process flow sheet.	1,3,	9,10, 14	12,13

CO3	Describe the technology of manufacturing chemicals.	-	9, 12, 15	14
CO4	Prioritize trouble shooting to overcome the bottlenecks in a process and develop the technology within realistic constraints.	-	3, 6, 7	14, 15
CO5	Appraise of themselves as industry ready chemical engineers.	-	12	13,14,15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1		1.5			2.5	2.5		2	2		3	3	2.75	2.66

Prerequisites: Nil

Course content:

1. **Introduction to Chemical Process Industries**: Chemical Industry in this millennium **2 Hrs.**
2. **Industrial and Fuel gases**: H_2, O_2, N_2, CO_2, Water gas, Producer gas. **5 Hrs.**
3. **Chlor-Alkali Industry**: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder **6 Hrs.**
4. **Acids:** Sulfuric, Nitric, Hydrochloric and Phosphoric acids. **6 Hrs.**
5. **Fertilizer Industry**: Ammonia, Urea, Ammonium Nitrate, Ammonium Sulfate, DAP, Potash fertilizers, Bio-fertilizers. **6 Hrs.**
6. **Phosphorous Industry**: Red and White phosphorous, Phosphorous pentoxide, Phosphate fertilizers, Super phosphate and Triple super phosphate. **5 Hrs.**
7. **Pulp and Paper Industry**: Raw materials, manufacture of pulp and paper, recovery of chemicals. **5 Hrs.**
8. **Rubber Industry**: Natural and synthetic, polymerization, classification, manufacture of SBR and NBR, compounding and fabrication, reclaimed rubber. **5 Hrs.**
9. **Fermentation & Distillery**: Manufacture of alcohol, beer, wine, vinegar. **4 Hrs.**
10. **Soaps and Detergents Industry**: Manufacture of soaps, detergents, fatty acid purification and types of soaps. **4 Hrs.**
11. **Oils and Fats Industry**: Manufacture of oils (vegetable and industrial), processing and refining, Production of essential oils and uses. **4 Hrs.**

Reference Books:

1. George T Austin: Shreves, “Chemical Process Industries”, Mc Graw Hill International ltd.

2. Gopal Rao and Marshall, “Dryden’s Outlines of Chemical Technology”, East-West Press.
3. S.D. Shukla and G.N. Pandey, “Text book of Chemical Technology” Vol.1 and 2, Vikas Publishing House Pvt. Ltd. New Delhi.
4. S.C. Bhatia, “Chemical Process Industries”, Vol.1 and 2, CBS Publishers, New Delhi

11UCHC702	Biochemical Engineering	(3-0-0) 3: 39 Hrs.

Course Learning Objectives:

1. To provide the forum to understand the principles and concepts of microbiology, cell biology and biochemistry and thereby apply chemical engineering principles to asses and evaluate the cell as a reactor.
2. To incorporate the principles of chemical engineering in understanding the upstream and downstream processing techniques in a biochemical industry.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline and identify the microorganisms in the context of industrial and environmental microbiology.	2	7	
CO2	Characterize and explain the chemicals of life with the properties and their derivate.		2, 14	
CO3	Interpret and evaluate the enzyme kinetic parameters with different effects of the reactors.	2	3	13
CO4	Explain the various configurations of bioreactors along with fermentation technology	2	3	13
CO5	Identify and explain the methods involved in product recovery and purification	2	3	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		1.2	2				2						3	2.5	

Prerequisites: Nil

Course content:

1. **Microbiology:** Scope, structure of cells: Prokaryotic and Eukaryotic, characterization and classification of microorganisms - Taxonomy and Whitaker's 5-Kingdom concept, environmental and industrial microbiology, control of microorganisms. **4 Hrs.**
2. **Biochemistry:** Chemicals of life - Lipids, sugars and polysaccharides; amino acids, proteins and enzymes; vitamins, biopolymers, nucleic acids and their derivatives. **6 Hrs.**
3. **Enzyme catalyzed reactions:** Enzyme Nomenclature and classification, enzyme kinetics, Mechanism and kinetics of enzymatic reactions, evaluation of kinetic parameters, factors affecting enzyme activity, Inhibitors and inhibition kinetics, Industrial enzymes and applications, methods of immobilization of enzymes. **10 Hrs.**
4. **Biomass production in cell cultures:** Ideal reactors for kinetic measurements - batch and continuous reactors, Monod's growth kinetics, Transient growth kinetics, Cell growth and kinetic patterns, Reactors and their configurations. **10 Hrs.**
5. **Fermentation technology:** Ideal bioreactors, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations. **4 Hrs.**
6. **Downstream processing:** Steps involved in product recovery, operations involved - centrifugation, chromatography and emerging technologies including membrane separation techniques. **5 Hrs.**

Reference Books:

1. Jay Bailey, James Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill, 1986.
2. Michael L. Shuler and Fikret Kargi, "Bioprocess Engineering - Basic Concepts", 2/e, Prentice Hall of India (2003).
3. Michael J. Pelczar, E. C.S. Chan and Noel R. Krieg, "Microbiology Concepts and Applications", 5/e, McGraw Hill reprint 2001.
4. Syed Tanveer Ahmed Inamdar, "Biochemical Engg: Principles and Concepts" 2/e, Prentice Hall of India Learning Pvt. Ltd. (2008), New Delhi.

11UCHL703	Major Project – Phase 1	(0-0-6)4

Course Learning Objectives:

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.

4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Analyse and compare the literature review of the topic chosen in chemical engineering	7,14	8,12	2,10
CO2	Identify the challenges related to the process industries or society with multidisplanery facets	10,14	8,12, 11	6,7,9
CO3	Select the suitable material, methodology and carry out the computation and economic analysis			3,4,5,15
CO4	Formulate, design and report the approaches to carry out the experiments with feasibility solutions	9	8,10,12	11,15
CO5	Outline the precise project report with appropriate guidelines and references	9	8,15	10
CO6	Discuss the results obtained with proper justification and conclusion		10,11	15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3	3	3	3	3	2	2	1.6	2.2	2.3	2		1	2.6

Course Content:

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VII semester or project of VI semester can also be extended here. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VII semester. After getting the approval from DUGC, the project work should be carried out in VII and VIII semester. The project report should be submitted in VII semester which includes literature survey, plan of work and any progress of the work. The final project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

11UCHL704	Process Control Laboratory	(0-0-3)1.5

Course Learning Objective:

1. The purpose of this laboratory is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Apply fundamentals of industrial processes, process measurement and process control theory.	1	15	
CO2	Analyse transient behavior of simple systems.	15	2	
CO3	Analyse data from experiments and prepare well organized laboratory report.	11	4	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2		2							1				1.5

Prerequisites: Process Control Theory.

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List of Experiments:

1. Time constant determination for first order systems (step input)
2. Single Tank System -I Order System (step input)
3. Non Interacting tanks - I Order system in series (step/impulse input)
4. Interacting tanks - I Order system in series (step/impulse input)
5. Second order system - U Tube Manometer
6. Simple level Control – P, PI,PD,PID action
7. Temperature Control – ON/OFF action
8. Valve Characteristics
9. Study of temperature sensors characteristics – RTD , Thermocouple, Thermistor
10. Study of Temperature Transmitter
11. Study of I/P and P/I converter
12. Control system in stirred tank heater
13. Study of Flapper-Nozzle

Note: At least 10 experiments to be conducted.

Reference Books

1. Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.

11UCHL705 Computer Applications in Chemical Engineering and Simulation Laboratory (0-0-3):1.5

Course Learning Objectives:

1. To make the students understand physical systems in chemical engineering and using C program to develop models and solutions for these models.
2. The students will also learn to use the commercial process simulations using simulation software.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Solve some problems related to chemical engineering using C-program	4, 10	4, 15	
CO2	Demonstrate the model solving ability of various process/unit	10, 15	9	4

	operations involved in chemical engineering.			
CO3	Analyse and optimize the parameters of a chemical process using simulation software.	4, 9, 10		15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				1.7					1.5	1					2.5

List of Experiments:

Chemical Engineering problems in the different areas like Design, Mass transfer, Heat transfer, thermodynamics and CRE are solved by applying Numerical Techniques and C-Programmes.

C – Programming:

1. Flash Vaporization for multi-component system
2. Design of Adiabatic Batch Reactor, PFR
3. Bubble and Dew temperature.
4. Double pipe Heat Exchanger (Area, Length and Pressure drop)
5. Distillation column (Bubble cap)

Simulation:

1. Introduction to suggested software available (flow sheeting)
2. Simulation Studies of flash drum, Distillation Column, CSTR, PFR, Heat Exchanger.
3. Simulation Studies of pump, compressor, cyclone, heater
4. Process simulation study of the following process:
    a. Ethylene Glycol from Ethylene oxide
    b. Atmospheric distillation of crude oil
    c. Phthalic anhydride process
    d. Aromatic stripper with Toluene, Xylene
    e. Styrene from Ethyl Benzene
5. Introduction to E-Fluent Software.

Reference Books

1. Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2/e, McGraw Hill, 1990.
2. William L. Luyben, “Process modeling, simulation and control for Chem. Engg.”, Mc. Graw Hill, 1990.
3. Asghar Hussain, “Chemical process simulation”, Wiley Eastern Ltd, 1986.
4. Roger G.E Franks, “Modeling and Simulation in Chemical Engineering” Wiley Inter science. New York, USA, 1972.

11UCHE706	Pilot Plant and Scale up Methods	(4-0-0) 4: 52 Hrs.

Course Learning Objectives:

1. To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results, and apply process scale-up methods.
2. To study proper designs, modeling and processing and the importance of the process geometry.

Course outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and explain the need for pilot plant and its demonstration	13	3	2
CO2	Interpret and analyse different approaches for scale up studies in chemical engineering system.	2	3	13
CO3	Predict and assess different challenges and techniques for scaling up the given system.	2	3	14
CO4	Illustrate and develop the different mathematical models for scale up methods	5	2	1, 3,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	3	1.75	2.25		1								2.3	3	

Prerequisites: Nil

Course content:

1. **Introduction to Pilot plant and scale up studies**. Major issues, approaches to scale up, describing process system. Need for Pilot plant. Concepts of prototype and models. **8 Hrs.**
2. **Mathematical modeling**- Major issues, fundamental principles. Dimensional analysis and Principles of similarity. **8 Hrs.**
3. **Pilot plants and demonstration**- Major issues, fundamental considerations, rules of thumb, predicting commercial performance. Regime concept. **8 Hrs.**
4. **Scale up of chemical reactor systems**. Mixing process: Principles scale up relations, guidelines for scale up. Agitated vessel. **10 Hrs.**

5. **Stage wise mass transfer process**. Principles, Vapour-Liquid systems. Distillation. Absorption and stripping. Extraction. **10 Hrs.**
6. **Scale up of Momentum and Heat Transfer systems**. Environmental challenges of scale up. **8 Hrs.**

Reference Books:

1. Attilio Bisio, Robert L. Kabel, "Scale up of Chemical Processes", John Wiley Interscience publication, 1985.
2. Ibrahim and Kuloor, "Pilot plant and Scale up Studies".
3. Johnstone and Thring, "Pilot Plants Models and scale up method in Chemical Engineering", McGraw Hill, 1962.
4. Marko Zlokarnik, "Dimensional Analysis and Scale-up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986.

11UCHE707	Transport Phenomena	(4-0-0) 4 :52 Hrs.

Course Learning Objectives:

1. To provide basic understanding of laws governing transport processes and effect of various parameters.
2. To provide an understanding of steady state shell balances for velocity, temperature and concentration distribution under laminar flow.
3. To deal with equations of change and analogies amongst transport processes along with their applications.

Course outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	State laws of momentum, energy and mass transport. Discuss effect of temperature and pressure on transport properties of fluid.			1
CO2	Formulate velocity, temperature and concentration distributions under laminar flow conditions and solve transport problems.	1	2,3,13	
CO3	Derive equations of change for isothermal systems. Apply these equations in solving steady state problems	1	2,3,13	

CO4	Write analogies between momentum, heat and mass transport problems.		1	2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.75	2.3	2										2		

Prerequisites: Nil

Course content:

1. **Introduction:** Momentum, Energy and Mass transport, Newton's law of viscosity, Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction, Ficks law of diffusion, effect of temperature and pressure on transport properties of fluids. Numerical problems using all laws **6 Hrs.**
2. **Velocity distribution in laminar flow:** Steady state shell momentum balance, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through circular tube, flow through annulus, flow between parallel plates and slit. Numerical problems using the equation derived above. **12 Hrs.**
3. **Temperature distribution in laminar flow**: Steady state shell balance, boundary conditions applicable to energy transport problems, heat conduction through compound walls, heat conduction with internal generation by electrical source, nuclear and viscous energy sources. Heat conduction in a cooling fin, Forced and free convection heat transfer. Numerical problems using equation derived above. **12 Hrs.**
4. **Concentration distribution in laminar flow:** Steady state shell balance, Boundary conditions applicable to mass transport problems, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion, Diffusion into falling film, Forced convection mass transfer, Diffusion with homogeneous and heterogeneous reaction. Numerical problems using the equation derived above. **12 Hrs.**
5. **Equation of change of Isothermal systems**: Non isothermal systems and Multicomponent systems. Application of these equations in solving steady state problem. **6 Hrs.**
6. **Analogies and Navier Stokes equation:** Simple numerical problems on it. Analogies between Momentum, Heat and mass transport and their numerical problems. **4 Hrs.**

Reference Books:

1. Bird, Stewart and Lightfoot, "Transport Phenomena", John Wiley, 1994.
2. Robert Brodkey and Henry C. Hershey, "Transport Phenomena Unified Approach", International Edition- 1988.

3. Bennet and J. E., "Momentum Heat and Mass Transfer", Myer- McGraw Hill-1982.
4. Suryavanshi and Dongre, "Transport Phenomena", Nirali Prakashan, 2012. ISBN: 978-81962-56-5.

11UCHE708 Process Modeling and Simulation in Chemical Engineering (4-0-0)4: 52 Hrs.

Course Learning Objectives:
1. To study basic concepts of modeling and formulation of mass and energy balance relationships and thereby it helps for the development of complex models.
2. To understand the advanced technologies in simulation field and the applicability in industries.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain and apply the different fundamentals to develop the models for chemical engineering system.		2	1,3
CO2	Interpret and develop different mathematical methods for chemical engineering system.		1, 2	3,13
CO3	Apply and assess different relevant software's for simulation of chemical engineering models.		2,3	5, 15
CO4	Demonstrate and analyse the different model solving ability for various chemical engineering process.		2,3	5, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.5	2	2.5		3								3		3

Prerequisites: Nil

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Course content:

1. **Modeling in Chemical Engineering**: Introduction, Principles of Formulation, Fundamental laws; Continuity Equation, Energy Equation, Equation of motion, Transport Equations, Equation of States, Equilibrium, Chemical Kinetics, Classification of Mathematical models. **10Hrs.**
2. **Numerical techniques:** Iterative convergence methods like bisection and secant method, Newton raphson method, Numerical integration of ordinary differential equations like Euler and Runge Kutta method. Numerical solution of partial differential equations of first order approximation with examples. **12Hrs**
3. **Models in Chemical engineering:** Introduction, Series of Isothermal, Constant-Holdup CSTRs, CSTRs with Variable Holdups, Two Heated Tanks, Gas-Phase, Pressurized CSTR, Non-isothermal CSTR, Single-Component Vaporizer, Multicomponent Flash Drum, Batch Reactor, Reactor With Mass Transfer, Ideal Binary Distillation Column, Multicomponent Non-ideal Distillation Column Batch Distillation With Holdup. **14Hrs**
4. **Computer simulation**: Introduction to Simulation, Role of Computers and Numerical Methods in simulation, Iterative convergence methods, Explicit Convergence methods, Explicit Numerical Integration algorithm, Implicit Methods, Numerical examples. **8Hrs**
5. **Specific simulation/ Model development:** Batch reactor, CSTR, Bioreactor, activity coefficient models, Distillation and equilibrium Flash vaporization. **8Hrs**

Reference Books:

1. William L. Luyben, “Process modeling, simulation and control for Chem. Engg.”, Mc. Graw Hill, 1990.
2. Edger TF and Himmelblau D M, “Optimization of chem. Process” Mcgraw Hill, 1989.
3. Asghar Hussain, “Chemical process simulation”, Wiley Eastern Ltd, 1986.
4. Roger G.E Franks, “Modeling and Simulation in Chemical Engineering” Wiley Inter science. New York, USA, 1972.

11UCHE709	Novel Separation Techniques	(4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To provide an understanding of novel/newer separations using mass transfer and thermodynamic considerations.
2. To provide an understanding of their applications at different levels in industry, viz. refineries, biochemical processing, pharmaceuticals, gaseous separations, metallurgical etc.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline continuous adsorption and advanced chromatographic techniques.			4, 5, 14
CO2	Classify membrane based separations and explain their mass transfer and thermodynamic considerations with applications.		4, 5	
CO3	Explain the surfactants based, micellar and foam separations with applications.		4, 5	14
CO4	Describe Super Critical Fluid Extraction process with applications.		4	5, 14
CO5	Explain the processes of thermal diffusion, electrophoresis and crystallization.	4	5	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				2.0	2.4									3.0	

Prerequisites: Nil

Course content:

1. **Adsorptive separations:** Thermal swing adsorption, pressure swing adsorption, ion-exchange, affinity chromatography, gradient chromatography and counter current separations etc. **12 Hrs.**
2. **Membrane separation processes:** Classification, structure and characteristics of membranes, Thermodynamic considerations, mass transfer considerations, design of R.O.U.F, Pervaporation, and gaseous separations. **12 Hrs.**
3. **Surfactant based separations:** Fundamentals of surfactants at surfaces and in solutions. Liquid membrane permeation, foam separations, micellar separations. **8 Hrs.**
4. **External field induced separations**: Electric and magnetic field separations. Centrifugal separations. **6 Hrs.**

5. **Super critical fluid extraction:** Physicochemical principles, thermodynamics, process description. Applications and case study. **8 Hrs.**
6. **Separation**: Thermal diffusion, electrophoresis and crystallization. **6 Hrs.**

Reference Books:

1. P.C. Wankat, “Large scale adsorption chromatography” CRC Press, 1986.
2. R.W. Rousseu, “Handbook of separation process technology”, John Wiley and sons 1987.
3. S.Sourirajan and T. Matsura, “Reverse osmosis and Ultra filtration process principle”, NRC publication Ottawa, 1985.
4. Richard Baker, “Membrane Technology and Applications”, 2/e, , John Wiley and Sons Ltd.

VIII Semester B.E.

11UCHC800	Seminar	(0-0-3)2

Course Learning Objective:

1. To provide platform to focus on knowledge of technical data collection, communication skills and report writing.
2. To develop intellectual and professional competence and work on the chosen topic to improve skills in writing and oral presentation.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Review and acquire knowledge on the chemical engineering topic outside the scope of curriculum	4, 5	6,7,8,9,12	14
CO2	Outline and consolidate the required information on chosen topic		6,7,8	9
CO3	Organize the technical matter in the required format and compile the same		9	12
CO4	Interpret and communicate the topic with proper justification and conclusion			9, 10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				1	1	2	2	2	2.5	3		2.5		3	

Prerequisites: Nil

Course content:

Seminar should be based on a detailed study of any topic related to Chemical Engineering (preferably the advanced areas / application) and the topic should preferably be relevant to the curriculum. Students may undertake studies in research survey, literature review and analysis, synthesis, design and development, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of the work.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. It is expected that the student collect information from reference books, standard journals. The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow. The discussion and conclusions shall form the last part of the text.

The seminar shall be evaluated with due weightage on:

Topic-10%
Literature survey-25%
Report-20%
Presentation-25%
Conclusion and querries-20%

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

11UCHC801 Process Engineering Economics and Management (4–0–0) 4:52 Hrs.

Course Learning Objectives:

1. Prepare the students to analyse cost/revenue data and carry out economic analyses in the decision making process to justify alternatives/projects on an economic basis and prepare students to function in the business and management side of professional engineering practice.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Comprehend the concepts of plant location, layout, feasibility survey, design and report writing.	12	9,10	
CO2	Apply economic concepts viz. cost estimation, depreciation, cash flow etc. in solving chemical engineering problems.	12	9,14	10,11
CO3	Apply economic tools viz. profitability, replacement, breakeven analysis to appraise chemical engineering processes.	12	9,14	10,11
CO4	Interpret production, material and	12	9	10,11

	marketing management with their virtues applied to a chemical industry.			

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level									2	2.2	3	1		2	

Prerequisites: Nil

Course Contents:

1. **Cost estimation.** Factors involved in project cost estimation, methods employed for the total cost estimation of investment. Cost Index. Feasibility survey. Plant location and Layout. **10 Hrs.**
2. **Depreciation,** Taxes and Insurance. Different methods of Depreciation. Time value of money and its equivalence. Cash flow diagram s **8 Hrs.**
3. **Profitability and methods of evaluation**. Replacement and alternative investments. Break even analysis. Financial statements **8 Hrs.**
4. **Production Management**. Types of production and planning, manufacturing planning, factory planning, production planning, schedule, work study, method study, systems of wage payments. Bonus. Automation. Organization of production. Planning and control department. **10 Hrs.**
5. **Material Management**. Functions of purchasing. Quality standards and Inspection. Sources of supply. Inventory management. ABC analysis. EOQ model. Value analysis and engineering. **8 Hrs.**
6. **Marketing Management.** Functions of marketing. Market research. Product life cycle. Promotion of sales. Pricing. **8 Hrs.**

Reference Books:

1. Peter and Timmerhaus, "Plant design and Economics for Chemical Engineers", McGraw Hill, 1991.
2. Banga and Sharma, "Industrial Organization and Engineering economics", Khanna Publications, 1999.
3. Tripathi and Reddy, "Principles of Management", 5/e, Tata McGraw-Hill Education, 2004.

11UCHL802	**Major Project – Phase 2**	**(0-0-12)10**

Course Learning Objectives:

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.

3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Analyse and compare the literature review of the topic chosen in chemical engineering	7,14	8,12	2,10
CO2	Identify the challenges related to the process industries or society with multidisplanery facets	10,14	8,12, 11	6,7,9
CO3	Select the suitable material, methodology and carry out the computation and economic analysis			3,4,5,15
CO4	Formulate, design and report the approaches to carry out the experiments with feasibility solutions	9	8,10,12	11,15
CO5	Outline the precise project report with appropriate guidelines and references	9	8,15	10
CO6	Discuss the results obtained with proper justification and conclusion		10,11	15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3	3	3	3	3	2	2	1.6	2.2	2.3	2		1	2.6

Course Content:

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has been assigned at the beginning of the VII semester. The project group would have carried out the preliminary literature survey, plan of project and submitted the synopsis in the VII semester. After the approval from DUGC, the left project work should be carried out and completed in the VIII semester. The detailed project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

11UCHE803	Solid Waste Management	(4-0-0) 4:52Hrs.

Course Learning Objectives

1. To provide students with a comprehensive understanding of integrated solid waste management from an environmental and public health perspective.
2. To study the detailed engineered system of solid waste management system.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Characterize the solid waste, management, planning and policies.	4	3,14	6,7,
CO2	Explain the process of collection, handling, storage and disposal techniques of solid waste and hazardous waste.	4	3,	6,7,14
CO3	Categorize different processing methods of solid waste used for recovery of resources.	4	3,	6,7,14
CO4	Apply different techniques of solid waste management for chemical industries through case studies.	4	3,14	6,7,

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2.0	1.0		3.0	3.0							2.5	

Prerequisites: Nil

Course content:

1. **Introduction to solid waste.** Definition, Characteristics, Types and properties. Organization and status of SWM, Components of integrated waste management strategy. Overview of materials flow in society and 4R concept of solid waste management. Evolution of SWM, Effect on health and environment. Legislation and government agencies, planning of SWM progress. **8 Hrs.**
2. **Engineered systems for solid waste management**. Generation of solid waste, Onsite handling, Storage and Processing, Transfer and transport, Collection system and devices, processing techniques and equipment. **10 Hrs.**
3. **Disposal of solid wastes.** Source reduction, Ocean dumping, Land filling, Composting and Thermal Incineration. **10 Hrs.**
4. **Recovery of resources,** physical, chemical and biological methods. Details of energy recovery system, heat recovery, gasification, pyrolysis and refuse derived fuels (RDFs). **8 Hrs.**
5. **Hazardous waste** and their management issues and planning methods. Origin, reduction at source, collection and handling. E-waste handling and disposal. **8 Hrs.**
6. **Case studies** on major industrial solid waste generation units- Coal fired power plant, Textile industry, Brewery, Oil refinery, Radioactive generation units, Spills, Sludge lagooning and Incineration. **8 Hrs.**

Reference Books:

1. George Tchobanoglous, “Integrated Solid waste Management-Engineering Principles and Management issues”, McGraw Hill, 1993.
2. Howard Peavy, “Environmental Engineering”, McGraw Hill,1986.
3. Dutta, “Industrial Solid waste Management and landfilling practice”, Narose Publication, 1999.

11UCHE804 Instrumental Methods of Analysis (4-0-0)4:52 Hrs.

Course Learning Objective:

1. To understand the principles and concepts behind the qualitative and

quantitative analysis of molecules and compounds using instrumental methods with their applications.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify the concepts for analysis of molecules and compounds using instrumental methods.	2	1	5
CO2	Interpret and analyse the different spectroscopic techniques.	5	3	1
CO3	Explain and analyse Flame photometry and AAS techniques and its application.	2	3	1
CO4	Explain and analyse the electrochemical techniques and its application.	3	1	2
CO5	Explain and analyse the chromatography technique and its applications.	1	2	5

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.2	1.75	1.67	-	2.33	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Content:

1. **Spectroscopy:** General introduction; Nature and interaction of electromagnetic radiations, Energies corresponding to various kinds of radiations, Atomic and molecular transitions, factors influencing positions and intensity of spectral line, introduction to UV-Vis spectroscopy. **6 Hrs.**
2. **Infrared spectroscopy:** Introduction, Theory, types of vibrations, fundamental modes of vibrations and group frequencies, factors affecting the group frequencies and band shapes, instrumentation FTIR. Instrument and its advantages, Sample handling techniques, Qualitative applications of IR, Applications of IR to structural elucidation of simple organic molecules. **6 Hrs.**
3. **Nuclear Magnetic Spectroscopy:** Introduction, Chemical shifts, Mechanism of shielding and deshielding. Types of nuclei, Theory of population of nuclear magnetic energy levels, , Spin –spin coupling, Rules of governing the

interpretation of first order spectra, Low and high resolution NMR, Instrumentation and application to structure elucidation of simple organic molecules. **6 Hrs.**

4. **Mass Spectroscopy:** Introduction, theory, Instrumentation of mass spectrometer, Methods of generation of positively charged ions, Mass analyzers, Resolving power, Molecular ion peak, Base peak, Metastable peak, Modes of fragmentations, Application of mass spectrometry in Qualitative and Quantitative analysis. Structural elucidation of simple organic molecules **6 Hrs.**
5. **Flame Photometry and Atomic Absorption Spectroscopy:** Introduction, Principle, Flame and flame spectra, variation of emission intensity with flame, Metallic spectra in flame, flame ground, Role of temperature on absorption emission and fluorescence. Comparative study of Flame Emission Spectroscopy (FES) and Atomic Absorption Spectroscopy (AAS) Instrumentation and Applications. Qualitative and quantitative determination of alkali and alkaline earth metals. Nephelometry and Turbidometry Introduction, Theory, effect of concentration, Particle size and wavelength on scattering. Instrumentation and applications of Nephelometry and Turbidometry. **10 Hrs.**
6. **Electrochemical Techniques:** Introduction to Electrochemistry, Electrode Potential, Nature, Measurement, sign convention, Effect of concentration, Standard electrode potential, Cell Potential: Thermodynamic, Liquid junction potential, Effect of current. Polarization: Sources, over voltage, concentration polarization, Mechanism of mass transport. Potentiometric Methods: reference electrodes- calomel electrode Ag- Agcl (s) electrode, Hydrogen electrode, Potentiometric titrations and applications. Membrane Electrodes: Classification of properties, Principle design, theory of ion selective electrodes Membrane potential, Selectivity, Crystalline liquid membrane and electrodes. **10 Hrs.**
7. **Chromatography:** Introduction to chromatographic techniques, General descriptions, definitions, terms and parameters used in chromatography. Classification of chromatographic methods, working principles, Instrumentation and applications of Thin layer chromatography (TLC), Gas chromatography(GC), High pressure liquid chromatography (HPLC). **8 Hrs.**

Reference Books:

1. Jaffery, G.H., Basset, J., et. al., “Vogel’s Text book of Quantitative Inorganic Analysis” ,5/e, ELBX, 1998.
2. Skoog, D.A., “Principles of Instrumental Analysis”, 3/e, Saunders College publishing, 1985.

3. W.H. Willard, "Instrumental Methods of analysis", 7/e, L.L., Merritt and J.A. Dean, 1988.
4. B.K. Sharma ,"Instrumental Methods of Chemical Analysis", Goel Publishing House Meerut, 2000.

11UCHE805	Sugar Technology	(4-0-0) 4:52 Hrs.

Course Learning Objective:

1. Studying this subject the students will understand the different processing methods practiced for production of sugar. Learn about the extraction and production of sugar learn different unit operation and unit process application with practical difficulties encountering during process along with its remedies.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Relate the Indian Sugar industry and World scenario	7, 14	6	
CO2	Analyze Working, operation and performance of sugar production process.	1	2	15
CO3	Identify various equipments for sugar production.		14	5
CO4	Design a system to meet the needs considering the constraints of economics, safety and environmental problems associated with sugar industry.	8	7	3, 14
CO5	Identify the various means of cogeneration and its importance on economy of sugar industry.	13, 14	2	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	3		3	2	1.5	1					1	1.75	3

Prerequisites: Nil

Course content:

1. **Sugar industry in India:** Chemical and physical properties of sucrose and reducing sugars. Sources of sucrose, formation of sucrose plants, non sugar

compounds of sugarcane, inorganic constituents of sugar cane juices and sugars analytical used in sugar industry. **8 Hrs.**

2. **Purification:** Technology of the purification process, fundamental reactions and physical chemistry aspects of clarification, liming, Sulphitation and carbonation process, filtration of sugar juices. **12 Hrs.**
3. **Unit operations:** Evaporation of sugar juice, heat transfer in evaporators, evaporation equipment and auxiliaries. Crystallography: solubility of sucrose, theoretical aspects of crystal growth, factors influencing rate of crystallization, control methods and equipment in sugar crystallization, technology of sugar crystallization, boiling scheme of crystallization Centrifugation: theory of the centrifugal process, centrifugal operation, engineering principles of sugar centrifugals, and the centrifugal equipment and auxiliaries, grading of sugar. **14 Hrs.**
4. **Distillery:** Production of final molasses and molasses's utilization and storage. Molasses characteristics for alcohol. Fermentation methodology for alcohol production, factors influencing the production. Distillation methods used in separation process, Design consideration for distillation column. **6 Hrs.**
5. **Co-generation:** Types of co-generation methods, quality of bagasse used, different types of boilers used and efficiency, factors influencing the operation, methods of obtaining steam, and quality of steam **6 Hrs.**
6. **Environmental management plan:** Pollution control measures for water, air, solid waste, noise in sugar industries. **6 Hrs.**

Reference Books:

1. Honing P (Ed), "Principles of Sugar Technology", Vol I to III, Elsevier publishing company, 1953.
2. Jenkinos. G.H., "Introduction to cane sugar Technology", Elsevier, 1966.
3. Mathur.R.B.L, "Handbook of cane Sugar Technology", 2/e, Oxford and I.B.H. Publishing Co., 1997.
4. R.K. Rajputh, "A text book on Power Plant Engineering", 2/e, Laxmi publications (p) Ltd., New Delhi, 2001.

11UCHE806	Catalyst Technology	(4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To provide forum to understand the Principles and concepts of Heterogeneous Catalysis, Catalyst Characterization and Chemical analysis.
2. To provide an understanding of catalyst preparation methods, data analysis and reactor design along with deactivation kinetics.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain the various methods to estimate properties of given catalyst and evaluate its performance		1	
CO2	Formulate performance equations for reactors containing porous catalyst and apply the same for reactor design		1,14	2,3
CO3	Describe the various methods and equipments used in the manufacture of industrial catalyst.		1,14	
CO4	List the various mechanisms and determine the deactivation and regeneration rates in catalytic reactors.		1	2,3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	3	3											2	

Prerequisites: Nil

Course Contents:

1. **Introduction:** Brief history of catalyst technology development and its Economic importance. **2 Hrs.**
2. **Fundamentals of catalytic phenomena**: Definitions, structure of supported catalyst, steps in heterogeneous catalytic reaction, adsorption and desorption, reaction and diffusional resistances, kinetics of catalytic surface reaction, effect of surface structure on catalytic activity. **6 Hrs.**
3. **Catalyst materials**: Make up of a typical heterogeneous catalyst, carrier materials, Promoters, active phases, inhibitors, Role and functions of each, molecular sieve and zeolite catalysts. **4 Hrs.**
4. **Catalyst characterization and selection**: Definition and objectives of catalyst characterization, Determination physical properties of catalyst like , surface area, pore size, pore volume, particle size and size distribution, mechanical strength and density. **10 Hrs.**

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5. **Determination of chemical properties**: Chemical composition chemical structure and morphology, Dispersion and crystallite size of active species, surface acidity and surface reactivity. **5 Hrs.**
6. **Catalyst preparation and forming**: Various methods like precipitation, impregnation, mixing techniques, preparation of finished catalyst by forming methods. **5 Hrs.**
7. **Manufacture of industrial catalysts:** Details of various equipments like reactors, Filters, dryers, calcinators, activators and impregnators. At least 5 different industrial catalysts manufacture to be dealt with. **6 Hrs.**
8. **Testing, evaluation of catalysts and scale up**: Basic approaches to reactor design, collection of data from laboratory reactors, choosing reactors for laboratory, rate data analysis and selection of plant reactors. **6 Hrs.**
9. **Catalyst Deactivation**: Causes and mechanism of deactivation, poisoning, fouling coking, thermal degradation, sintering volatilization and Mechanical failure, Prevention and regenerative treatments, reactor design and operation strategies with deactivation catalysts. **8 Hrs.**

Reference Books:

1. Prof.I.P.Mukhlyonov, “Catalyst Technology”, MIR Publishers.
2. Alvin Stoes and Marcell Decker, “Catalyst Manufacture”.
3. R.P.Farrauto and C.H. Bartholomew, “Fundamentals of Industrial Catalytic Processes”.
4. J. J. Carberry, “Chemical Catalytic Reaction Engineering”, McGraw Hill, New York.
5. Hamid Al-Mergen and Tian Cun Xiao, “Petrochemical Catalyst Materials, Processes and Emerging Technologies”, IGI Global Series Book, 2016, ISBN: 9781466699755.

11UCHE807 Unit Processes in Organic Synthesis (4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To study the fundamental concepts of Industrial Chemistry and their applications.
2. To have knowledge on various reaction mechanisms, preparation of organic compounds, classification of the compounds etc.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**

CO1	To apply basic knowledge of chemical processes and equations to solve numerical problems.	5	3	2
CO2	To develop appropriate techniques in industrial scales for the preparation of value added products.	7	2	1
CO3	To converge the concepts of chemical processes like sulfonation and sulfation for industrial products	1	5	3,13
CO4	To elaborate halogenations its process, kinetics and interpret it for modern industrial processes.	6	1	5,13
CO5	To correlate oxidation and analyse various unit processes of many organic compounds for improvement of existing techniques for the preparation of better yield and quality,	3	2	1
CO6	To evaluate hydrogenation reaction and processes with mechanisms for innovative industrial products.	1	3	2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.25	2.25	2.5	-	1.75	1	1	-	-	-	-	-	3	-	-

Prerequisites: Chemistry, Thermodynamics and Unit processes.

Course content:

1. **Introduction**: Unit processes and principles of thermodynamics and kinetics related to unit processes. **6 Hrs.**
2. **Nitration:** Introduction, nitrating agents, aromatic nitration, thermodynamics kinetics and mechanism, nitration of paraffin hydrocarbon, other nitration. Mixed acid for nitration, process equipment for technical nitration typical industrial nitration processes (nitrobenzene). **10 Hrs.**
3. **Sulfonation and sulfation:** Introduction sulfonating and sulfation agents and their application, chemical and physical factors, kinetics mechanism and thermodynamics od sulfonation, industrial equipments for batch and continuous processes industrial processes (Monosulphonation of benzene, detergent alkylate). **10 Hrs.**
4. **Halogenation:** Introduction survey of halogenation processes thermodynamics and kinetics, chlorination in presence of catalyst, photo

halogenation, industrial equipment for halogenation, typical processes (Chorobenzene). **9 Hrs.**

5. **Oxidation:** Types of oxdative reactions oxidizing agents. Typical liquid phase oxidation processes, vapor phase oxidation of alpha-tic and aromatic compounds. Industrial processes (strene from ethyl benzene, acetaldehyde to acetic acid.) **9 Hrs.**
6. **Hydrogenation:** Introduction, methods of hydrogen production, general principles relating to hydrogenation catalysts, kinetics and thermodynamics, industrial apparatus for hydrogenation and typical examples of hydrogenation processes (Hydrogenation of oils and fats). **8 Hrs.**

Reference Books:

1. P. H. Groggins. "Unit Processes in Organic Synthesis ", 5/e, Tata Mc Graw Hill, 1995.
2. Kirk R. E. Othmer D. F. "Encyclopedia of Chemical Technology", Inter Science Publishers.

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- **To have contextually relevant curricula.**
- **To promote effective teaching learning practices supported by modern educational tools and techniques.**
- **To enhance research culture.**
- **To involve industrial expertise for connecting classroom content to real life situations.**
- **To inculcate ethics and impart soft skills leading to overall personality development**

SDMCET- Quality Policy

- **In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.**

SDMCET- Core Values

- **Competency**
- **Commitment**
- **Equity**
- **Team work and**
- **Trust**

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. By fostering research culture with ethics to disseminate knowledge..
3. By collaborating with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes and Program Specific outcomes

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis

and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for III Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UMAC300	Engineering Mathematics – III	4-0-0	4	50	100	3		
15UCHC300	Technical Chemistry**	3-0-0	3	50	100	3		
15UCHC301	Chemical Process Calculations	3-2-0	4	50	100	3		
15UCHC302	Fluid Mechanics	4-0-0	4	50	100	3		
15UCHC303	Particulate Technology	4-0-0	4	50	100	3		
15UCHC304	Chemical Engineering Drawing	0-0-4	2	50	100	3		
15UCHL305	Particulate Technology Laboratory	0-0-3	1.5	50			50	3
15UCHL306	Chemical Analysis Laboratory	0-0-3	1.5	50			50	3
	Total	**18-2-10**	**24**					

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

** To be handled by the Chemistry department faculty

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Scheme for IV Semester

Course Code	Course Title	Teaching		Examination					
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)		
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours	
15UMAC400	Engineering Mathematics – IV	4-0-0	4	50	100	3			
15UCHC400	Process Heat Transfer	4-0-0	4	50	100	3			
15UCHC401	Chemical Engineering Thermodynamics	4-0-0	4	50	100	3			
15UCHC402	Chemical Reaction Engineering – I	4-0-0	4	50	100	3			
15UCHC403	Mass Transfer – I	3-2-0	4	50	100	3			
15UCHC404	Pollution Control Engineering	3-0-0	3	50	100	3			
15UCHL405	Computational methods in chemical Engineering Laboratory	0-0-3	1.5	50			50	3	
15UCHL406	Fluid mechanics Laboratory	0-0-3	1.5	50			50	3	
	Total	**22-2-6**	**26**						

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the Second year: 50

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III Semester

15UMAC300	Engineering Mathematics - III	(4-0-0)4: 52 Hrs.

Course Learning Objective:

1. Learn to represent a periodic function in terms of sine and cosine. Learn the concepts of a continuous and discrete integral transform in the form of Fourier and Z-transforms. Learn the concepts of calculus of functions of complex variables. Learn the concept of consistency, method of solution for linear system of equations and Eigen value problems. Understand the concepts of PDE and its applications to engineering.

Course outcome:

COs	Description: At the end of course the student will able to	Mapping to POs (1-12)		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Express periodic function as a Fourier series.		1	
CO2	Describe Fourier transform and its properties.		1	
CO3	Define and describe Z transforms and properties and solve difference equations using Z transform.		1	
CO4	Explore analytical functions and properties and describe Bilinear transformations.	13	1	
CO5	Solve set of linear equations. Estimate rank, eigen value and eigen vectors as applied to engineering problems.		1, 2	
CO6	Construct and solve partial differential equation resulting from one dimensional heat equation and wave equation.		1, 2	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	2											1		

Contents:

1. **Fourier Series and Fourier Transform:** Fourier series, Fourier series of Even and Odd functions, exponential form of the Fourier series, half range Fourier series, practical harmonic analysis. Infinite Fourier transform, Infinite

Fourier sine and cosine transforms, properties of Inverse transform, Convolution theorem, Parseval's identity for Fourier transform, Fourier Sine and Cosine transform. **14 Hrs.**

2. **Z–Transform**

   Basic definitions of z-transform, transform of standard forms, linearity property, damping rule, shifting rule, initial and final value theorems, Inverse z-transforms (Partial Fraction method), convolution theorem, applications of z-transforms to solve difference equations. **6 Hrs.**

3. **Complex variables:** Functions of complex variables, Analytic function, Cauchy-Riemann equations in cartesian and polar coordinates, Consequences of Cauchy-Riemann equations, Construction of analytic functions. Conformal Transformations: Standard transformation $w = z^2$, $w = e^z$, $w = z + \frac{a^2}{z}$ (only theoretical discussions). Bilinear Transformation. **10 Hrs.**

4. **Linear Algebra:** Rank of a matrix by elementary transformations, solution of system of linear equations - Gauss-Elimination method, Gauss-Seidel method and L-U decomposition method. Eigen values and Eigen vectors. Rayleigh's power method to find the largest Eigen value and the corresponding Eigen vector. Application to Electric circuits, spring mass system, parachutist problem. **12 Hrs.**

5. **Partial Differential equations:** Formulation of PDE by elimination of arbitrary constants/functions, Solution of Lagrange's equations. Solution of non-homogeneous PDE by direct integration, solution of homogeneous PDE involving derivative with respect to one independent variable only. Solution of First and Second order PDE by method of separation of variables. Derivation of one dimensional heat and wave equations, solutions by variable separable method, as applied to engineering problems. **10 Hrs.**

Reference Books:

1. Kreyszig E., "Advanced Engineering Mathematics", 8/e John Wiley and sons, 2003.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 40/e, 2007.
3. Lathi B. P, "Modern Digital and Analog Communication System", 2/e, pp. 29-63.
4. Chapra S C and Canale R P, "Numerical methods for Engineers", 5/e, TATA McGraw-Hill, 2007.

15UCHC300 Technical Chemistry (3-0-0) 3: 39 Hrs.

Course Learning Objectives:

1. Acquisition of knowledge and development of scientific attitude among the learners.
2. Development of intellectual abilities and skills.
3. To inculcate social virtues among students so as to contribute significantly towards the progress of society.

Course Outcomes:

Cos	Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	To interpret the complex problems with an approach to its chemical nature and chemical bonding.	3	7	4
CO2	Apply the knowledge of inorganic polymers and applicability in material use, optimization and in various engineering applications.	6	8	1
CO3	Implement the reaction mechanisms and the rate of chemical reactions, factors affecting for designing of various industrial processes.	4	5	2 , 13
CO4	To emphasize on modern technologies and the use of Nanotechnological tools for synthesis and engineering activities.	1	4	5
CO5	To converge and design the vibrant mechanisms and correlate the reactions generating critical thinking for specified products for the benefit of society with environmental considerations.	8	2	3 , 13
CO6	To demonstrate the parameters, theory and mathematical approach of catalysts to formulate the process and product formation in chemical engineering processes.	1	3	2 , 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.67	2.67	2	1.67	1.67	1	2	1.5	-	-	-	-	3	-	-

Prerequisites: Nil

Course Content:

1. **Chemical Bonding:** Introduction, Ionic bond – Definition, steps involved in the formation of ionic bond, conditions and factors affecting the formation of ionic bond; Ionic solids- lattice energy, Barn-Haber cycle, lattice defects; semiconductors. Covalent bond - Definition, Lewis concept; Types of covalent bonds – sigma, pi, polar and non-polar. Valence bond theory (VBT) – postulates and explanation, Limitations of VBT; Molecular orbital theory – comparison between atomic orbitals and molecular orbitals, Linear combination of atomic orbitals (LCAO), conditions for effective combination of atomic orbitals. Molecular orbital configuration of simple molecules (H_2 and He); Comparison between valence bond theory and molecular orbital theory. Hydrogen bond- consequences of hydrogen bonding, boiling points of binary hydrogen compounds, solubility; unique properties of water. Hybridization- geometry of molecules- VSEPR theory; geometry of molecules of bonding pairs (BF3, CH4), geometry of molecules of nonbonding pairs (H_2O, NH_3). **8 Hrs.**
2. **Inorganic Polymers:** Introduction, preparation, properties and applications of Phosphorous-based polymers-polyphosphonitrilic chlorides and ultraphosphate glasses. Sulphur-based polymers-polymeric sulphur nitride and chalcogenide glasses. Silicon-based polymers-fluid polysiloxanes gums and silicone resins. **5 Hrs.**
3. **Nano-Technology:** Introduction, Nanoscale; Nanomaterials-Introduction, properties and applications of-one dimensional nanomaterials-Thin films, two dimensional nanomaterials-Carbon Nanotubes and Nonowires, three dimensional nanomaterials- Fullerens, Dendrimers; Construction of Nanomaterials-Top down and Bottom up methods. **6 Hrs.**
4. **Catalysis:** Introduction, General Characteristics, Types of catalysis with examples, Homogeneous catalysis-acid-base catalysis with mechanism, Enzyme catalysis with mechanism and kinetics; effect of temperature on Enzyme catalysis; Heterogeneous catalysis - explanation with examples; effect of temperature; Autocatalysis. **6 Hrs.**
5. **Organic Reactions and their Mechanisms:** Types of reactions – (a) Substitution – free radical; nucleophilic - S_{N1} and S_{N2}, Electrophilic – halogenation; nitration; sulphonation; Friedel-Craft's alkylation and acylation, Electronic interpretation of orienting influences of substituents in aromatic

electrophilic substitution of toluene, chlorobenzene, benzoic acid and nitrobenzene, (b) Addition – free radical; electrophilic and nucleophilic, (c) Elimination – unimolecular and bimolecular, (d) Rearrangement – intra and inter molecular. **10 Hrs.**

6. **Introduction to Spectroscopy:** Study of chromatography,FTIR and UV-visible spectroscopy and their applications in analysis of organic compounds **4 Hrs.**

Reference Books:

1. J.D. Lee “Concise Inorganic Chemistry” ,5/e, Wiley’s Publication,2012.
2. Wahid U. Malik; G.D. Tuli; R. D. Madan,“Selected Topics in Inorganic Chemistry” ,Publisher: S Chand & Co Ltd, 2010, ISBN 10: 8121906008
3. B.R. Puri, L.R. Sharma and M.S. Pathania, “Physical Chemistry”, S. Chand and Co., New Delhi.ISBN 10:9382956018
4. Samuel Glasstone “Text book of Physical chemistry”, Published by D. Van Nostrand company, inc
5. Er. Rakesh Rathi S, “Nanotechnology”, Chand & Company Ltd., Ram Nagar, New Delhi,2010.
6. Peter Sykes, “Organic Reactions Mechanism”, ULBS Publishers, New Delhi.
7. I. L. Finar “Organic Chemistry” Vol I & II, 5/e,Pearson Publication.

15UCHC301	Chemical Process Calculations	(3-2-0) 4: 52 Hrs

Course Learning Objectives:

1. To study the analysis of chemical processes through calculations and also to develop systematic problem-solving skills.
2. To formulate and solve material and energy balances in processes with and without chemical reactions.

Course Outcomes:

Cos	Description: Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline the fundamentals of units and dimensions and Psychrometry.	13	2, 3	
CO2	Categorize methods of expressing chemical compositions.	1	2, 3	13
CO3	Evaluate problems on steady state material balance with and without chemical reactions.	1	2, 3	13
CO4	Compute ultimate and proximate	1	2, 3	13

	analysis of solid, liquid and gaseous fuels.			
CO5	Perform calculations on energy balances.	1, 2	3	13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.0	1.8	2.0										2.6		

Prerequisites: Nil

Course content:

1. **Units and dimensions:** Fundamental and derived units, Conversion. Dimensional consistency of equations. Dimensionless groups and constants. Conversion of equations. Psychrometry: absolute humidity, molal humidity, dry bulb and wet bulb thermometry, humidity chart, humidification and dehumidification , air conditioning. **8Hrs**
2. **Basic chemical calculations:** Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases. Concept of normality, molarity, molality, ppm. Ideal gas law calculations. **8 Hrs.**
3. **Material balance without reaction:** General material balance equation for steady and unsteady state. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying, mixing and evaporation. Elementary treatment of material balances involving bypass, recycle and purging. **12 Hrs.**
4. **Steady state material balance with reaction:** Principles of stoichiometry, Concept of limiting and excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, related problems. Ultimate and proximate analyses of fuels, Calculations involving burning of solid, liquid and gaseous fuels, excess air, air-fuel ratio calculations. **12 Hrs.**
5. **Energy Balance:** General steady state energy balance equation, Heat capacity. Enthalpy, Heat of formation, Heat of reaction, Heat of combustion. Heat of mixing. Determination of Heat of formation at Standard and Elevated temperatures, Theoretical flame temperature and adiabatic flame temperature. **12 Hrs.**

Reference Books:

1. Hougen, O.A., Waston, K.M. and Ragatz, R.A., “Chemical Process Principles Part – I, Material and Energy Balances”, 2/e, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau, D.M., “Basic Principles and Calculations in Chemical Engineering”, 6/e, Prentice Hall Of India, New Delhi, 1997.

3. Bhatt, B.L. and Vora, S.M., "Stoichiometry", SI Units, 3/e, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
4. K.V. Narayanama B. Lakshmikutty, "Stoichiometry and Process calculations" Prentice Hall India Limited, New Delhi, 2006. ISBN: 978-81-203-2992-8

15UCHC302 Fluid Mechanics (4-0-0) 4: 52 Hrs.

Course Learning Objectives:

1. To introduce the concepts, principles, laws, observations and models of fluids at rest and in motion.
2. To provide the basis for understanding the fluid behaviour, engineering design and control of fluid systems.

Course Outcomes:

COs	Description: At the end of course the student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify the nature of fluids along with the properties and its measuring devices.		3	
CO2	Interpret and analyze the parameters of fluid flow with equations derived for liquids	1	2	3, 13
CO3	Interpret and analyze the parameters of fluid flow with equations derived for gases	1	2	3, 13
CO4	Explain and characterize the different pipe fittings, pumps and flow measuring devices.	1	2	3, 13
CO5	Interpret and solve the fluid flow problems using dimensional analysis.	1	3	5

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	2.6		3								3		

Prerequisites: Nil

Course Content:

1. **Fluid Statics and Applications:** Introduction to momentum transfer and unit operations. Nature of fluids, pressure and its measurements. Hydrostatic equilibrium, barometric equation, measurement of fluid pressure-manometers (U tube manometer, Inverted manometer, differential manometer), continuous gravity decanter, centrifugal decanter. **8 Hrs.**

2. **Fluid Flow Phenomena:** Newtonian and Non-Newtonian fluids, types of flows, Shear rate, Shear stress, Rheological properties of fluids. Flow in boundary layer-Boundary layer separation and wake formation. Basic Equations of Fluid Flow: Macroscopic momentum balances, Mechanical energy equations. **10 Hrs.**
3. **Incompressible Fluids:** Laminar flow of incompressible fluids in pipes and conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy equation. Turbulent flow of incompressible fluids in pipes and conduits-Universal velocity distribution equation. Friction factor and Reynolds number relationship and friction factor chart. Nikuradse and Karman equation-Blasius equation, Prandtl one seventh power law. Changes in velocity or direction-Sudden expansion and contraction. **10 Hrs.**
4. **Compressible Fluids:** Continuity equation, Mach number, total energy balance, velocity of sound, Ideal gas equation, adiabatic and isothermal flow equations, Flow through convergent-divergent sections. **8 Hrs.**
5. **Transportation and Metering of Fluids:** Pipes, fittings and valves. Performance characteristics of Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors, Measurement of flowing fluids - full bore meters, area meter, insertion meters with flow rate equations. **10 Hrs.**
6. **Dimensional Analysis:** Dimensional homogeneity, Rayleigh's and Buckingham-Pi methods, dimensionless numbers, models and prototypes. **6 Hrs.**

Reference Books:

1. McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGraw Hill chemical engineering series. ISBN-10: 0072848235
2. Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1 and 2, 5/e. Butterworth publications. ISBN-10: 0750644451
3. Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4. R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

15UCHC303	Particulate Technology	(4-0-0) 4:52 Hrs

Course Learning Objective:

1. To study the basic principles of the unit operations and to study the construction, working and applications of the equipments involved in each of the unit operations.

Course Outcomes:

COs	Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain the characteristics of particulate solids and equipments dealing with them.	3	13	1,2
CO2	Explain and evaluate drag and pressure drop through a bed of solids immersed in fluid.	4	13	1,2
CO3	Evaluate the terminal velocity of particles moving in a fluid under different regimes.	4	13	1,2
CO4	Comprehend and analyse gravity and centrifugal sedimentation.	13	2	1
CO5	Categorize and explain the industrial filters.	13	2	1
CO6	Describe the types of impellers, mixers and calculate the power consumption in different agitation systems.	13	2	1

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	2.5	1	1									1.5		

Prerequisites: Nil

Course Content:

1. **Particle Technology:** Particle shape, particle size, sphericity, mixed particles size analysis. Screens – ideal and actual screens, standard screens, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture. Industrial screening equipments, grizzly, gyratory screen, vibrating screen, trommels. Sub sieve analysis – Air permeability method, sedimentation and elutriation methods.

   Size Reduction: Introduction, types of forces and criteria for communition, characteristics of communited products, laws of size reduction, open and closed circuit grinding. Equipments for size reduction – jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, impactors, attrition mill, ball mill, fluid energy mill, knife cutter. **12Hrs.**

2. **Flow of Fluids Past Immersed Bodies:** Drag, drag coefficient. Pressure drop – Ergun's, Kozeny – Carman and Burke – Plummer equations. Fluidization - conditions for fluidization, minimum fluidization velocity, types of fluidization, applications of fluidization, pneumatic conveying. **9 Hrs.**

3. **Motion of Particles Through Fluids**: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, motion of spherical particles in Stoke's region, Newton's region and intermediate region. Criterion for settling regime, centrifugal separators, cyclones and hydro cyclones. **9 Hrs.**
4. **Sedimentation:** Batch settling test, application of batch settling test to design of continuous thickener. Coe and Clevenger theory, Kynch theory. Thickener design, determination of thickener area**.** **6 Hrs**
5. **Filtration:** Introduction, classification of filtration, cake filtration, batch and continuous filtration, pressure and vacuum filtration, constant pressure filtration, characteristics of filter media. Industrial filters - sand filter, filter press, leaf filter, rotary drum filter. Filter aids, application of filter aids. Principles of cake filtration, modification of Kozeny – Carman equation for filtration. **9 Hrs.**
6. **Agitation and Mixing:** Application of agitation, agitation equipment, types of impellers – propellers, paddles and turbines, flow patterns in agitated vessels, prevention of swirling, standard turbine design, power correlation and power calculation. Mixing of solids, types of mixers- change can mixer, Muller mixer, mixing index, ribbon blender, internal screw mixer, tumbling mixer.

   Sampling, Storage and Conveying of Solids: Sampling of solids, storage of solids, open and closed storage, bulk and bin storage. Conveyors – belt conveyor, chain conveyor, apron conveyor, bucket conveyor, bucket elevators, screw conveyor. **7 Hrs.**

Reference Books:

1. McCabe and Smith, "Unit Operation of Chemical Engineering", 4/e, McGraw Hill International, Singapore, 2001.
2. Badger, W.L. and Banchero J.T., "Introduction to Chemical Engineering", 3/e, McGraw Hill International, Singapore, 1999.
3. Coulson, J.M. and Richardson, J.F., "Chemical Engineering Vol.2", 5/e, Particle Technology and Separation Processes, 1998.
4. Foust, A.S. et.al, "Principles of Unit Operation", 3/e, John Wiley and Sons, New York, 1997.

15UCHC304	Chemical Engineering Drawing	(0-0-4) 2: 52 Hrs.

Course Learning Objective:

1. To increase competency in drawing through the development of sound observational skills.

Course Outcomes:

Cos	Description: Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Demonstrate symbols for different applications	11	10	
CO2	Translate sketches to engineered drawings.	10,11		
CO3	Analyze sectional views and assembly drawing.	10		

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO 15
Mapping Level										2.66	1				

Prerequisites: Nil

Course Content:

1. **Conventions:** Equipment and piping, colour codes, materials, nuts and bolts. **4 Hrs.**
2. **Proportionate Drawing of Process Equipment**: Jackets-types, Vessel Supports, Storage vessel, Reaction vessel, Heat Exchanger, Evaporator, Distillation column. **4 Hrs.**
3. **Sectional views:** Representation of the sectional planes, Sectional lines and hatching, Selection of section planes and types of sectional views. **6 Hrs.**

   Assembly Drawings:

   i. Shaft Joints: Cotter joint with sleeve, Gib and Cotter joint, Socket and Spigot joint. **8 Hrs.**

   ii. Pipe joint: Flanged type, Union Joint, Expansion joint **8 Hrs.**

   iii. Valves: Stop valve, Lever safety valve, Rams Bottom safety valve, Non-return valve, Plug valve **17 Hrs.**
4. **Process Flow Diagram**: with conventions and blocks, P&ID. **5 Hrs.**

Note:

- First angle projection to be followed.
- Drafter to be used for all drawings.

Reference Books:

1. Gopal Krishna, K.R., “Machine Drawing,” 2/e. Subhash Publication
2. Joshi, M.V., “Process Equipment Design” 3/e, Macmillan India publication.
3. Bhat N.D., “Machine Drawing”. Charotar Publishing, 50/e, 2011
4. Vilbrant and Dryden., “Chemical Engineering Plant Design” Publisher: New York, McGraw-Hill, 1959.

15UCHL305 Particulate Technology Laboratory (0-0-3) 1.5

Course Learning Objectives:

1. To get hands on experience on various unit operations by conducting experiments on size separation, size reduction, filtration etc.
2. To analyze experimental data and project in the form of a report and oral presentation.

Course Outcomes:

Cos	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Determine the average particle diameter by sieve and sub-sieve analysis experiments.	9	10	4, 15
CO2	Evaluate the energy consumed for the size reduction of solid samples by applying size reduction laws.	9	10	4, 15
CO3	Calculate the medium and cake resistance in filtration equipments.	9	10	4, 15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3					1.25	2.25					3

List of Experiments:

1. Ball mill
2. ICI sedimentation
3. Beaker decantation
4. Cyclone separator
5. Drop weight crusher
6. Jaw crusher
7. Leaf filter
8. Plate and frame filter
9. Screen effectiveness
10. Sieve analysis
11. Thickener
12. Batch sedimentation
13. Air elutriation

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Note: Atleast 10 experiments to be conducted

Reference Books:

1. McCabe and Smith, “Unit Operations of Chemical Engineering” 6/e, McGraw Hill International
2. Foust A.S. et al., “Principles of Unit Operations”, John Wiley and Sons.

15UCHL306 Chemical Analysis Laboratory (0-0-3)1.5

Course Learning Objectives:

1. To get hands on experience on various analysis of materials
2. To analyze experimental data and understand the importance of Chemical analysis

Course Outcomes:

Cos	Description: At the end of course the student will able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Determine the various properties of the fluids and solids given.	9	10	4, 15
CO2	Estimation and characterization of the given material.	9	10	4, 15
CO3	Analysis of various fluids with the measuring techniques used.	9	10	4, 15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3					1.25	2.25					3

Prerequistes: Nil

List of Experiments:

1. Conductometric titration an Acid vs Base.
2. Standardization of potassium permanganate.

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3. Determination of percentage of available chlorine present in bleaching power sample.
4. Determination of moisture content of soil and ash content of coal.
5. Determination of calorific value of solid &liquid fuels by bomb colorimeter.
6. Estimation of hardness, calcium and chlorides in water sample.
7. Determination of optimum dosage of alum of raw water.
8. Determination of bulk density, porosity and specific surface area of a sample.
9. Estimation of oil in seeds by solvent extraction method.
10. Qualitative analysis of proteins and aminoacids.
11. Qualitative analysis of carbohydrates and lipids.
12. Estimation of total loss on ignition of cement sample.
13. Estimation of reducing sugar by DNS method.
14. Estimation of sulphates and nitrates ina given water sample.

Note: Atleast 10 experiments to be conducted.

Reference Books:

1. Jaffery, G.H., Basset, J., et al., "Vogel's Text book of Quantitative Inorganic Analysis" 5/e, ELBX. 1998
2. Skoog, D.A., "Principles of Instrumental Analysis" 3/e, Saunders College publishing 1985.

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IV Semester

15UMAC400	Engineering Mathematics - IV	(4-0-0) 4: 52 Hrs.

Course Learning Objective:

1. Learn to solve algebraic and transcendental equations numerically. Learn the concepts of finite differences and its applications. Learn the concept of special functions. Learn fitting of a curve, correlation, regression for a statistical data. Learn the basic concepts of probability, random variables and probability distributions. Learn the concepts of stochastic process and Markov chain.

Course outcome:

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12)		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO-1	Solve the problems of algebraic and transcendental equations using numerical methods.		1	
CO-2	Use numerical methods to solve first order differential equations.	13	1	
CO-3	Derive the solution of Bessel's differential equation, Legendre's differential equation.	1		
CO-4	Analysis the bivariate statistical data and calculate correlation and regression. Apply concepts of probability to solve engineering problems.	1	15	
CO-5	Recite Markov chains and describe stochastic process.	1,2	15	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.4	1											1		2

Course Content:

1. **Numerical Methods**: Roots of equations: Regula Falsi method, Newton-Raphson Method, Finite differences: Forward, Backward and central differences. Newton Gregory forward and backward interpolation formulae. Striling's and Bessel's interpolation formulae. Lagrange's interpolation formulae. Numerical integration: Simpson's 1/3rd rule and Weddle's rule, Solutions to Engineering problems. **10 Hrs**
2. **Numerical solution of O.D.E:** Numerical solution of ordinary differential equations of first order and first degree, Picards method. Taylor's series

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method, modified Euler's method, Runge-Kutta method of fourth order. Milne's predictor and corrector methods (no derivations of formulae). Numerical solution of simultaneous first order ordinary differential equations: Picards method, Runge-Kutta method of fourth- order. **10 Hrs**

3. **Special functions:** Introduction to series solution, Series solution of Bessel's differential equation leading to Bessel function of first kind, orthogonal property of Bessel function, Series solution of Legendre's leading to Legendre's polynomial, Rodrigues formula. **8 Hrs**
4. **Statistics and probability**: Curve fitting by the method of least squares: $y = a+bx$, $y = a+bx+cx^2$, $y = ab^x$, Correlation and regression. Random Variables: Discrete and continuous random variables-PDF-CDF- Binomial, Poisson, exponential and Normal distribution. Joint probability distribution of two discrete random variables. **Sampling**: Sampling distribution, standard error, test of hypothesis for means and population, confidence limits for means. *t*-Students distribution as a test of goodness of fit. **14 Hrs.**
5. **Markov Chains:** Introduction, probability vectors, Stochastic Matrices, Fixed points and Regular stochastic matrices, Markov chains, higher transition probabilities, stationary distribution of regular Markov chains and absorbing states. **10 Hrs.**

Reference Books:

1. Jain, Iyengar and Jain, Numerical Methods for Engg. & Scientist, PHI, 3rd Edn., 2005.
2. Gupta S C and Kapoor V K, Fundamentals of Mathematical Statistics, 9th Edn, Sultan Chand & Sons, New Delhi, 2002.
3. B. S. Grewal, Higher Engineering Mathematics – Khanna Publishers – 40th edition – 2007.
4. Kreyszig E., Advanced Engineering Mathematics, 8th Edn, John Wiley & sons, 2007.

15UCHC400	Process Heat Transfer	(4-0-0) 4: 52 Hrs.

Course Learning Objective:

1. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Define the mechanism of heat transfer and apply concepts to engineering applications.	2,13	1	
CO2	Evaluate steady state heat conduction, radiation and convective heat transfer processes.	13	2,7	
CO3	Apply the thermal insulation for engineering systems.		6,13	
CO4	Select appropriate extended surfaces to enhance overall heat transfer coefficient.	2,3,13		
CO5	Design and assess the performance of heat exchangers, condensers and evaporators.	13	2,3	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	1.5	1			2	2						1.2		

Prerequisites: Nil

Course Content:

1. **Modes of Heat Transfer:** Mechanism of thermal conduction in solids, liquids and gases, thermal conductivity, steady state unidirectional heat conduction. Fourier's law, Heat transfer through composite walls and cylinders. Analogy with Ohm's law. **8 Hrs.**
2. **Insulation and Extended Surfaces:** Types of insulating materials, general properties and application of insulators, Critical and optimum thickness of insulation. Extended Surfaces: Fins – types of fins, fin efficiency for longitudinal fins, Fin effectiveness. **8 Hrs.**
3. **Convection:** Individual and overall heat transfer coefficient, Forced convection: In laminar flow - Heat transfer in plate and in tubes. In turbulent flow - Empirical equations for individual coefficients: inside tubes, outside tubes, outside bundle of tubes, flow past spheres. Dimensional Numbers: Dimensional analysis, Empirical correlation for forced and natural convection. Analogy between momentum and heat transfer – Reynolds, and Coulburn analogies Significance of Prandtl No., Nusselt No., Correction for heating and cooling. Natural convection from vertical plates and horizontal cylinders. Grashof No., Rayleigh No. **10 Hrs.**
4. **Heat Transfer with Phase Change:** condensation of vapor, Film wise and drop wise condensation. Condensation – Film and Drop wise condensation,

Nusselt's equation for vertical, horizontal and inclined plate. Condensation outside horizontal tube or bank of tube. Evaporator: Natural circulation, Forced circulation, Falling film evaporator, Performance of steam heated tubular evaporators-capacity and economy, single effect evaporator and multiple effect evaporators. **8 Hrs.**

5. **Heat Exchangers:** Classification of HE, Individual and overall heat transfer coefficient. DPHE, STHE, PTHE-general constructions, temperature profiles in heat exchangers. LMTD and LMTD correction factor. Fouling and types of fouling, fouling factor. Analysis of HE's - LMTD, ε-NTU method **10 Hrs.**
6. **Radiation:** Radiation laws - Stefan Boltzman's law, Kirchoff's law, Wien's law, Plank"s law. Black body, Grey body. Transmittivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces, radiation shields. **8 Hrs.**

Reference Books:

1. J.P.Holman," Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2. Rao Y.V.C., "Heat Transfer", Edition illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3. McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4. Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1.6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

15UCHC401 Chemical Engineering Thermodynamics (4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To relate state changes in a system to the quantity of energy in the form of heat and work transferred across its boundaries.
2. Understanding of the laws of thermodynamics and their application in the analysis of chemical and engineering problems.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Mastering 3**
CO1	State thermodynamic laws, Identify and distinguish the types of properties, systems and processes	1		

CO2	Apply and evaluate heat and work interactions for the flow and nonflow processes	13, 2		1
CO3	Analyze and evaluate pressure, volume and temperature with equations of state for gases	3	13, 2	1
CO4	Explain and estimate the enthalpy changes in chemical reactions	2, 13		1
CO5	Determine the entropy changes associated with processes	3	13, 2	1
CO6	Apply the laws of thermodynamics to important fluid flow processes	2	1	

POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PO1 3	PO1 4	PO1 5
Mapping level	2.5	1.4	1										1.5		

Course Content:

1. **Basic Concepts:** System, surrounding, state and properties, state and Path functions, Equilibrium state, phase rule, Zeroth law, reservoirs and heat engines. **8 Hrs.**
2. **First law of thermodynamics:** Statement, cyclic process and nonflow processes, Heat capacity. **8 Hrs.**
3. **P-V-T behavior:** Pure fluids, Equations of state, Processes involving ideal gas law: Constant volume, constant pressure, constant temperature adiabatic and polytrophic processes, cubic equations of state, Compressibility charts, principles of corresponding states. **10 Hrs.**
4. **Heat effects accompanying chemical reactions:** Standard heat of reaction, formation, combustion. Hess's law of constant heat summation, effect of temperature. **8 Hrs.**
5. **Second law of thermodynamics:** Statements of second law, entropy, the Carnot principle, entropy changes, Clausius inequality, irreversibility, third law. **8 Hrs.**
6. **Applications of thermodynamics to flow processes:** Duct flow of compressible fluids, Turbines (expanders), compression processes. **10 Hrs.**

Reference Books:

1. Smith J.M and Vanness H.C. and Abbot, "Introduction to Chemical Engineering Thermodynamics", 5/e & 6/e, McGraw Hill, New York, 1996.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" New Age International Publication, Nagpur, 2000.
3. Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.

15UCHC402	Chemical Reaction Engineering- I	(4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To provide basic understanding of kinetic models and mechanisms for homogeneous chemical reactions.
2. To understand the interpretation of reactor data and thereby exploring the rate law for chemical reactions.
3. To provide an understanding and application of rate law in design of Ideal reactors and to assess their performances based on temperature effects.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Mastering 3**
CO1	List the classification of reactions and explain the effect of temperature on rate of reaction		1	
CO2	Interpret reaction data and determine the rate equation	1		2
CO3	Formulate performance equations for ideal batch and flow reactors		2	3
CO4	Design ideal batch and flow reactors for single and multiple reactions under isothermal and non-isothermal conditions.		2,13	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO 14	PO 15
Mapping Level	1.5	2.3	3										2		

Prerequisites: Nil

Course Content:

1. **Introduction:** Scope of Chemical Reaction Engineering, classification of reactions, Rate equation and rate of reaction. Factors affecting the rate of reaction. Chemical kinetics, thermodynamics and Equilibrium. Temperature dependency of rate constant from Arrhenius, collision and Transition state theories. Molecularity and order of reaction. Elementary and non-elementary reactions. Kinetic models for non- elementary reactions. **8 Hrs.**
2. **Homogenous reactions**: Interpretation of batch reactor data. Constant volume batch reactor. Analysis of total pressure data in a constant volume system. Integral method of analysis for Irreversible zero, first, second and n^{th} order reactions. Reversible first and second order reactions, series, parallel and autocatalytic reactions. Variable volume reactions. Differential method of analysis. Over all order from half-life method. **12 Hrs.**

3. **Design of Ideal Reactors:** Formulations of performance equations for Ideal batch, Plug and mixed flow reactors for both constant and variable volume reactions. Rate equation from data obtained from ideal reactors. Comparison of Ideal reactors. Multiple reactor systems. Series and parallel combinations. Recycle reactors, introduction and qualitative treatment for single reactions only. **12 Hrs.**
4. **Multiple reactions:** Batch, plug and mixed flow reactors for parallel, series reactions. Yield and selectivity. **10 Hrs.**
5. **Thermal characteristics of reactors:** Heat of reactions, equilibrium constant, optimum temperature progression. Conversion in reactors operated under adiabatic and nonadiabatic conditions. Reactor design by solving material and energy balance equations simultaneously. **10 Hrs.**

Reference Books:

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, McGraw Hill, 1981.ISBN:0-07-066574-5
3. H. Scott Fogler, “Elements of Chemical Reaction Engineering”, 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

15UCHC403	Mass Transfer- I	(3-2-0) 4:52 Hrs.

Course Learning Objectives:

1. To understand the fundamentals and principles of diffusion mechanism in all the phases of matter along with equilibrium diffusion between the phases with an insight of interphase mass transfer.
2. To understand and apply analogy between transport processes along with an insight of interphase mass transfer applied to industrial diffusional separations, obtain transfer coefficients to propose and evaluate experimental investigations on mass transfer.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Interpret mechanisms of molecular and turbulent diffusion both in fluids and solids, develop mathematical expressions for one dimensional steady state diffusion and analyze	10	1,3,7,13	12

	interphase mass transfer.			
CO2	Apply interphase concept to crystallization along with stoichiometric calculations to evaluate performance of crystallizers.	10	1,3,12,13	
CO3	Analyze humidification process, configurations and design of cooling tower for air-water system.	10	1,3,7,12,13	
CO4	Apply interphase concept to drying along with stoichiometric computations for assessing the performance of dryers.	7,10	1,13	12
CO5	Interpret adsorption, types with industrial adsorbents and analyze stage wise operations.	10,13	1,3,7,14	12

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2		2				1.7			1		2.6	1.8	2	

Prerequisites: Nil

Course content

1. **Diffusion**: Types, importance, molecular versus turbulent diffusion, molecular diffusion in fluids, rates of diffusion, Fick's I-law. Diffusion in a binary system, steady state unidirectional diffusion in the fluids at rest and laminar flow. Cases with examples: 1. Unicomponent diffusion and 2. Equimolal counter diffusion. Pseudo steady state diffusion. Diffusivity of gases, empirical treatment. Convective mass transfer, Local and Overall mass transfer coefficients and correlations. Analogies; Reynold's, Prandtl's, Von Karman's, and Chilton and Colburn J-factor. Theories of convective mass transfer; Diffusion in solids, importance, types with different geometrical shapes. **12 Hrs.**
2. **Interphase Mass Transfer:** Introduction, concentration profile. Use of Film Transfer Coefficients in unicomponent diffusion and equimolal counter diffusion. Use of Overall Transfer Coefficients. Graphical approach, equilibrium diffusion between the phases, types of operations. Material balance in each process. Stages, efficiencies **10 Hrs.**
3. **Crystallization:** Introduction, importance with examples, solubility concept, equilibrium solubility etc. Saturation/equilibrium, super saturation, mechanism of crystallization etc. Myer's theory of super saturation, Methods of generating super saturation. Nucleation types, crystal breeding, growth regimes. Ostwald's ripening, crystal growth and coefficients, crystal size and shape

factors. Material and balance calculations, ΔL law of crystal growth, caking of crystals. **8 Hrs.**

4. **Humidification:** Importance and terminology, Psychrometric chart for air-water system. Measurement of Wet Bulb Temperature, Adiabatic Saturation Temperature, Lewis relation. Cooling towers, Theory of cooling towers. Types, construction and working. Design of cooling towers, NTU and HTU. **7 Hrs.**
5. **Drying:** Importance with examples. Terminology in drying. Graphical representations of various terms. Typical rate of drying curve. Drying time calculations. Mechanism of drying, use of heat transfer and mass transfer coefficients. Theories of moisture movement. Industrial Dryers. **7 Hrs.**
6. **Adsorptio**n: Introduction, importance with examples, applications. Types of adsorption; nature of adsorbents, chemisorption and vander waal's adsorption. Adsorption equilibria; isotherms, isobars and isosteres. Adsorption calculations, Freundlich and Langmuir adsorption isotherms. Stage wise calculations and graphical representation. Adsorption equipments. **7 Hrs.**

Reference Books:

1. Robert E. Treybal, "Mass Transfer Operations", 3/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 1981 ISBN: 0-07-066615-6.
2. Warren L. McCabe, Julian C. Smith and Peter Harriott, "Unit Operations of Chemical Engineering", 6/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 2001; ISBN: 0-07-118173-3.
3. Christie J. Geankoplis, "Transport Processes and Unit Operations", 3/e., Prentice Hall of India, New Delhi; 1993; ISBN: 13: 978-0139304392.
4. Binay K. Dutta, "Principles of Mass Transfer and Separation Processes", PHI Learning, New Delhi; 2009; ISBN-13-9788120329904.

15UCHC404	Pollution Control Engineering	(3-0-0)3: 39 Hrs.

Course Learning Objectives:

1. To create awareness on the various environmental pollution aspects and issues and give a comprehensive insight into natural resources, ecosystem, and biodiversity.
2. To understand the different parameters, treatment methods and control techniques of various environmental pollution.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the importance of the environment on mankind, regulatory bodies and guidelines.	3, 6, 7	14	
CO2	Interpret various parameters of waste water and explain different methods of treatment.		14, 15	3, 6, 7
CO3	Identify the sources and effects of different types of air pollution, their prevention and control techniques.		3, 6, 7	14
CO4	Identify the different methods for handling and disposal of solid waste and effects and control methods of noise pollution.		3, 6, 7	14
CO5	Explain the pollution problems of specific industries and control techniques.	3, 6, 7	14, 15	4

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			1.8	3.0		1.8	1.8							2.4	2.0

Prerequisites: Nil

Course content:

1. **Introduction:** Importance of Environment for Mankind. Engineering, ethics and environment. Ecological systems and pollution, hydrological cycle and nutrient cycle. Damages from environmental pollution. Fundamental definition of pollution parameters- air, water and soil quality criteria, standards and legislation and acts, EIA, EIS and EMP. **6 Hrs.**
2. **Water Pollution:** Water Resources. Wastewater sources and Classification. Types of Water Pollutants. Waste Water Sampling, Methods of Analysis: DO, BOD, COD, TOC, Nitrogen, Phosphorus, Trace Elements and Alkalinity. **6 Hrs.**
3. **Water treatment:** Wastewater Treatment: Preliminary, Primary, Secondary and Tertiary. Advanced wastewater Treatment: Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electrodialysis cell. Design of sedimentation tanks and biological treatment processes. Applications to Industries: Petroleum refinery, distillery, Fertilizer and Textile processing. **8 Hrs.**

4. **Air Pollution:** Definition, Sources, Classification, Properties of air pollutants, Effects of air pollution on health vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling. Analysis of air pollutants. Air pollution meteorology (generation transportation and dispersion of air pollutants). **8 Hrs.**
5. **Air treatment:** Control methods and Equipments for particulates and gaseous pollutants. Selection design and performance analysis of air pollution control equipment: gravity settling chambers, air cyclones, ESPs, filters and wet scrubbers. Applications to Industries: Thermal power plants, Metallurgical and Cement industries. **6 Hrs.**
6. **Solid Waste Treatment and Noise pollution:** Sources and Classification, Effect on public health, Methods of Collection, onsite handling, storage and processing techniques, 5R concept for minimizing the Solid Waste, Solids waste disposal methods- open and ocean dumping, compositing, landfill and incineration. Definition, Sources and Effects of Noise, Equipments and units used for Noise Measurement, Approaches for Noise Control at different levels. **8 Hrs.**

Reference Books:

1. C. S. Rao “Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2. S .P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill.
3. Metcalf and Eddy, "Waste Water Engineering Treatment Disposal Reuse” Tata McGraw Hill, 4/e, 2003.
4. Frank Kreith and George Tchobanoglous- “Hand book of Solid waste Management”, Tata Mc-Graw Hill, 2/e.

15UCHL405	Computational Methods in Chemical Engineering Laboratory	(0-0-3) 1.5

Course Learning Objective:

1. To understand the application of mathematics using computer to solve the simple Chemical Engineering problems.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Solve Chemical Engineering problems using the analytical methods and programming.	9	10	4,15

CO2	Compute the chemical engineering problems with nonlinear-algebraic equations.	9	10	4,15
CO3	Compute the chemical engineering problems with Numerical Integration	9	10	4,15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	-	8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3					1.25	2.25					3

Prerequisites: C Programming

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – simpson's 1/3 rule.
6. Estimation of power requirement of centrifugal pump and annual cost.
7. Calculate average particle size of material from sieve analysis data.
8. Power requirement of mixing tank agitator.
9. Pressure drop in a pipe.
10. Heat dissipated by fin.
11. Curve fitting – List square method
12. Double pipe heat exchanger (Area, Length)
13. Bubble and dew point calculation.

Note: Atleast 10 experiments to be conducted.

Reference Books:

1. Jenson, V.J. and Jeffereys, G.V., "Mathematical Methods in Chemical Engineering", Academic Press, London and New York, 1977.
2. Mickley, H.S., Thomas. K. Sherwood and Road, C.E., "Applied Mathematics in Chemical Engineering", Tata McGraw-Hill Publications, 1957.
3. S. Pushpavanam, "Mathematical Methods in Chemical Engineering", PHI
4. E. Balagurusamy, "Programming in ANSI C", 6/e, TMH 2012.

15UCHL406	Fluid Mechanics Laboratory	(0-0-3) 1.5

Course Learning Objective:

1. To understand the principle, construction, working and analysis of different equipment's in the fluid flow phenomena.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Calculate the discharge rate for flow measuring devices and pumps	9	10	4,15
CO2	Distinguish the types of pipe fitting and identify their applications	9	10	4,15
CO3	Identify the flow pattern of the fluid and evaluate the friction factor of the spiral coil	9	10	4,15
CO4	Calculate the minimum fluidization velocity	9	10	4,15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	-	8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3				2	1.2	2.2					3

Prerequisites: Fluid Mechanics Theory

List of Experiments:

1. Fluidized bed.
2. Study and development of characteristics for centrifugal pump
3. Local velocity measurement using Pitot tube.
4. Positive Displacement Pump Characteristics
5. Packed Bed
6. Reynolds Experiment
7. Flow through spiral coil
8. Orifice meter and venturimeter characteristics
9. Friction in circular pipes
10. Pipe fittings
11. Weir characteristics

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Note: Atleast 10 experiments to be conducted.

Reference Books:

1. McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, Mc Graw Hill.
2. Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1, 5/e. Butterworth publications.
3. Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4. R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- **To have contextually relevant curricula.**
- **To promote effective teaching learning practices supported by modern educational tools and techniques.**
- **To enhance research culture.**
- **To involve industrial expertise for connecting classroom content to real life situations.**
- **To inculcate ethics and impart soft skills leading to overall personality development**

SDMCET- Quality Policy

- **In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.**

SDMCET- Core Values

- **Competency**
- **Commitment**
- **Equity**
- **Team work and**
- **Trust**

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. By fostering research culture with ethics to disseminate knowledge..
3. By collaborating with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes and Program Specific outcomes

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

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Scheme for V Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC500	Chemical Reaction Engineering – II	4-0-0	4	50	100	3		
15UCHC501	Mass Transfer – II	4-0-0	4	50	100	3		
15UCHC502	Chemical Equipment Design	4-0-0	4	50	100	3		
15UCHC503	Chemical Plant Utilities and Safety	4-0-0	4	50	100	3		
15UCHL504	Heat Transfer Laboratory	0-0-3	1.5	50			50	3
15UCHL505	Environmental Engineering Laboratory	0-0-3	1.5	50			50	3
15UCHE50X	Elective-1	4-0-0	4	50	100	3		
15UCHE50X	Elective-2	4-0-0	4	50	100	3		
	Total	**24-0-6**	**27**					
15UCHE506	Process Instrumentation	4-0-0	4	50	100	3		
15UCHE507	Energy Technology and Management	4-0-0	4	50	100	3		
15UCHE508	Solution Thermodynamics	4-0-0	4	50	100	3		
15UCHE509	Food Technology	4-0-0	4	50	100	3		
15UCHE510	Fertilizer Technology	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study *SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Scheme for VI Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC600	Management, Entrepreneurship and Protection of Intellectual Property Rights	4-0-0	4	50	100	3		
15UCHC601	Chemical Process Integration	4-0-0	4	50	100	3		
15UCHC602	Process Equipment Design and Drawing	3-0-2	4	50	100	4		
15UCHL603	Mass Transfer Laboratory	0-0-3	1.5	50			50	3
15UCHL604	Chemical Reaction Engineering Laboratory	0-0-3	1.5	50			50	3
15UCHL605	Mini Project	0-0-8	4	50			50	3
15UCHE60X	Elective – 3	4-0-0	4	50	100	3		
15UCHE60X	Elective – 4	4-0-0	4	50	100	3		
	Total	**18-2-16**	**27**					
15UCHE606	Petroleum and Petrochemicals	4-0-0	4	50	100	3		
15UCHE607	Catalyst Technology	4-0-0	4	50	100	3		
15UCHE608	Applied Mathematics in Chemical Engineering	4-0-0	4	50	100	3		
15UCHE609	Polymer Science and Technology	4-0-0	4	50	100	3		
15UCHE610	Composite Materials	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study *SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the third year: 54

V Semester

15UCHC500	Chemical Reaction Engineering-II	(4-0-0)4: 52 Hrs.

Course Learning Objectives:

1. To understand Non-Ideal flow behavior in Chemical reactors.
2. To provide the forum to understand the Principles and concepts involved in Catalytic reactions.
3. To understand kinetics of heterogeneous reactions (Non-Catalytic) and apply the same for reactor design.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Define residence time distribution and determine conversion using single parameter models for real reactors.	1		2
CO2	Explain various methods to estimate properties of a given catalyst and evaluate its performance.		1	4
CO3	Develop performance equations for reactors containing porous catalyst and apply the same for reactor design.		4	3,13
CO4	Develop the mechanism and determine the deactivation and regeneration rates in various reactors.		4	3
CO5	Interpret various kinetic regimes for heterogeneous non- catalytic reactions and apply the same for reactor design.	4	2	3,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2.5	3	2									3		

Prerequisites: Chemical Reaction Engineering-I

Course Content:

1. **Basics of non-ideal flow:** Causes for non-ideal flow, the residence time distribution (RTD), E, C and F. Curves, Experimental methods for finding extent of non-ideal behavior, Micro and macro mixing, conversion in non-ideal flow reactors from tracer information, dispersion model and tanks-in-series model. **10 Hrs.**

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2. **Fluid-Particle reactions:** Introduction to heterogeneous non-catalytic reactions, industrial examples, overall rate expression, Ideal contacting patterns, progressive conversion and shrinking core model, overall rate expression for various controlling mechanisms from shrinking core model, conversion – time expressions, Design of reactors for particles of single size and different sizes under ideal flow patterns. **10 Hrs.**
3. **Fluid – Fluid reactions:** Industrial examples, Rate equations for straight mass transfer and mass transfer with chemical reaction, various kinetic regimes, liquid film enhancement factor, Role of Hatta number, Design of reactors for fluid-fluid reactions under co current and counter current operations based on ideal flow patterns. **10 Hrs.**
4. **Fluid – Solid Catalytic reactions:** The nature and mechanism of catalytic reactions, Adsorption isotherms, physical, chemical dynamic and mechanical properties of solid catalyst and their determination, catalyst preparation, overall rate expressions for various controlling mechanisms. **10 Hrs.**
5. **Catalyst deactivation:** Causes for deactivation, mechanisms of deactivation, Experimental methods to find deactivation kinetics using Batch- solids and Batch-fluids, Batch solids and Mixed constant and variable flow of fluid, Batch solids and plug constant and variable flow of fluid. **10 Hrs.**

Reference Books:

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, McGraw Hill, 1981. ISBN:0-07-066574-5
3. H. Scott Fogler, “Elements of Chemical Reaction Engineering”, 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

15UCHC501	**Mass Transfer - II**	**(4-0-0)4:52 Hrs.**

Course Learning Objectives:

1. To understand the principles and mechanism of diffusion mass transfer in applying to various separation processes viz. distillation, absorption, extraction and leaching.
2. To propose and evaluate the performance of the related equipment for separations involving diffusion.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the principles of different mass transfer equipment.	13	-	1, 2
CO2	Interpret and analyze the concept and mechanism of gas absorption, and sizing of absorption column	1	2	3, 13
CO3	Explain the phenomena of vapor-liquid equilibria, principle and types of distillation process	1	2	3, 13
CO4	Calculate the no of stages for distillation process by different methods	1	2	3, 13
CO4	Explain the extraction and leaching concepts and processes and to determine the no of stages required.	1	2	3, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	1.5	2.25	3										2.5		

Prerequisites: Mass Transfer-I

Course Content:

1. **Gas Liquid Contacting Systems:** Types, construction and working of equipment – Distillation, Absorption, Humidification & Drying.
   Gas Absorption: Mechanism of gas absorption, equilibrium in gas absorption, Choice of solvent, Equilibrium concept in absorption, application of mass transfer theories to absorption, calculation of HETP, HTU, NTU, calculation of height of packing. Absorption and stripping factors, tray efficiencies, absorption with chemical reaction. **14 Hrs**
2. **Distillation:** Vapor-liquid equilibria, Relative volatility, Ideal Solutions, Relative volatility, Azeotropic mixtures, Raoult's law, Types of distillation, extractive, azeotropic, flash, differential distillation, low-ressure distillation; steam distillation, **08 Hrs**

Continuous Distillation: multistage continuous rectification, Total reflux, minimum reflux ratio, optimum reflux ratio. Design calculations by McCabe-Thiele and Ponchon-Savarit methods; Murphree, stage and overall efficiency, calculation of actual number of stages, Multicomponent distillation. **12Hrs**

3. **Liquid-Liquid Extraction** Liquid-Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Different types of extractors: Selection, construction, and operation **10 Hrs**
4. **Leaching operation:** Solid-liquid extraction (Leaching), various types with application, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages Leaching equipment: Selection, construction, and operation **8 Hrs**

Reference Books:

1. Robert. E. Treybal, "Mass Transfer Operation", 3/e, McGraw Hill, 1981.
2. McCabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/ e, Mc Graw Hill, 2001.
3. Coulson and Richardson, "Chemical Engg Vol. 2 and Vol 4, 4/e. Pergamon press, 1998.
4. Geankoplis, C.J., "Transport Processes and Unit Operations", 3/e, Prentice Hall (I).

15UCHC502	Chemical Equipment Design	(4-0-0)4: 52Hrs.

Course Learning Objective:

1. To develop key concepts and techniques with relevant codes and standard procedures of different equipments.
2. To study the detailed design considerations of different types of equipments used in chemical industries.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Congregate the data from relevant code books and identify the standard procedures for the design of chemical plant equipment.	3		14
CO2	Design and evaluate the components of the reaction and pressure vessels.	1	2	3, 13
CO3	Design and evaluate the components	1	2	3, 13

	of the storage and tall vertical vessels.			
CO4	Estimate the pipe size; pump rating with accessories to provide the valid conclusions for their use.		3	13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	1	2	2.25										3	3	

Prerequisites: Nil

Course Content:

1. **Introduction:** Design procedure, equipment classification and components, design parameters, pressure vessel codes. Design considerations: Material selection, factors affecting design, stresses due to static and dynamic loads (Internal and External), temperature effects, and economic considerations **08 Hrs.**
2. **Design of Pressure Vessels:** Design parameters, conditions and stresses. Design of shell and other vessel components. Vessel at low and high operating temperatures. Design of components, supports and selection of vessels accessories and mountings. Numerical problems. **12 Hrs.**
3. **Design of Reaction Vessels:** Design of reaction tanks-agitators, baffles, jackets, tank dimensions. Power calculations. Drive calculations and accessories. Support calculations for the system. Numerical problems **10 Hrs.**
4. **Design of Tall Vertical Vessels:** Vessels subjected to wind loads. Multi shell constructions. Determination of shell thickness. Supports for columns. Numerical problems **08 Hrs.**
5. **Pipe Line Design:** Pipe thickness, pipe diameter. Optimum size of delivery line in pumping operations. Pump rating. Numerical problems. **08 Hrs.**
6. **Introduction to Design of Storage Vessels:** Process conditions and design parameters for storage of volatile, nonvolatile fluids and gases. Design of components, supports and selection of vessels accessories and mountings. Roofs for vessel. Numerical problems. **06 Hrs.**

Note: IS code book 2825 for pressure vessel design is permitted in the exams for reference.

Reference Books:

1. V V Mahajani & S B Umarji, "Joshi‟s Process Equipment Design" – Trinity Press, Delhi, India 4 th edition.

2. S. D. Dawande, "Process Design of Equipment", Vol 1, Central Techno Publications. 3rd edition, 2003.
3. Brownell & Young, "Process equipment design" Willy student, 1 st edition, 2009
4. Don W. Green & Robert H. Perry, "Chemical Engineers Handbook", 6 th edition, McGraw Hill, 2014.
5. Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, , New Delhi, 1969.

15UCHC503	**Chemical Plant Utilities and Safety**	**(4-0-0)4: 52 Hrs.**

Course Learning Objectives:

1. To understand the utilities in a chemical process plant, types, role and their selection.
2. To understand the principles of safety with insight of safety analysis techniques and application of safety devices.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	List and comprehend the selection and role of utilities in a chemical plant.	-	3,8,9,10,14	6,7
CO2	Appraise the generation, handling and role of water, steam and air in a chemical plant.	-	6,8,9,10	3,14
CO3	Assess refrigerants, evaluate the performance and apply refrigeration.	-	6,8,9,10	3,14
CO4	Prioritize safety aspects, plan and use safety devices in defiant situations in a chemical plant.	-	9	3,6,7,8,10,14
CO5	Interpret safety analysis tools and techniques and translate to hazardous conditions.	-	3,8	6,7,9,10,14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2.6			2.6	3	2.2	2.2	2.4				2.8	

Prerequisites: Nil

Course Content:

1. **Water and Steam:** Resources, Cooling water-requirements and treatments, Process water-Ion Exchange, Water softening methods-Ion exchange, Reverse osmosis, Electro dialysis, Water pretreatment, recycle and reuse, various pumps. Generators, Boiler ratings, Efficiency, Feed water Treatment and Steam quality, Steam consumption, various steam flow meters, Steam distribution, Condensate removal, condensate recovery, Piping ancillaries, efficient utilization of Steam. **12 Hrs.**
2. **Air:** Compressed air for process and instruments, Blowers and Fans-Characteristics, Compressed- Positive displacement and Centrifugal features, Multistage Compression-features, Vacuum pumps, Air Drying-Pressure swing and Thermal swing. **8 Hrs.**
3. **Refrigeration:** Carnot Cycle and Reverse Carnot Cycles, Tonnage, Primary and Secondary refrigerants, Vapor Compression Refrigeration; various refrigerants, Tonnage. Vapor Absorption Refrigeration- Characteristics, Comparison. **9 Hrs.**
4. **Process Safety and Devices:** Safety aspect, safe design, Intrinsic and Extrinsic safety, Hazards, Risk, Toxicity, Flammability, Fire, Explosion, TLV, Sources of ignition, Hazardous materials and conditions, Reactive chemicals, Combustion and Flammability, Gas explosion, Dust Explosion, UCVCE, Static Electricity, Vacuum Hazards, Inert Gas Hazards, Gas Dispersion, Safety Devices; Pressure Relief Systems, Emergency relief devices, Flame arrestors, storage and handling. **12 Hrs.**
5. **Safety Analysis & Case studies:** Hazard Analysis (HAZAN), Hazard and Operability studies (HAZOP), Comparison, Risk Analysis and Estimation, Safety check list. Case Studies: Bhopal, Jaipur, Flixborough, Seveso, Piper Alpha, Mexico [LPG Fire] **9 Hrs.**

Reference Books:

1. Perry's "Handbook of Chemical Engineers" 7/e, Mc-Graw Hill Publications.
2. Frank P. Lees, "Loss Prevention", Vol 1 and Vol 2.
3. Jack Broughton, "Process Utilities", I Chem publications.

15UCHL504 Heat Transfer Laboratory (0-0-3)1.5

Course Learning Objective

1. To study the phenomena of conduction, convection and radiation effects in different equipments and know the rate of heat transfer.
2. To study the working, construction and analyse the efficiency and performance of heat exchangers.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify the different modes of heat transfer and evaluate the rate of heat transfer coefficient.	9	10	4,15
CO2	Determine the thermal conductivity of solids and liquids.	9	10	4,15
CO3	Distinguish the different types of heat exchangers and identify their applications.	9	10	4,15
CO4	Evaluate the performance and efficiency of the heat exchangers using the steam and recognize the boiler characteristics.	9	10	4, 15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report.		8, 10	9

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level				3				2	1.4	2					3

Prerequisites: Process heat transfer theory.

List of Experiments:

1. Double pipe heat exchanger
2. Cross flow heat exchanger
3. Thermal conductivity of liquids
4. Heat transfer through lagged pipe
5. Emissivity determination
6. Stefan - Boltzmann apparatus
7. Extended surfaces
8. Packed bed vertical condenser
9. Heat transfer through helical coil

10. Unsteady state heat transfer
11. Natural and forced convection in a jacketed vessel
12. Evaporator
13. Solar heater
14. Heat transfer through fluidized bed

Note: Atleast 10 experiments to be conducted

Reference Books

1. J.P.Holman, "Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2. Rao Y.V.C., "Heat Transfer", Edition illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3. McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4. Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1. 6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

15UCHL505	**Environmental Engineering Laboratory**	**(0-0-3)1.5**

Course Learning Objectives:

1. To understand the employability of instruments in determining various parameters of solid, liquid and gas samples to analyze completely and present a good technical report.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Reproduce theory and apply into practice for using high precision instruments for analysis.	9	10	4,15
CO2	Characterize the samples through the use of pollution indicators and report the results.	9	10	4,15
CO3	Comprehend the use of instruments in projects.	9	10	4,15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report.		8, 10	9

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3				2	1.5	2					3

Prerequisites: Instrumental method of analysis
Pollution Control theory.

List of Experiments:

1. Analysis of effluents for pH, alkalinity and turbidity
2. Determination of COD and BOD
3. Volatile, Fixed, Filterable and Dissolved solid analysis
4. Analysis by ion selective electrode (any two anions)
5. Measurements of particulate matter in Air
6. Analysis of exhaust by Orsat Apparatus.
7. Dissolved Oxygen Measurement
8. KF Auto Titrator
9. Flame Photometer
10. Turbidometer
11. Viscometer
12. mV Titrator

Note: Atleast 10 experiments to be conducted

Reference Books

1. C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2. Metcalf and Eddy - "Waste Water Engineering Treatment Disposal Reuse" 4/e, Tata McGraw Hill, 2003.
3. Jaffery, G.H., Basset, J., et. al., " Vogel's Text book of Quantitative Inorganic Analysis" 5/e, ELBX, 1998
4. Skoog, D.A., "Principles of Instrumental Analysis" 3/e, Saunders College publishing 1985.

15UCHE506	Process Instrumentation	(4-0-0)4: 52 Hrs.

Course Learning Objectives:

1. To make students understand the Identification, classification construction, working principle and application of various transducers used for Displacement, Temperature, Level, flow and Miscellaneous measurement.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Comprehend the fundamentals of instrumentation to control chemical processes.	3	1,13	
CO2	Explain process control instrumentation with principles and theory	3,13	1	
CO3	Apply correct practice to installation, calibration of instrument and analyze limitations of each measuring instruments.	1,13	3	
CO4	Troubleshoot, isolate and fix electronic instrumentation problems.		1,3,13	
CO5	Design a simple instrumentation system.	13	1	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.8	1.8											1.4		

Prerequisites: Nil

Course content:

1. **Introduction:** classification, characteristics of instruments- static and dynamic. Sensor and Transducer: Definition, classification (active, passive, primary, secondary, mechanical, electrical, analog, digital).Transducer specifications. Transmitters, Converters, Control panel, Recorders and monitors. Error: definition, classification. **5 Hrs.**
2. **Flow Measurement:** Head Type: orifice, venturi, nozzle, pitot tube. Variable Area Type: Rotameter type. Other flow meters: Turbine, electromagnetic, ultrasonic, positive displacement, anemometers, solid flow measurements. **7Hrs.**
3. **Pressure Measurement:** Pressure scales, units and relations, classification, U-tube types, well type, inclined type manometer, micro manometer, bellows, diaphragm, bourdon tube,. Vacuum Measurement

Units and relations, McLeod gauge, Pirani gauge, thermocouple gauge, hot cathode ionization gauge, Knudsen gauge. **5 Hrs.**

4. **Level Measurement:** Need for Level Measurement, Classification of Level Measurement Techniques. Construction and working of Dipstick, displacer, float system, bubbler, capacitive devices for level measurement, ultrasonic level gauge, DP cell, vibrating type, radar, radioactive type level gauges, LASER type transducers, fiber optic level sensors. **6 Hrs.**
5. **Temperature Measurement:** Temperature scales, classification of Temperature Sensors, a) Thermometers: Classification, Construction and working of glass thermometers, liquid expansion thermometer, gas thermometer (filled system thermometer), bimetallic thermometer, Specifications. b)Resistance temperature detector (RTD):Principle, types, Configurations, construction and working of RTD, Material for RTD, Lead wire Compensation in RTD, Specifications, advantages, disadvantages and applications of RTD. c) Thermistors: Principle, types (NTC and PTC), characteristics, Construction and working, materials, specifications of Thermistor, applications. **10 Hrs.**
6. **Thermocouples:** Principle, thermoelectric effect, See beck effect, Peltier effect, laws of thermocouple, types of thermocouple with characteristic curve, thermocouple table, Sensitivity, constructional features of Thermocouples, Thermo couple specifications, cold junction Compensation method, thermopile, thermocouple emf measurement method, Thermo well. Pyrometers: Principle, Construction and working of Radiation and optical pyrometers and its Applications. **6 Hrs.**
7. **Displacement Measurement:** a) Resistance potentiometer: piezo-resistive effect, ultrasonic transducer. LVDT, RVDT. Selection and properties of materials for LVDT, and general electromagnetic sensors. b) Capacitance type transducers: with applications, materials for capacitive, ultrasonic and elastic transducers. c) Digital transducer: translational and rotary encoders, Optical and magnetic pickups. d) Pneumatic transducer: flapper- nozzle transducer. **6 Hrs.**
8. **Miscellaneous Transducers:** Transducers for Position, speed, acceleration, humidity, and moisture measurement. Electronic measuring instruments, Electronic voltmeters, Principle of A/D and D/A converters. **7 Hrs.**

Reference Books:

1. Donald Eckman, "Automatic Process Control", Wiley Eastern Limited
2. John P. Bentley, "Principles of Measurement Systems", 3/e, Addison Wesley Longman Ltd., UK, 2000.

3. Doebelin E.O, "Measurement Systems - Application and Design", 4/e, McGraw-Hill International Edition, New York, 1992.
4. Stephanopoulos George, "Chemical Process Control".

15UCHE507 Energy Technology and Management (4-0-0) 4: 52 Hrs.

Course Learning Objective:

1. Understand the utilization of conventional and non – conventional energy sources and the principle of working of related equipments.
2. Recognize the effects of current energy systems on the environment and society.
3. Study energy costs/waste minimization without affecting production and quality.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and comprehend the effects of current energy systems based on solid and gaseous fuels.	3	2,13	1
CO2	Analyze the principles and concepts involved in non – conventional energy sources such as solar, geothermal, wind, biomass, ocean and tidal energy.	3, 14	2, 13	1
CO3	Describe the challenges and problems associated with solar, geothermal, wind, biomass, ocean and tidal energy sources with regards to future energy supply and environmental concern.	1	2,13	3, 14
CO4	Discuss the principles and need of energy audit and management programs.		2,13	1

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.5	2	1.7										2	2	

Prerequisites: Nil

Course Content:

1. **Introduction to Energy sources:** World energy futures, Indian energy scenario, Conventional and non-conventional energy sources.
   Fuels: Classification, properties and tests and analysis of solid, liquid and gaseous fuels. **6 Hrs.**
2. **Solar Energy:** Solar constant, Solar radiation at earth's surface, Solar radiation geometry, Solar radiation measurement. Solar water heating, space cooling, Solar distillation, pumping and Solar cooking- Basic principles, methods, applications, advantages and limitations. **10 Hrs.**
3. **Wind Energy:** Introduction, Basic components of WECS (wind energy conversion system). Classification of WEC Systems. Types of wind energy machines- (wind energy collectors) horizontal axis, vertical axis machines.
   6 Hrs.
4. **Bio – Energy (Thermal Conversion):** Introduction, Biomass conversion technology, Wet and Dry process,Factors affecting Bio digestion or Generation of gases, Classification of Bio gas plants, Floating Drum, Fixed Dome plants -Basic principles, Construction and Working principles, Advantages and disadvantages, Thermal gasification of biomass. Classification of Bio gasifiers. **10 Hrs.**
5. **Fuel cells**: Design and Principle of operation, Classification, Types, Advantages and disadvantages, Conversion efficiency, Types of electrodes, Work output and EMF of Fuel Cells, Applications of Fuel Cells.
   6Hrs.
6. **Geothermal and ocean energy:** Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India.
   Ocean Energy: Principle of working, performance and limitations of Wave Tidal Energy. Ocean Thermal Energy-Availability, theory and working principle, performance and limitations. **8 Hrs.**
7. **Energy management:** Principles and needs initiating and managing an energy management programs, Energy Audit – Elements and concepts, Types of Energy Audits, Energy Audit of any one chemical industries. **6 Hrs.**

Reference Books:

1. G.D. Rai, "Non-Conventional Energy Sources", 4/e Second Reprint, Khanna Publications", 1997.
2. P.C. Jain and M. Jain, "Engineering Chemistry", 10/e, 3rd Reprint, Dhanpat Rai and Sons, 1995.

3. S.P. Sukhatme, “Solar Energy”, 2/e, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.
4. G.D. Rai, “Solar Energy Utilization”, 4/e, Khanna Publications.
5. G.N.Tiwari and M.K.Ghosal, “Renewable Energy Resource: Basic Principles and Applications”, Narosa Publishing House, 2004.

15UCHE508	Solution Thermodynamics	(4-0-0) 4: 52 Hrs.

Course Learning Objectives:

1. To calculate thermodynamic properties of fluids and fluid mixtures using equations of state.
2. To determine the equilibrium compositions of chemical reactions and two-phase Liquid /vapor mixtures.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Classify thermodynamic properties of pure fluids and derive equations which relate them to non measurables.			1,2,3,13
CO2	Differentiate between ideal and non- ideal solutions and calculate the partial molar properties.			1,2,3,13
CO3	Generate VLE data for solution using various correlations and interpret their consistency.		4	1,2,3,13
CO4	Determine the conversion at equilibrium and predict the effect of controllable variables on conversion.		4	1,2,3,13
CO5	Explain the important refrigeration cycles and list the properties of refrigerants.	3,13,15		1,2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	3	2.6	2									2.6		1

Prerequisites: Chemical Engineering Thermodynamics

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Course Content:

1. **Thermodynamic Properties of Pure Liquids:** Reference Properties, Energy properties, Derived properties, Work function, Gibbs free energy, Relationships among thermodynamic Properties: Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, Modified equations for U and H, Effect of temperature on U, H and S, Relationships between C_p and C_v, Gibbs-Helmholtz equation, Fugacity: Fugacity, Fugacity coefficient, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: effect of temperature and pressure, Thermodynamic diagrams. **10 Hrs**.
2. **Properties of Solutions:** Partial molar properties, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, Activity and Activity coefficients, Gibbs-Duhem equation, Property changes of mixing, excess properties. **10 Hrs.**
3. **Phase Equilibria:** Criteria of phase Equilibria, and stability, Duhem's theorem, Vapor-Liquid Equilibria, ideal and nonideal solutions, Consistency test for VLE data, Calculation of Activity coefficients using Gibbs-Duhem equation, Liquid-Liquid Equilibrium diagrams. **10 Hrs.**
4. **Chemical Reaction Equilibrium:** Reaction stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant-temperature and pressure effect, standard free energy change, factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous reaction Equilibria, phase rule. **12 Hrs.**
5. **Refrigeration:** Carnot Refrigerator, Vapor compression cycle, choice of refrigerants. **10 Hrs**.

Reference Books:

1. Smith J.M and Vanness H.C. and Abbot, "Introduction to Chemical Engineering Thermodynamics", 5/e & 6/e, McGraw Hill, New York, 1996.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" New Age International Publication, Nagpur, 2000.
3. Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.

15UCHE509	Food Technology	(4-0-0) 4: 52 Hrs.

Course Learning Objective

1. To understand the basic principles of Food Science and Technology and applying this understanding to the growing and dynamic needs of the Food Industries.
2. To study the application of unit operations and modern trends in food processing industries.

Course Out comes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Understand the quality attributes and the chemistry of food	2		14
CO2	Apply unit operations and modern techniques for food processing	1	5	3
CO3	Identify and analyse the different food preservative, enzymes and additives required	14	2	6,7
CO4	Assess the impact of environmental concern and food safety	14	8	6, 7

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	1.5	3		2	3	3							1.6	

Prerequisites: Nil

Course Content:

1. **Introduction and Quality Attributes of Food:** Function of foods. Food in relation to health. Aim of food science and technology. Quality attributes – Appearance factors, Textural factors, Flavour factors. Visual and objectively measurable attributes. Aroma of foods –introductory ideas, formation, chemistry and analysis. Taste – introductory ideas, formation and chemistry. Additional quality; quality standards, quality control. Introduction to sensory evaluation of foods and beverages. **6 Hrs**
2. **Formation and Chemistry of Food:** Carbohydrates. Proteins. Lipids. Vitamins. Minerals. Water. Biotin. Choline. Phytochemicals. **4 Hrs**
3. **Food Processing and Preservation:** Food deterioration – Causes. Aims and objectives of preservation and processing. Unit operations in processing. Different methods of food preservation – low temperature, high temperature, preservatives, osmotic pressure, dehydrations. Food irradiation; processing and preservations of milk and dairy, vegetables and fruits, cereals, legumes and nuts, meat and meat products, fats and oils, beverages, sugars, sweeteners, honey and confectionary, salt and spices. **8 Hrs**
4. **Enzymatic and Non-Enzymztic reactions during storages:** Introduction to enzymes. Nature and function of enzymes. Classification of enzymes. Hydrolases – Esteraus, amylases, pectic enzymes. Proteases. Oxidoreductases – phenolases, glucose oxidase, catalose, peroxidase,

lipoxygenase, xantine oxidase. Immobilized enzymes. Uses and suggested uses of enzyme in food processing. Non-enzymatic reactions. **8 Hrs**

5. **Food Additives:** Introduction and need for food additives. Types of additives –antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and antichoking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety. **9 Hrs**
6. **Food Contamination and Adultration:** Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. **9 Hrs**
7. **Environmental Concerns and Food Safety:** Water in food production. Properties and requirements of processing water. Environmental concerns – solid waste disposal, waste water properties, wastewater treatment. Safety hazards and risks. Food related hazards. Processing and handling. Cleaning and sanitizing. **4 Hrs**
8. **Modern Trends in Food Science:** Biotechnology in food. Biofortification. Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition label in. Careers in food science and food industries. **4 Hrs**

Reference Books:

1. N. Shakuntala Manay and M. Shadaksharamurthy, “Foods (facts and principles)”, 3/e, New Age International, 2016.
2. Heid, J.L. and Joslyn, M.A., Fundamentals of Food Processing Operation, The AVI Publishing Co., Westport, 1967.
3. Heldman, D.R., Food Process Engineering, The AVI Publishing Co., Westport, 1975.
4. Hall, C.W., Farall, A.W. and Rippen, A.L., Encyclopedia of Food Engineering, Van Nostrand, Reinhold, 1972.

15UCHE510	Fertilizer Technology	(4-0-0) 4 : 52 Hrs.

Course Learning Objective:

1. It is needed to provide comprehensive and balanced understanding of essential link between chemistry and the synthetic fertilizer industry. It is therefore vital for chemical engineers to understand the fertilizer production and technology.
2. To study the different reaction and separation steps of the different fertilizers and application of unit operations in fertilizer industries.

Course Out comes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Use reactions and unit operations steps in manufacturing of various fertilizers	1	2	13
CO2	Characterize fertilizers on the basis of different properties		3	14
CO3	Identify engineering problems in fertilizer manufacturing	3	13	6,7
CO4	Handle the fertilizers	7,8	14	
CO5	Select appropriate synthesis fertilizer	7,8		14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	1.5			3	1.6	1						3	

Prerequisites: Nil

Course Content:

1. **Overview of Fertilizer:** Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crop. Development of fertilizer industry; Fertilizer production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers. **8 Hrs**
2. **Nitrogenous Fertilizers:** Introduction to Ammonia: Physical &chemical properties, applications, Synthesis gas by Catalytic partial oxidation Steam Hydrocarbon reforming, Ammonia converters: Design aspect of Single bed and multi-bed converter, Kellogg process and Haldor Topsoe process, Storage and Transportation of Ammonia. Introduction to Nitric acid: Chemical, physical properties and applications, Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process, Concentration of Nitric acid by $Mg(NO_3)_2$. Physical, chemical properties of Urea. Manufacturing of Urea by Stamicarbon's CO2 stripping process, Montecatini Solution recycle process Toyo-Koatsu total recycle process **16 Hrs**
3. **Phosphate Fertilizers:** Physical, chemical properties and applications of Phosphorus and Phosphoric acid. Manufacturing of elemental phosphorous by Electric furnace method. Manufacturing phosphoric acid by Wet Process. Strong Sulphuric Acid Leaching Hydrochloric Acid Leaching Electric Furnace Process. **08 Hrs**

4. **Potassium Fertilizers:** Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate, Manufacturing of potassium chloride from sylvinite, Preparation of Potassium nitrate, Potassium sulphate. **10 Hrs**
5. **Miscellaneous Fertilizer and Bio Fertilizers:** Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate(CAN), Biofertilizers, Types of Biofertilizers, Nitrogen fixing biofertilizers, Phosphate-solubilizing biofertilizers, Preparation of a biofertilizers. **10 Hrs**

Reference Books:

1. Collings, G.H., "Commercial Fertilizers", 5/e, Mcgraw Hill, New York, 1955.
2. Editorial board, "Handbook of Fertilizer Technology", The Fertilizer Association of India, New Delhi, 1977.
3. Slacks, A.V., "Chemistry and Technology of Fertilizers", Interscience, New York, 1966.

VI Semester B.E.

15UCHC600 Management, Entrepreneurship and Protection of Intellectual Property Rights (4–0–0)4: 52 Hrs.

Course Learning Objectives:

1. To understand the development and function of management, the concept of entrepreneurship, intellectual property rights and legal issues.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain historical development of management and Engineering; Defend the synthesis of Engineering and Management.	6		
CO2	Explain the five functions of management in modern organization structures.		9, 10	7, 8
CO3	Explain foundation of entrepreneurship, role of entrepreneurs in economic development.		9, 10	7, 8
CO4	Asses impact of liberalization, privatization and globalization on small scale industries.		9, 10	7, 8
CO5	Identify Institutional support to small scale industries and prepare project report and its feasibility studies.		9, 10, 14	8, 11
CO6	Explain forms of intellectual property rights and procedure for registration, infringements and penalties.		5, 6	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level					2	1.5	3	3	2	2	3			2.5	

Prerequisites: Nil

Course Content:

Management:

1. **Introduction:** Development and evolution of management thoughts, Modern management approaches, Scope and characteristics of

management, tools of management, management and administration, levels of management, principles of management, roles of management **4 Hrs.**

2. **Planning:** Nature and importance of planning, types of planning, steps of planning, essential of planning, planning process, planning tools and techniques. **5Hrs.**
3. **Organizing and staffing:** Steps and nature of organizing, organization structure, purpose of organization, types and principles of organization, Departmentation, span of control, authority, power and responsibility, delegation, centralization and decentralization, management by objectives, nature and importance staffing, recruitment and selection. **5Hrs.**
4. **Directing and controlling:** Nature of direction, principles of direction, leadership and styles, motivation, communication, types and forms of communication, coordination and cooperation, managerial control, steps in control process, control methods. **4Hrs**

Entrepreneurship:

1. **Entrepreneurship:** Evolution and Meaning of entrepreneur, characteristics of entrepreneur, entrepreneur and manager, functions and types of entrepreneur, Intrapreneur, role of entrepreneurship in economic development, barriers of entrepreneurship. **5 Hrs.**
2. **Small Scale Industry:** Definition, characteristics, objects, role of SSI in economic development, advantages of SSI, steps to start a SSI, impact of liberalization, privatization, and globalization on SSI, impact of WTO/GATT on SSI, definition of ancillary and tiny industry. **5 Hrs.**
3. **Institutional Support:** Nature of support of government, objectives and functions of NSIC, SIDO, SISI, SSIB, SSIDC, SIDBI, DIC, KIADB, KSSIDC, KSFC. **4 Hrs.**
4. **Preparation of Project:** Meaning of project identification, project report, contents and formulation, identification of business opportunities, feasibility studies, types and purpose **4 Hrs.**

Protection of Intellectual Property:

1. Introduction: Meaning and forms of intellectual property right, competing rationale for protection, international conventions, world court. **3 Hrs.**
2. Copyright: Meaning of copyright, content of copy right, ownership and rights, period of copyright, assignment and relinquishment of copyright, license, infringement of copy right, fair use, offenses and penalties. **4 Hrs.**
3. Patents: Concept of patent, patentable inventions, procedure for obtaining patent, rights and obligations of patent holders, infringements and remedies, offenses and penalties. **4Hrs.**

4. Industrial Designs and Trademarks: Definition of design, procedure for registration, rights conferred by registration, infringements. Concept of trademarks, procedure of registration, duration and fees of trademark.

5Hrs.

Reference Books:

1. Thomas W. Zimmerer, “Essentials of Entrepreneurship”, PHI, 2005.

2. Veerabhadrappa Havinal, “Management and Entrepreneurship”, 1/e, ISBN (13): 978-81-224-2659-5, New Age International, 2009.

3. Peter Drucker, “The Practice of Management”, ISBN-10: 0060878975 Harper Business Reissue edition, 2006

4. N.K. Acharya, “Text book on Intellectual Property Rights”, 4/e, Asia Law House.

15UCHC601	**Chemical Process Integration**	**(4-0-0) 4 : 52 Hrs.**

Course Learning Objectives:

1. To teach students basic principles and methodologies for energy, mass and material integration for sustainable process synthesis and design.
2. It helps in understanding the usage of material, Heat and Mass effectively for the profit of Industry using pinch analysis.
3. It helps in formulating the design and optimizing the process in plant for the integrated approach.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and explain the importance of process integration.	14	3	6,7
CO2	Evaluate and analyze the direct recycle strategy through material balance, graphical and algebraic approach.	1	2,3	13
CO3	Predict and evaluate the visualization strategies of mass integrated system through graphical and algebraic approach	1	2,3	13
CO4	Illustrate and develop heat exchange network by pinch diagram with screening of exchangers along with combined heat and power integration	1	2,3	13
CO5	Formulate and optimize the different process integration networks	1,2		5,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	2		3	3	3						3	1	

Prerequisites: Nil

Course Content:

1. **Introduction to Process Integration:** Categories of process integration. Mass targeting for minimum discharge of waste and minimum purchase of fresh utilities. **6 Hrs.**
2. **Direct recycle strategies.** Source-Sink mapping diagram, Multicomponent source sink mapping. Graphical and algebraic approach for direct recycle strategies. Property based pinch diagram. **14 Hrs.**
3. **Heat Integration**. Design and synthesis of heat exchange network (HENs). Heat exchange pinch diagram and algebraic approach for pinch point. Grand composite curves (GCC). Combined heat and power integration (Heat Pumps and Engines). Cogeneration process targeting. **14 Hrs.**
4. **Mass Integration**. Synthesis of mass exchange network (MEN). Design and cost optimization of mass exchangers. Visualization strategies for the development of mass integrated system. Algebraic and graphical approach to targeting mass exchange (Mass Integration) **12 Hrs.**
5. **Optimization.** Overview of optimization, classification and formulation of optimization programs. Different methods of optimization programming. Approach for direct recycle and synthesis of mass and heat exchange network using a programming language. **6 Hrs.**

Reference Books:

1. Mahmoud Halwagi, "Process Integration", 1/e, Elsevier, 2006.
2. I. C. Kemp, "Pinch analysis and process Integration" 2/e, Butterworth, 2006.
3. Robin smith, "Chemical Process Design and Integration", 1/e, Wiley, 2005

15UCHC602 Process Equipment Design and Drawing (3-0-2)4: 52 Hrs.

Course Learning Objectives:

1. To develop key concepts and techniques to design process equipment in a process plant.
2. To expose students to the practices followed in the design of chemical equipment's and their drawing.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Congregate and analyze the data from the hand book, code book and literature.			1, 2
CO2	Design and evaluate the heat transfer equipment: DPHE, STHE condenser.	1	2	3, 13
CO3	Design and evaluate mass transfer equipment: Distillation column and absorption tower.	1	2	3, 13
CO4	Design and evaluate the simultaneous heat and mass transfer equipment: calendria evaporator and rotary dryer.	1	2	3,13
CO5	Draw the equipment as per the design.			3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2.25	3										3		

Prerequisites: Process Heat Transfer, Chemical Engineering Drawing, Mass Transfer I and II

Course Content:

- Detailed Chemical Engineering Process Design of the following equipment.
- Necessary aspects studied in “Chemical Equipment Design” is to be applied for mechanical design.
- Use of standard code books to be taught.
- The detailed dimensional drawings shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template.

NOTE:

1. The question paper to contain two full design problems (100 Marks each) for the equipment from the above list and student to answer any **One.**
2. Perry’s Chemical Engineer’s Handbook shall be allowed in the examination as reference. IS Code 4503 for Heat Exchangers (if required) shall be permitted.

3. The answer shall include detailed process design steps using the data given in the problem, mechanical design for component dimensions and drawing (Sectional Front View, Top/Side View and major Component Drawings with Part Template).

1. Double Pipe Heat Exchanger
2. Shell and Tube Heat Exchanger.
3. Condenser
4. Distillation Column.
5. Evaporator
6. Absorption Column.
7. Rotary Dryer.

Reference Books:

1. R. H. Perry and D. W. Green “Chemical Engg Hand Book”, 6/e, McGraw Hill, 1998.
2. Donald Q. Kern, "Process Heat Transfer”, McGraw Hill, 1997.
3. Robert E. Treybal, "Mass Transfer Operations", 3/e, McGraw Hill, 1981.
4. J. M. Coulson & J. F. Richardson, "Chemical Engineering", Vol. 6 Pergamon Press, 1993.

15UCHL603	**Mass Transfer Laboratory**	**(0-0-3)1.5**

Course Learning Objectives:

1. To provide an understanding of extending the theory into practice through various experiments related to diffusion, both molecular and convective; transfer coefficients and other diffusion based separation processes.
2. To analyze experimental data from the experiment conducted and present a good technical report, thereby demonstrating skills in communication through mandatory oral presentations.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Evaluate Rayleigh’s equation, vaporization and thermal efficiencies using distillation principles.	9	10	4, 15

CO2	Estimate the percentage recovery for types of Extraction equipments.	9	10	4, 15
CO3	Calculate the Diffusion coefficient for Diffusion of organic vapour experiment.	9	10	4, 15
CO4	Explain the temperature dependency on ternary phase diagram.	9	10	4, 15
CO5	Evaluate Freundlich equation using adsorption principles	9	10	4, 15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3.0					1.0	2.0					3.0

Prerequisites: Mass Transfer I and II

List of Experiments:

1. Diffusion of organic vapors in Air
2. Steam distillation
3. Distillation - Simple (Differential) distillation
4. Solid - liquid leaching
5. Surface evaporation
6. Adsorption studies
7. Liquid - Liquid / Vapor - Liquid equilibrium
8. Liquid extraction - (Cross current: single and 2 or 3 Stage)
9. Wetted wall column
10. Cooling tower
11. Solid dissolution

Note: Atleast 10 experiments to be conducted.

Reference Books:

1. Robert E. Treybal, “Mass Transfer Operation” 3/e, Mc Graw Hill.
2. Coulson and Richardson, “Chemical Eng Vol. 1 and Vol. 2”, 4/e.
3. Geankoplis C.J, “Transport Processes and Unit Operations”, 3/e,Prentice Hall (I).
4. Mc Cabe and J.M.Smith, “Unit Operations in Chemical Engineering”, 7/e Mc Graw Hill.

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15UCHL604 Chemical Reaction Engineering Laboratory (0-0-3)1.5

Course Learning Objectives:

1. To study the reaction kinetics for lab scale reactors by applying the knowledge of chemistry and engineering into practice.
2. To analyze and interpret the experimental data to find the rate law and project in the form of a report and oral presentation.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Determine the kinetics of the reaction for batch, semi batch and flow reactors	9	10	4, 15
CO2	Evaluate the activation energy of the reaction	9	10	4, 15
CO3	Characterize the non ideal behavior in the reactors	9	10	4, 15
CO4	Analyse and interpret the data for reactor design	9	10	4, 15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12 .	PO13	PO14	PO15
Mapping Level				3				2	1.2	2.2					3

Prerequisites: Chemical Reaction Engineering I and II.

List of Experiments

1. Batch Reactor
2. Isothermal plug flow reactor
3. Semi Batch Reactor
4. Mixed flow reactor
5. Heterogeneous catalytic reactor
6. Segregated flow reactor
7. Adiabatic reactor
8. Packed Bed Reactor
9. RTD Studies in Tubular reactor

10. Effect of temperature on Rate of reaction
11. RTD Studies in mixed flow reactor
12. CSTRs in series
13. RTD studies on spouted bed reactor

Note: Atleast 10 experiments to be conducted

Books

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley and Sons, 1999.
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, Mc Graw Hill, 1984.

15UCHL605	**Mini Project**	**(0-0-8) 4**

Course Learning Objectives:

1. To carry out the experimental/design tasks of relatively minor intensity and scope as compared to the major project and in line with the guidelines formulated by the DUGC.
2. To see that this project could be a prologue for the upcoming major projects in the final year.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify the topic of chemical engineering or integrated problems (allied fields).	7, 14	8, 12	2,10
CO2	Compare the literature review and select suitable materials and methodologies for selected topic.	7, 10,14	8,11,12	3,4,5,15
CO3	Plan and carry out the experimental work and economic analysis.	9	8,10,12	11,15
CO4	Prepare a precise report on the work done with proper guidelines and references.	9	8,15	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3.0	3.0	3.0	3.0		1.0	2.0	1.0	2.2	2.5	2.0		1.0	2.6

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VI semester. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VI semester. After getting the approval from DUGC, the project work should be carried out in VI semester. The project report should be submitted along with the presentation on the work carried out at the end of VI semester

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field.

15UCHE606	Petroleum and Petrochemicals	(4-0-0)4 : 52 Hrs.

Course Learning Objective:
1. Studying this subject the students will learn about the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline the Indian petroleum industry and world scenario	6		
CO2	Apply the basic procedure and role of all fundamental system used in petroleum and petrochemical industry		15	1
CO3	Identify and characterize the different products of hydrocarbon	3, 14	2	15

CO4	Analyze the measuring parameters to be measured according to the operational conditions	13	1	4
CO5	Analyze the key issues in the design and optimization of petroleum and petrochemical production system	1‘	2, 13, 15	3
CO6	Apply critical thinking and problem solving approaches towards the principles of petroleum and petrochemical engineering	1, 13	2, 12	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.75	2	2	3		1						2	1.33	2	2.33

Prerequisites: Nil

Course Content:

1. **Indian Petroleum Industry:** prospects & future, major companies, world production, markets, offshore & onshore, oil well technology. **4 Hrs.**
2. **Petroleum crude characterization**: Composition and classification, UOP K factor, TBP analysis, EFV Analysis, Average Boiling points, ASTM Curves, Thermal properties, Pour Point. **4 Hrs.**
3. **Product properties and test methods:** Characterization -Flash point, Fire point, Reid vapor pressure Analysis, Octane Numbers, Cetane Index, smoke point, Burning quality, Carbon Residue, Viscosity Index, Softening point, Penetration Index, Oxidation Stability, Volatility, Aniline point, Pour point . Various Petroleum products & Additives for Naphtha, Gasoline, Gas, ATF, LPG, Kerosene, Diesel, Lubricating oils, Bitumen. **12 Hrs.**
4. **Crude pretreatment**: Pumping, dehydration, comparison, petroleum furnaces and comparison, Refining of petroleum – Atmospheric and vacuum distillation. **6 Hrs.**
5. **Treatment techniques**: Removal of sulphur compounds, storage and stability, product treatment using solvent, dewaxing, clay treatment and hydro refining. **5 Hrs.**
6. **Thermal cracking:** Visbreaking, Coking, Catalytic cracking (FCC), Hydro cracking, Air blowing of bitumen. Catalytic reforming, Extraction of Aromatics. **5 Hrs.**
7. **Petrochemicals:** Definition, importance and growth potential of the field, raw materials for petrochemical industries, sources, economics and advantages. Production of petrochemicals like dimethyl terephathalate (DMT), ethylene glycol, synthetic glycerin, LAB, acrylonitrile, methyl methacrylate (MMA), phthalic

anhydride, maleic anhydride, phenol acetone, formaldehyde, production of carbon black. **14 Hrs.**

Reference Books:

1. B.K. Bhaskar Rao, “Modern Petroleum Processes”, 3/e, Oxford IBH publisher.
2. Ram Prasad , “Petroleum Refining Technology”, Khanna Publishers, 2000.
3. W.L. Nelson, “Petroleum Refinery Engineering” 4/e, McGraw Hill, 1985.
4. B.K.Bhaskar Rao, “A text book on petrochemicals” 1/e, Khanna Publishers, New Delhi, 1987.

15UCHE607	**Catalyst Technology**	**(4-0-0)4 : 52 Hrs.**

Course Learning Objectives:

1. To under stand controlling mechanisms in solid catalyzed reactions, characterization of catalyst properties and is preparation.
2. To provide catalytic reactor design concepts involving solid catalyzed reaction and catalyst deactivation.

Course Outcomes:

COs	Description: At the end of the course student will be able to	**Mapping to POs and PSOs**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain the various methods to estimate properties of given catalyst and its preparation. List controlling mechanisms and formulate rate expressions.		1,2	
CO2	Formulate performance equations for reactors containing porous catalyst and apply the same for reactor design.		1,14	2,3
CO3	Explain various causes and mechanisms of catalyst deactivation and experimental methods to determine catalyst deactivation kinetics.		1,2,15	

POs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mapping Level	2	2.3	3											2	2

Prerequisites: Nil

Course Contents:

1. **Fundamentals of catalytic phenomena:** Brief history of catalyst technology development and its economic importance. Various controlling mechanisms involved in solid catalyzed reactions, overall rate expressions. **10 Hrs.**
2. **Catalyst materials and properties:** Makeup of a typical heterogeneous catalyst and their functions. Molecular sieves and zeolites. Physical, Chemical, Dynamic and Mechanical properties of solid catalyst and their characterization. **10 Hrs.**
3. **Catalyst preparation and forming:** Various catalyst preparation methods and equipmentsused, catalyst activation and forming**.** **8hrs.**
4. **Reactor design**: Basic approaches toreactor design, performance equations, collection of data form laboratory reactors, experimental methods to find rate equations and reactor design. **12 Hrs**.
5. **Catalyst deactivation:**Causes and mechanisms of catalyst deactivation, prevention and regeneration. Experimental methods to find rate of deactivation, design and operation strategies with deactivating catalysts. **12 Hrs.**

Reference Books:

1. Prof. I.P. Mukhlyonov, " Catalyst Technology", MIR Publishers.
2. R.P. Farrauto and C.H. Bartholomew, "Fundamentals of Industrial Catalytic Processes".
3. Hamid Al-Mergen and Tian Cum Xiao, " Petrochemical Catalyst Materials, Processes and Emerging Technologies", IGI Global Series Book, 2016, ISBN:97814666699755.

15UCHE608	Applied Mathematics in Chemical Engineering	(4-0-0) 4:52 Hrs.

Course Learning Objective:

1. To understand the Computational techniques and use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand calculations for application in Chemical Engineering.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and apply mathematical methods to solve chemical engineering problems	3	2	1
CO2	Evaluate and analyse different chemical engineering problems using different mathematical techniques		2	3, 13
CO3	Interpret and develop the relationship in chemical engineering using different techniques		2	3, 13
CO4	Formulate and optimize with different methods to solve chemical engineering problems unit operation and process.	1	2	3, 5, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2	2.5		3								3		

1. **Computation and Error Analysis:** Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation. Linear Systems and Equations Matrix representation, Calculation of Eigen Values and Eigen vectors, Solution by Cramer's rule; Iterative Method-- Jacobi iteration; Gauss-Seidel Method, Chemical Engineering Examples: Material and energy balance problems involving at least 3 simultaneous equations Non-linear Algebraic Equations (single and multivariable) Secant, Multivariate Newtons method Chemical Engineering Examples: Equation of state (van der Waals, Beattie-Bridgeman, etc.), Friction factor equation etc. **14 Hrs**
2. **Regression and Interpolation:** Polynomial regression, Newtons Difference Formulae, Cubic Splines Chemical Engineering Examples: Free settling velocity of particles, Arrhenius Equation, Specific heat w.r.to temperature etc. **8 Hrs**
3. **Numerical differentiation:** Numerical differentiation; higher order formulae. Integration and Integral Equations Two and Three point Gaussian quadrature formula Chemical Engineering Examples: Rayleighs equation, Rate equation. **8 Hrs**
4. **ODEs:** Initial Value Problems Runge – Kutta method for second order differential equations, Explicit Adams-Bashforth technique, Implicit Adams-Moulton technique, Predictor-Corrector technique. Stiffness of ODE‟s ODEs: Boundary Value Problems: Orthogonal Collocation, shooting techniques.

Chemical Engineering Examples: Rate equation, Steady-state material or energy balance equations etc. **10 Hrs**

5. **Solution of partial differential equations:** Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, implicit and explicit methods, Cranks Nicolson Method, Chemical Engineering Examples: unsteady-state one dimensional heat conduction. Use of Matlab with chemical engineering examples. **12 Hrs**

Reference Books

1. Gupta S.K , "Numerical Methods for Engineers", 3/e, ISBN : 978-81-224-3359-3, New Age International, 1995
2. Alkis Constantinides and Navid Mostoufi, "Numerical Methods for Chemical Engineers with MATLAB Applications", ISBN-10: 0130138517, Prentice Hall, 1999.
3. Steven Chapra and Raymond Canale, "Numerical Methods for Engineers.", 6/e, McGrew Hill Publication, 2010.
4. M. K. Jain, S. R. K. Iyengar, and R. K. Jain, "Numerical Methods", 6/e New Age International Publishers, New Delhi, 2012

15UCHE609 Polymer Science and Technology (4-0-0) 4: 52 Hrs.

Course Learning Objective:

1. To provide a broad and fundamental knowledge of the polymers and their chemical, physical and mechanical behavior.

Course Out comes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Classification, chemistry, kinetics, characteristics and types of polymers.	1	2	13
CO2	Comprehend polymer properties, their testing procedures and methods of polymerization.		1,4	15
CO3	Explain different polymer processing techniques.	1	3	15
CO4	Comprehend manufacturing processes and frontiers of polymers	2	1	15
CO5	Polymer recycling, challenges and engineering applications.	2	7	14

POs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14	PO 15
Mapping Level	1.5	1.3	2	2			2								

Prerequisites: Nil

Course Content:

1. **Polymer science:** Introduction, IUPAC names, Classification of polymers (source, occurrence, elemental composition, geometry and tacticity, stereo regularity), Definition of polymerization, characterization, Chain polymerization (free radical, ionic and co-ordination polymerizations), Step (condensation) polymerization, copolymerization. **6 Hrs.**
2. **Polymerization kinetics:** Definition of reaction rate, order, molecularity, kinetics of step reaction polymerization, kinetics of addition polymerization. **5 Hrs.**
3. **Methods of Polymerization*:*** Bulk, solution, Suspension, Emulsion, solid phase, gas phase polymerizations (formulation, mechanism, properties of the polymer produced, advantages and disadvantages). **8 Hrs.**
4. **Polymer properties:** Tensile strength, Impact strength, glass transition temperature, melting temperature, testing : sample preparation, testing standards & methods, analysis of polymer **6 Hrs.**
5. **Processing Technology:** Extrusion, Injection moulding, blow moulding Compression moulding, rotational moulding, thermoforming, Calendering, Compounding. **7 Hrs.**
6. **Polymer manufacturing:** Industrial production methods of PE, PP, PS, PVC, UF,PF, PU, Poly butadiene, Nylon 6 and Nylon 66. **8 Hrs.**
7. **Frontiers of polymer materials:** biodegradable polymers, biomedical polymers, conducting polymers, polymers for space. **5 Hrs.**
8. **Problems of polymer:** Thermoxidative degradation, fire hazards, toxicity, effluent disposal. **4 Hrs**.
9. **Recycle:** Recycle and Reuse of polymers. **3 Hrs.**

Reference Books:

1. R.J.Young and P.A.Lovell, “Introduction to polymers”, Chapman and Hall, London.
2. Fred W.Billmeyer, “Text book of Polymer Science”, J.R.John Wiley and Sons, New York.
3. F. Rodrignek, “Principles of Polymer Systems”, McGraw Hill, N.Y.
4. Gowarikar, “Polymer Science”, Wiley Eastern Ltd. New Delhi.

15UCHE610	Composite Materials	(4-0-0)4: 52 Hrs.

Course Learning Objective:

1. To understand the nature, properties, structure and processing of composite materials and their engineering applications.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Characterize and explain the different synthesis of advanced and future materials for industrial application		6	2,14
CO2	Analyse and compile the different techniques for preparing the materials	7	2	14
CO3	Compare and assess the different processing techniques for advanced materials	7	2	14
CO4	Distinguish between mechanical and chemical techniques for fabrication and synthesis of composite materials	7	2	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		2.25				2	1							3	

Prerequisites: Nil

Course Content:

1. **Synthesis and Fabrication of advanced and future material:** emphasis on ceramic, Semi-conducting and Super-conducting materials with superior structural, optical and electrical properties. **10 Hrs.**
2. **Techniques for preparation of ultra-pure, ultrafine powders:** of oxides, nitrides, carbides etc., with very well defined characteristics and superior properties. **12 Hrs.**
3. **Processing Techniques:** Sintering, hot pressing, hot isostatic pressing, tape-casting sol-gel processing for the formation of monolithic ceramics, composites (ceramic, ceramic metal, as well as metal matrix), SiO_2, Glasses from above powders. **10 Hrs.**
4. **Processing Techniques based on reaction methods:** Chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI),

self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibers and semi conducting materials such as Si and gallium arsenide. **12 Hrs.**

5. **Synthesis and processing**: mixed ceramic oxides with high temperature super conducting properties. Comparison of properties of such advanced materials with conventional materials such as metals and polymers. **8 Hrs.**

Reference Books:

1. W.D. Kingery "Introduction to Ceramics".
2. Chawla "Advanced Composites".
3. James.T.Schockel Ford, "Introduction to Material Science for Engg", McMillan publications.
4. L.H. Vanvlack, "Material Science and Engineering".

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- **To have contextually relevant curricula.**
- **To promote effective teaching learning practices supported by modern educational tools and techniques.**
- **To enhance research culture.**
- **To involve industrial expertise for connecting classroom content to real life situations.**
- **To inculcate ethics and impart soft skills leading to overall personality development**

SDMCET- Quality Policy

- ✣ **In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.**

SDMCET- Core Values

- **Competency**
- **Commitment**
- **Equity**
- **Team work and**
- **Trust**

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. By fostering research culture with ethics to disseminate knowledge..
3. By collaborating with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

I. Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.

II. Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.

III. Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.

IV. Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes and Program Specific outcomes

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for VII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC700	Process Dynamics and Control	4-0-0	4	50	100	3		
15UCHC701	Chemical Technology	4-0-0	4	50	100	3		
15UCHC702	Biochemical Engineering	3-0-0	3	50	100	3		
15UCHL703	Major Project-Phase 1	0-0-6	4	50			50	3
15UCHL704	Process Control Laboratory	0-0-3	1.5	50			50	3
15UCHL705	Computer Applications in Chemical Engineering and Simulation Laboratory	0-0-3	1.5	50			50	3
15UCHE70X	Elective – 5	4-0-0	4	50	100	3		
15UCHE70X	Elective – 6	4-0-0	4	50	100	3		
	Total	**19-0-12**	**26**					
15UCHE706	Pilot Plant and Scale up Methods	4-0-0	4	50	100	3		
15UCHE707	Transport Phenomena	4-0-0	4	50	100	3		
15UCHE708	Process Modeling and Simulation in Chemical Engineering	4-0-0	4	50	100	3		
15UCHE709	Novel Separation Techniques	4-0-0	4	50	100	3		
15UCHE710	Wastewater Treatment and Engineering	4-0-0	4	50	100	3		

Scheme for VIII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC801	Seminar	0-0-3	2	50				
15UCHC800	Process Engineering Economics and Management	4-0-0	4	50	100	3		
15UCHL802	Major Project- Phase 2	0-0-12	10	50			50	3
15UCHE80X	Elective – 7	4-0-0	4	50	100	3		
15UCHL80X	Elective – 8	4-0-0	4	50	100	3		
Total		**12-0-15**	**24**					
15UCHE803	Solid Waste Management	4-0-0	4	50	100	3		
15UCHE804	Instrumental Methods of Analysis*	4-0-0	4	50	100	3		
15UCHE805	Sugar Technology	4-0-0	4	50	100	3		
15UCHE806	Bioprocess Engineering	4-0-0	4	50	100	3		
15UCHE807	Unit Processes in Organic Synthesis*	4-0-0	4	50	100	3		

***** To be handled by the Chemistry department faculty

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CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical **S**: Self-study
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the Fourth year: 50 Hrs

VII Semester B.E.

15UCHC700 Process Dynamics and Control (4-0-0)4:52 Hrs.

Course Learning Objective:

1. The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Comprehend the fundamentals of process controls	13	1,10	
CO2	Derive transfer function models for dynamic processes and study the transient response characteristics.	2	3,4	
CO3	Predict the closed-loop behavior using block diagram and evaluate the stability of the system.	2	4,13	
CO4	Analyse the principles involved in selecting a control value and understand the interaction with other process components.	5	2,13	
CO5	Analyse controllers to achieve desired performance.	2	3,5,13	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	1.25	2	2	1.5					2			1.75		

Prerequisites: Nil

Course Content:

1. **Introduction:** Classification of variables, control configuration, classification of control systems. Laplace Transform, types of inputs- step, impulse, linear and sinusoidal **6 Hrs.**
2. **Process dynamics:** First order systems, transfer functions - mercury in glass thermometer, level, mixing tanks, stirred tank reactors, I order system in Series-interacting and non interacting systems, response equations, linearization of non-linear system. **12 Hrs.**
3. **Second order systems:** U-tube manometer, damped oscillator, response equations, terms of second order under damped system. **7 Hrs.**
4. **Block diagram:** Importance, reduction rules, steps, problems **6 Hrs.**

5. **Final control element:** control valves, types, actuators, positioners, valve plugs, characteristics. **5 Hrs.**
6. **Controllers:** Proportional, Proportional +Integral (P+I), Proportional + Integral + Derivative (P+I+D), On-Off controller, servo and regulator control system. **7 Hrs**
7. **Stability:** Stability of linear control system, Routh –Hurwitz, Root Locus methods. **9 Hrs.**

Reference Books:

1. Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.
3. Coulson and Richardson, "Chemical Engineering" Vol, III, 3/e, Pengeman Press.
4. George Stephanopoules, "Chemical Process Control" An Introduction to Theory and Practical, Prentice Hall, New Delhi, 1998.

15UCHC701	Chemical Technology	(4-0-0)4: 52 Hrs.

Course Learning Objectives:

1. To understand the industry protocols used in the manufacture of chemicals both inorganic and organic with the use of reference flow sheets.
2. Identify major engineering problems associated with manufacturing processes.
3. Overcoming bottlenecks and trouble shooting.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline the impetus of Chemical Industry globally	1	12	6,7
CO2	Apply the concepts of unit operations and processes, reaction kinetics, thermodynamics, stoichiometry, transport processes, materials engineering etc. and translate to develop a process flow sheet.	1,3,	9,10, 14	12,13

CO3	Describe the technology of manufacturing chemicals.	-	9, 12, 15	14
CO4	Prioritize trouble shooting to overcome the bottlenecks in a process and develop the technology within realistic constraints.	-	3, 6, 7	14, 15
CO5	Appraise of themselves as industry ready chemical engineers.	-	12	13,14,15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1		1.5			2.5	2.5		2	2		3	3	2.75	2.66

Prerequisites: Nil

Course content:

Introduction to Chemical Process Industries: Chemical Industry in this millennium

1. **Industrial and Fuel gases**: H_2, O_2, N_2, CO_2, Water gas, Producer gas. **6 Hrs.**
2. **Chlor-Alkali Industry**: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder **6 Hrs.**
3. **Acids:** Sulfuric, Nitric, Hydrochloric and Phosphoric acids. **6 Hrs.**
4. **Fertilizer Industry**: Ammonia, Urea, Ammonium Nitrate, Ammonium Sulfate, DAP, Potash fertilizers, Bio-fertilizers. **7 Hrs.**
5. **Phosphorous Industry**: Red and White phosphorous, Phosphorous pentoxide, Phosphate fertilizers, Super phosphate and Triple super phosphate. **7 Hrs.**
6. **Pulp and Paper Industry**: Raw materials, manufacture of pulp and paper, recovery of chemicals. **6 Hrs.**
7. **Fermentation & Distillery**: Manufacture of alcohol, beer, wine, vinegar. **6 Hrs.**
8. **Oils, Fats and Soaps Industry**: Manufacture of oils (vegetable and industrial) processing and refining, essential oils and uses, soaps, fatty acid purification and types. **6 Hrs.**

Reference Books:

1. George T Austin: Shreves, “Chemical Process Industries”, Mc Graw Hill International ltd.
2. Gopal Rao and Marshall, “Dryden’s Outlines of Chemical Technology”, East-West Press.
3. S.D. Shukla and G.N. Pandey, “Text book of Chemical Technology” Vol.1 and 2, Vikas Publishing House Pvt. Ltd. New Delhi.

4. S.C. Bhatia, "Chemical Process Industries", Vol.1 and 2, CBS Publishers, New Delhi

15UCHC702	Biochemical Engineering	(3-0-0) 3: 39 Hrs.

Course Learning Objectives:

1. To provide the forum to understand the principles and concepts of microbiology, cell biology and biochemistry and thereby apply chemical engineering principles to asses and evaluate the cell as a reactor.
2. To incorporate the principles of chemical engineering in understanding the upstream and downstream processing techniques in a biochemical industry.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline and identify the microorganisms in the context of industrial and environmental microbiology.	2	7	
CO2	Characterize and explain the chemicals of life with the properties and their derivate.		2, 14	
CO3	Interpret and evaluate the enzyme kinetic parameters with different effects of the reactors.	2	3	13
CO4	Explain the various configurations of bioreactors along with fermentation technology	2	3	13
CO5	Identify and explain the methods involved in product recovery and purification	2	3	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		1.2	2				2						3	2.5	

Prerequisites: Nil

Course content:

1. **Microbiology:** Scope, structure of cells: Prokaryotic and Eukaryotic, characterization and classification of microorganisms - Taxonomy and Whitaker's 5-Kingdom concept, environmental and industrial

microbiology, control of microorganisms. **4 Hrs.**

2. **Biochemistry:** Chemicals of life - Lipids, sugars and polysaccharides; amino acids, proteins and enzymes; vitamins, biopolymers, nucleic acids and their derivatives. **6 Hrs.**
3. **Enzyme catalyzed reactions:** Enzyme Nomenclature and classification, enzyme kinetics, Mechanism and kinetics of enzymatic reactions, evaluation of kinetic parameters, factors affecting enzyme activity, Inhibitors and inhibition kinetics, Industrial enzymes and applications, methods of immobilization of enzymes. **10 Hrs.**
4. **Biomass production in cell cultures:** Ideal reactors for kinetic measurements - batch and continuous reactors, Monod's growth kinetics, Transient growth kinetics, Cell growth and kinetic patterns, Reactors and their configurations. **10 Hrs.**
5. **Fermentation technology:** Ideal bioreactors, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations. **4 Hrs.**
6. **Downstream processing:** Steps involved in product recovery, operations involved - centrifugation, chromatography and emerging technologies including membrane separation techniques. **5 Hrs.**

Reference Books:

1. Jay Bailey, James Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill, 1986.
2. Michael L. Shuler and Fikret Kargi, "Bioprocess Engineering - Basic Concepts", 2/e, Prentice Hall of India (2003).
3. Michael J. Pelczar, E. C.S. Chan and Noel R. Krieg, "Microbiology Concepts and Applications", 5/e, McGraw Hill reprint 2001.
4. Syed Tanveer Ahmed Inamdar, "Biochemical Engg: Principles and Concepts" 2/e, Prentice Hall of India Learning Pvt. Ltd. (2008), New Delhi.

15UCHL703	Major Project – Phase 1	(0-0-6)4

Course Learning Objectives:

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Analyse and compare the literature review of the topic chosen in chemical engineering	7,14	8,12	2,10
CO2	Identify the challenges related to the process industries or society with multidisplanery facets	10,14	8,12, 11	6,7,9
CO3	Select the suitable material, methodology and carry out the computation and economic analysis			3,4,5,15
CO4	Formulate, design and report the approaches to carry out the experiments with feasibility solutions	9	8,10,12	11,15
CO5	Outline the precise project report with appropriate guidelines and references	9	8,15	10
CO6	Discuss the results obtained with proper justification and conclusion		10,11	15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3	3	3	3	3	2	2	1.6	2.2	2.3	2		1	2.6

Course Content:

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VII semester or project of VI semester can also be extended here. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VII semester. After getting the approval from DUGC, the project work should be carried out in VII and VIII semester. The project report should be submitted in VII semester which includes literature survey, plan of work and any progress of the work. The final project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

15UCHL704	Process Control Laboratory	(0-0-3)1.5

Course Learning Objective:
1. The purpose of this laboratory is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Apply fundamentals of industrial processes, process measurement and process control theory.	1	15	
CO2	Analyse transient behavior of simple systems.	15	2	
CO3	Analyse data from experiments and prepare well organized laboratory report.	11	4	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2		2							1				1.5

Prerequisites: Process Control Theory.

List of Experiments:
1. Time constant determination for first order systems (step input)
2. Single Tank System -I Order System (step input)
3. Non Interacting tanks - I Order system in series (step/impulse input)
4. Interacting tanks - I Order system in series (step/impulse input)

5. Simple level Control – P, PI,PD,PID action
6. Temperature Control – ON/OFF, P, PI,PD,PID action
7. Valve Characteristics
8. Study of temperature sensors characteristics – RTD , Thermocouple, Thermistor
9. Study of Temperature Transmitter
10. Study of I/P and P/I converter
11. Control system in stirred tank heater
12. Study of Flapper-Nozzle

Note: At least 10 experiments to be conducted.

Reference Books

1. Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.

15UCHL705 Computer Applications in Chemical Engineering and Simulation Laboratory (0-0-3):1.5

Course Learning Objectives:

1. To make the students understand physical systems in chemical engineering and using C program to develop models and solutions for these models.
2. The students will also learn to use the commercial process simulations using simulation software.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Solve some problems related to chemical engineering using C-program	4, 10	4, 15	
CO2	Demonstrate the model solving ability of various process/unit operations involved in chemical engineering.	10, 15	9	4
CO3	Analyse and optimize the parameters of a chemical process using simulation software.	4, 9, 10		15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				1.7					1.5	1					2.5

List of Experiments:
Chemical Engineering problems in the different areas like Design, Mass transfer, Heat transfer, thermodynamics and CRE are solved by applying Numerical Techniques and C-Programmes.

C – Programming:

1. Flash Vaporization for multi-component system
2. Design of Adiabatic Batch Reactor, PFR
3. Bubble and Dew temperature.
4. Double pipe Heat Exchanger (Area, Length and Pressure drop)
5. Distillation column (Bubble cap)

Simulation:

1. Introduction to suggested software available (flow sheeting)
2. Simulation Studies of flash drum, Distillation Column, CSTR, PFR, Heat Exchanger.
3. Simulation Studies of pump, compressor, cyclone, heater
4. Process simulation study of the following process:
    a. Ethylene Glycol from Ethylene oxide
    b. Atmospheric distillation of crude oil
    c. Phthalic anhydride process
    d. Aromatic stripper with Toluene, Xylene
    e. Styrene from Ethyl Benzene
5. Introduction to E-Fluent Software.

Reference Books

1. Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2/e, McGraw Hill, 1990.
2. William L. Luyben, “Process modeling, simulation and control for Chem. Engg.”, Mc. Graw Hill, 1990.
3. Asghar Hussain, “Chemical process simulation”, Wiley Eastern Ltd, 1986.
4. Roger G.E Franks, “Modeling and Simulation in Chemical Engineering” Wiley Inter science. New York, USA, 1972.

15UCHE706	Pilot Plant and Scale up Methods	(4-0-0) 4: 52 Hrs.

Course Learning Objectives:

1. To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results, and apply process scale-up methods.
2. To study proper designs, modeling and processing and the importance of the process geometry.

Course outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and explain the need for pilot plant and its demonstration	13	3	2
CO2	Interpret and analyse different approaches for scale up studies in chemical engineering system.	2	3	13
CO3	Predict and assess different challenges and techniques for scaling up the given system.	2	3	14
CO4	Illustrate and develop the different mathematical models for scale up methods	5	2	1, 3,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	3	1.75	2.25		1								2.3	3	

Prerequisites: Nil

Course content:

1. **Introduction to Pilot plant and scale up studies**. Major issues, approaches to scale up, describing process system. Need for Pilot plant. Concepts of prototype and models. **8 Hrs.**
2. **Mathematical modeling**- Major issues, fundamental principles. Dimensional analysis and Principles of similarity. **8 Hrs.**
3. **Pilot plants and demonstration**- Major issues, fundamental considerations, rules of thumb, predicting commercial performance. Regime concept. **8 Hrs.**
4. **Scale up of chemical reactor systems**. Mixing process: Principles scale up relations, guidelines for scale up. Agitated vessel. **10 Hrs.**
5. **Stage wise mass transfer process**. Principles, Vapour-Liquid systems. Distillation. Absorption and stripping. Extraction. **10 Hrs.**
6. **Scale up of Momentum and Heat Transfer systems**. Environmental challenges of scale up. **8 Hrs.**

Reference Books:

1. Attilio Bisio, Robert L. Kabel, “Scale up of Chemical Processes”, John Wiley Interscience publication, 1985.
2. Ibrahim and Kuloor, “Pilot plant and Scale up Studies”.
3. Johnstone and Thring, “Pilot Plants Models and scale up method in Chemical Engineering”, McGraw Hill, 1962.
4. Marko Zlokarnik, “Dimensional Analysis and Scale-up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986.

15UCHE707	Transport Phenomena	(4-0-0)4 :52 Hrs.

Course Learning Objectives:

1. To provide basic understanding of laws governing transport processes and effect of various parameters.
2. To provide an understanding of steady state shell balances for velocity, temperature and concentration distribution under laminar flow.
3. To deal with equations of change and analogies amongst transport processes along with their applications.

Course outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	State laws of momentum, energy and mass transport. Discuss effect of temperature and pressure on transport properties of fluid.			1
CO2	Formulate velocity, temperature and concentration distributions under laminar flow conditions and solve transport problems.	1	2, 3, 13	
CO3	Derive equations of change for isothermal systems. Apply these equations in solving steady state problems	1	2, 3, 13	
CO4	Write analogies between momentum, heat and mass transport problems.		1	2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.75	2.3	2										2		

Prerequisites: Nil

Course content:

1. **Introduction:** Momentum, Energy and Mass transport, Newton's law of viscosity, Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction, Ficks law of diffusion, effect of temperature and pressure on transport properties of fluids. Numerical problems using all law. **6 Hrs.**
2. **Velocity distribution in laminar flow:** Steady state shell momentum balance, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through circular tube, flow through annulus, flow between parallel plates and slit. Numerical problems using the equation derived above. **12 Hrs.**
3. **Temperature distribution in laminar flow**: Steady state shell balance, boundary conditions applicable to energy transport problems, heat conduction through compound walls, heat conduction with internal generation by electrical source, nuclear and viscous energy sources. Heat conduction in a cooling fin, Forced and free convection heat transfer. Numerical problems using equation derived above. **12 Hrs.**
4. **Concentration distribution in laminar flow:** Steady state shell balance, Boundary conditions applicable to mass transport problems, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion, Diffusion into falling film, Forced convection mass transfer, Diffusion with homogeneous and heterogeneous reaction. Numerical problems using the equation derived above. **10 Hrs.**
5. **Equation of change of Isothermal systems**: Non isothermal systems and Multicomponent systems. Application of these equations in solving steady state problem. **6 Hrs.**
6. **Analogies and Navier Stokes equation:** Simple numerical problems on it. Analogies between Momentum, Heat and mass transport and their numerical problems. **6 Hrs.**

Reference Books:

1. Bird, Stewart and Lightfoot, "Transport Phenomena", John Wiley, 1994.
2. Robert Brodkey and Henry C. Hershey, "Transport Phenomena Unified Approach", International Edition- 1988.
3. Bennet and J. E., "Momentum Heat and Mass Transfer", Myer- McGraw Hill-1982.
4. Suryavanshi and Dongre, "Transport Phenomena", Nirali Prakashan, 2012. ISBN: 978-81962-56-5.

15UCHE708	**Process Modeling and Simulation in Chemical Engineering**	**(4-0-0)4: 52 Hrs.**

Course Learning Objectives:

1. To study basic concepts of modeling and formulation of mass and energy balance relationships and thereby it helps for the development of complex models.
2. To understand the advanced technologies in simulation field and the applicability in industries.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Explain and apply the different fundamentals to develop the models for chemical engineering system.		2	1,3
CO2	Interpret and develop different mathematical methods for chemical engineering system.		1, 2	3,13
CO3	Apply and assess different relevant software's for simulation of chemical engineering models.		2,3	5, 15
CO4	Demonstrate and analyse the different model solving ability for various chemical engineering process.		2,3	5, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.5	2	2.5		3								3		3

Prerequisites: Nil

Course content:

1. **Modeling in Chemical Engineering**: Introduction, Principles of Formulation, Fundamental laws; Continuity Equation, Energy Equation, Equation of motion, Transport Equations, Equation of States, Equilibrium, Chemical Kinetics, Classification of Mathematical models. **10Hrs.**
2. **Numerical techniques:** Iterative convergence methods like bisection and secant method, Newton raphson method, Numerical integration of ordinary differential equations like Euler and Runge Kutta method. Numerical solution

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of partial differential equations of first order approximation with examples. **12Hrs**

3. **Models in Chemical engineering:** Introduction, Series of Isothermal, Constant-Holdup CSTRs, CSTRs with Variable Holdups, Two Heated Tanks, Gas-Phase, Pressurized CSTR, Non-isothermal CSTR, Single-Component Vaporizer, Multicomponent Flash Drum, Batch Reactor, Reactor With Mass Transfer, Ideal Binary Distillation Column, Multicomponent Non-ideal Distillation Column Batch Distillation With Holdup. **14Hrs**
4. **Computer simulation**: Introduction to Simulation, Role of Computers and Numerical Methods in simulation, Iterative convergence methods, Explicit Convergence methods, Explicit Numerical Integration algorithm, Implicit Methods, Numerical examples. **8Hrs**
5. **Specific simulation/ Model development:** Batch reactor, CSTR, Bioreactor, activity coefficient models, Distillation and equilibrium Flash vaporization. **8Hrs**

Reference Books:

1. William L. Luyben, "Process modeling, simulation and control for Chem. Engg.", Mc. Graw Hill, 1990.
2. Edger TF and Himmelblau D M, "Optimization of chem. Process" Mcgraw Hill, 1989.
3. Asghar Hussain, "Chemical process simulation", Wiley Eastern Ltd, 1986.
4. Roger G.E Franks, "Modeling and Simulation in Chemical Engineering" Wiley Inter science. New York, USA, 1972.

15UCHE709	Novel Separation Techniques	(4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To provide an understanding of novel/newer separations using mass transfer and thermodynamic considerations.
2. To provide an understanding of their applications at different levels in industry, viz. refineries, biochemical processing, pharmaceuticals, gaseous separations, metallurgical etc.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline continuous adsorption and advanced chromatographic			4, 5, 14

	techniques.			
CO2	Classify membrane based separations and explain their mass transfer and thermodynamic considerations with applications.		4, 5	
CO3	Explain the surfactants based, micellar and foam separations with applications.		4, 5	14
CO4	Describe Super Critical Fluid Extraction process with applications.		4	5, 14
CO5	Explain the processes of thermal diffusion, electrophoresis and crystallization.	4	5	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				2.0	2.4									3.0	

Prerequisites: Nil

Course content:

1. **Adsorptive separations:** Thermal swing adsorption, pressure swing adsorption, ion-exchange, affinity chromatography, gradient chromatography and counter current separations etc. **12 Hrs.**
2. **Membrane separation processes:** Classification, structure and characteristics of membranes, Thermodynamic considerations, mass transfer considerations, design of R.O.U.F, Pervaporation, and gaseous separations. **12 Hrs.**
3. **Surfactant based separations:** Fundamentals of surfactants at surfaces and in solutions. Liquid membrane permeation, foam separations, micellar separations. **8 Hrs.**
4. **External field induced separations**: Electric and magnetic field separations. Centrifugal separations. **6 Hrs.**
5. **Super critical fluid extraction:** Physicochemical principles, thermodynamics, process description. Applications and case study. **8 Hrs.**
6. **Separation**: Thermal diffusion, electrophoresis and crystallization. **6 Hrs.**

Reference Books:

1. P.C. Wankat, "Large scale adsorption chromatography" CRC Press, 1986.
2. R.W. Rousseu, "Handbook of separation process technology", John Wiley and sons 1987.

3. S.Sourirajan and T. Matsura, "Reverse osmosis and Ultra filtration process principle", NRC publication Ottawa, 1985.
4. Richard Baker, "Membrane Technology and Applications", 2/e, , John Wiley and Sons Ltd.

15UCHE710 Wastewater Treatment and Engineering (4-0-0) 4: 52 Hrs.

Course Learning Objectives:

1. To create awareness on the water pollution aspects and understand the kinetics and the designing system of the plant.
2. To understand the different parameters, treatment methods and control techniques of water pollution.

Course Outcomes:

COs	Description: At the end of course the student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Cognize the different regulatory standards with design criteria for environmental parameters	3, 6, 7	14	
CO2	Learn the wastewater treatment criteria based on the regional requirement.		14, 15	3, 6, 7
CO3	Comprehend the reaction kinetics, reactor selection and its process analysis.		3, 6, 7	14
CO4	Design the treatment plant based on the fundamentals studies, bench scale and pilot plant studies		3, 6, 7	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2			2	2							2.5	2.0

Prerequisites: Nil

Course Content:

1. **Objectives of wastewater treatment**: Flow measurements and Composition. Characterization -properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central. **08 Hrs**
2. **Microbiology of waste treatment**: Growth and inhibition of bacteria. Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization. Effects of endogenous metabolism &

kinetics Manod's and Michaclis menton kinetics and their applications. Determination of kinetic coefficients. **10Hrs**

3. **Sewerage System- Design of sanitary sewer**: Sewerage System- Design of storm water sewers, Physical and Chemical treatment of wastewater, Screens, Comminuters, Grit chambers, Sedimentation Chemical treatment. **10 Hrs.**
4. **Biological treatment process**: Activated sludge process standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds Treatment disposal of sludge- Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation. **12 Hrs**
5. **Advanced Waste Water Treatment**: Introduction, Need of Advanced Waste Water Treatment, Purpose of Advanced Waste Water Treatment. Nitrogen & Phosphorus Nitrogen Removal: Nitrification , Denitrification Simultaneous nitrification and denitrification Phosphorus Removal. Membrane Bioreactor with Membrane Module Submerged in the Bioreactor. Electro-coagulation: Factors affecting Electrocoagulation, Electrode materials, Reactor configurations. **12 Hrs**.

Reference Books:

1. Metcalf and Eddy. Waste water Engineering: Treatment and disposal
2. Gaudy and Gaudy- Microbiological for environmental Scientist and engineers McGraw Hill 1980. 4.
3. G. Tchobanoglous and F.I. Biston Waste water Engineering Treatment and Reuse: Mc Graw Hill, 2002.
4. McGhee. Water Supply and Sewerage, McGraw Hill.

VIII Semester B.E.

15UCHC800	Seminar	(0-0-3)2

Course Learning Objective:

1. To provide platform to focus on knowledge of technical data collection, communication skills and report writing.
2. To develop intellectual and professional competence and work on the chosen topic to improve skills in writing and oral presentation.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Review and acquire knowledge on the chemical engineering topic outside the scope of curriculum	4, 5	6,7,8,9,12	14
CO2	Outline and consolidate the required information on chosen topic		6,7,8	9
CO3	Organize the technical matter in the required format and compile the same		9	12
CO4	Interpret and communicate the topic with proper justification and conclusion			9, 10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				1	1	2	2	2	2.5	3		2.5		3	

Prerequisites: Nil

Course content:

Seminar should be based on a detailed study of any topic related to Chemical Engineering (preferably the advanced areas / application) and the topic should preferably be relevant to the curriculum. Students may undertake studies in research survey, literature review and analysis, synthesis, design and development, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of the work.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. It is expected that the student collect information from reference books, standard journals. The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow. The discussion and conclusions shall form the last part of the text.

The seminar shall be evaluated with due weightage on:

Topic-10%
Literature survey-25%
Report-20%
Presentation-25%
Conclusion and querries-20%

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

15UCHC801	Process Engineering Economics and Management	(4–0–0) 4:52 Hrs.

Course Learning Objectives:

1. Prepare the students to analyse cost/revenue data and carry out economic analyses in the decision making process to justify alternatives/projects on an economic basis and prepare students to function in the business and management side of professional engineering practice.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Comprehend the concepts of plant location, layout, feasibility survey, design and report writing.	12	9,10	
CO2	Apply economic concepts viz. cost estimation, depreciation, cash flow etc. in solving chemical engineering problems.	12	9,14	10,11
CO3	Apply economic tools viz. profitability, replacement, breakeven analysis to appraise chemical engineering processes.	12	9,14	10,11

CO4	Interpret production, material and marketing management with their virtues applied to a chemical industry.	12	9	10,11

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level									2	2.2	3	1		2	

Prerequisites: Nil

Course Contents:

1. **Cost estimation.** Factors involved in project cost estimation, methods employed for the total cost estimation of investment. Cost Index. Feasibility survey. Plant location and Layout. **10 Hrs.**
2. **Depreciation,** Taxes and Insurance. Different methods of Depreciation. Time value of money and its equivalence. Cash flow diagram s **8 Hrs.**
3. **Profitability and methods of evaluation**. Replacement and alternative investments. Break even analysis. Financial statements **8 Hrs.**
4. **Production Management**. Types of production and planning, manufacturing planning, factory planning, production planning, schedule, work study, method study, systems of wage payments. Bonus. Automation. Organization of production. Planning and control department. **10 Hrs.**
5. **Material Management**. Functions of purchasing. Quality standards and Inspection. Sources of supply. Inventory management. ABC analysis. EOQ model. Value analysis and engineering. **8 Hrs.**
6. **Marketing Management.** Functions of marketing. Market research. Product life cycle. Promotion of sales. Pricing. **8 Hrs.**

Reference Books:

1. Peter and Timmerhaus, “Plant design and Economics for Chemical Engineers”, McGraw Hill, 1991.
2. Banga and Sharma, “Industrial Organization and Engineering economics”, Khanna Publications, 1999.
3. Tripathi and Reddy, “Principles of Management”, 5/e, Tata McGraw-Hill Education, 2004.

15UCHL802	Major Project – Phase 2	(0-0-12)10

Course Learning Objectives:

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.

3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Analyse and compare the literature review of the topic chosen in chemical engineering	7,14	8,12	2,10
CO2	Identify the challenges related to the process industries or society with multidisplanery facets	10,14	8,12, 11	6,7,9
CO3	Select the suitable material, methodology and carry out the computation and economic analysis			3,4,5,15
CO4	Formulate, design and report the approaches to carry out the experiments with feasibility solutions	9	8,10,12	11,15
CO5	Outline the precise project report with appropriate guidelines and references	9	8,15	10
CO6	Discuss the results obtained with proper justification and conclusion		10,11	15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3	3	3	3	3	2	2	1.6	2.2	2.3	2		1	2.6

Course Content:

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has been assigned at the beginning of the VII semester. The project group would have carried out the preliminary literature survey, plan of project and submitted the synopsis in the VII semester. After the approval from DUGC, the left project work should be carried out and completed in the VIII semester. The detailed project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

15UCHE803	Solid Waste Management	(4-0-0) 4:52Hrs.

Course Learning Objectives

1. To provide students with a comprehensive understanding of integrated solid waste management from an environmental and public health perspective.
2. To study the detailed engineered system of solid waste management system.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Characterize the solid waste, management, planning and policies.	4	3,14	6,7,
CO2	Explain the process of collection, handling, storage and disposal techniques of solid waste and hazardous waste.	4	3,	6,7,14
CO3	Categorize different processing methods of solid waste used for recovery of resources.	4	3,	6,7,14
CO4	Apply different techniques of solid waste management for chemical industries through case studies.	4	3,14	6,7,

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2.0	1.0		3.0	3.0							2.5	

Prerequisites: Nil

Course content:

1. **Introduction to solid waste.** Definition, Characteristics, Types and properties. Organization and status of SWM, Components of integrated waste management strategy. Overview of materials flow in society and 4R concept of solid waste management. Evolution of SWM, Effect on health and environment. Legislation and government agencies, planning of SWM progress. **8 Hrs.**
2. **Engineered systems for solid waste management**. Generation of solid waste, Onsite handling, Storage and Processing, Transfer and transport, Collection system and devices, processing techniques and equipment. **10 Hrs.**
3. **Disposal of solid wastes.** Source reduction, Ocean dumping, Land filling, Composting and Thermal Incineration. **10 Hrs.**
4. **Recovery of resources,** physical, chemical and biological methods. Details of energy recovery system, heat recovery, gasification, pyrolysis and refuse derived fuels (RDFs). **8 Hrs.**
5. **Hazardous waste** and their management issues and planning methods. Origin, reduction at source, collection and handling. E-waste handling and disposal. **8 Hrs.**
6. **Case studies** on major industrial solid waste generation units- Coal fired power plant, Textile industry, Brewery, Oil refinery, Radioactive generation units, Spills, Sludge lagooning and Incineration. **8 Hrs.**

Reference Books:

1. George Tchobanoglous, “Integrated Solid waste Management-Engineering Principles and Management issues”, McGraw Hill, 1993.
2. Howard Peavy, “Environmental Engineering”, McGraw Hill,1986.
3. Dutta, “Industrial Solid waste Management and landfilling practice”, Narose Publication, 1999.

15UCHE804	**Instrumental Methods of Analysis**	**(4-0-0)4:52 Hrs.**

Course Learning Objective:

1. To understand the principles and concepts behind the qualitative and

quantitative analysis of molecules and compounds using instrumental methods with their applications.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify the concepts for analysis of molecules and compounds using instrumental methods.	2	1	5
CO2	Interpret and analyse the different spectroscopic techniques.	5	3	1
CO3	Explain and analyse Flame photometry and AAS techniques and its application.	2	3	1
CO4	Explain and analyse the electrochemical techniques and its application.	3	1	2
CO5	Explain and analyse the chromatography technique and its applications.	1	2	5

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.2	1.75	1.67	-	2.33	-	-	-	-	-	-	-	-	-	-

Prerequisites: Nil

Course Content:

1. **Spectroscopy:** General introduction; Nature and interaction of electromagnetic radiations, Energies corresponding to various kinds of radiations, Atomic and molecular transitions, factors influencing positions and intensity of spectral line, introduction to UV-Vis spectroscopy. **6 Hrs.**
2. **Infrared spectroscopy:** Introduction, Theory, types of vibrations, fundamental modes of vibrations and group frequencies, factors affecting the group frequencies and band shapes, instrumentation FTIR. Instrument and its advantages, Sample handling techniques, Qualitative applications of IR, Applications of IR to structural elucidation of simple organic molecules. **6 Hrs.**
3. **Nuclear Magnetic Spectroscopy:** Introduction, Chemical shifts, Mechanism of shielding and deshielding. Types of nuclei, Theory of population of nuclear magnetic energy levels, , Spin –spin coupling, Rules of governing the

interpretation of first order spectra, Low and high resolution NMR, Instrumentation and application to structure elucidation of simple organic molecules. **6 Hrs.**

4. **Mass Spectroscopy:** Introduction, theory, Instrumentation of mass spectrometer, Methods of generation of positively charged ions, Mass analyzers, Resolving power, Molecular ion peak, Base peak, Metastable peak, Modes of fragmentations, Application of mass spectrometry in Qualitative and Quantitative analysis. Structural elucidation of simple organic molecules **6 Hrs.**
5. **Flame Photometry and Atomic Absorption Spectroscopy:** Introduction, Principle, Flame and flame spectra, variation of emission intensity with flame, Metallic spectra in flame, flame ground, Role of temperature on absorption emission and fluorescence. Comparative study of Flame Emission Spectroscopy (FES) and Atomic Absorption Spectroscopy (AAS) Instrumentation and Applications. Qualitative and quantitative determination of alkali and alkaline earth metals. Nephelometry and Turbidometry Introduction, Theory, effect of concentration, Particle size and wavelength on scattering. Instrumentation and applications of Nephelometry and Turbidometry. **10 Hrs.**
6. **Electrochemical Techniques:** Introduction to Electrochemistry, Electrode Potential, Nature, Measurement, sign convention, Effect of concentration, Standard electrode potential, Cell Potential: Thermodynamic, Liquid junction potential, Effect of current. Polarization: Sources, over voltage, concentration polarization, Mechanism of mass transport. Potentiometric Methods: reference electrodes- calomel electrode Ag- Agcl (s) electrode, Hydrogen electrode, Potentiometric titrations and applications. Membrane Electrodes: Classification of properties, Principle design, theory of ion selective electrodes Membrane potential, Selectivity, Crystalline liquid membrane and electrodes. **10 Hrs.**
7. **Chromatography:** Introduction to chromatographic techniques, General descriptions, definitions, terms and parameters used in chromatography. Classification of chromatographic methods, working principles, Instrumentation and applications of Thin layer chromatography (TLC), Gas chromatography(GC), High pressure liquid chromatography (HPLC). **8 Hrs.**

Reference Books:

1. Jaffery, G.H., Basset, J., et. al., “Vogel’s Text book of Quantitative Inorganic Analysis” ,5/e, ELBX, 1998.
2. Skoog, D.A., “Principles of Instrumental Analysis”, 3/e, Saunders College publishing, 1985.

3. W.H. Willard, "Instrumental Methods of analysis", 7/e, L.L., Merritt and J.A. Dean, 1988.
4. B.K. Sharma ,"Instrumental Methods of Chemical Analysis", Goel Publishing House Meerut, 2000.

15UCHE805	Sugar Technology	(4-0-0) 4:52 Hrs.

Course Learning Objective:

1. Studying this subject the students will understand the different processing methods practiced for production of sugar. Learn about the extraction and production of sugar learn different unit operation and unit process application with practical difficulties encountering during process along with its remedies.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Relate the Indian Sugar industry and World scenario	7, 14	6	
CO2	Analyze Working, operation and performance of sugar production process.	1	2	15
CO3	Identify various equipments for sugar production.		14	5
CO4	Design a system to meet the needs considering the constraints of economics, safety and environmental problems associated with sugar industry.	8	7	3, 14
CO5	Identify the various means of cogeneration and its importance on economy of sugar industry.	13, 14	2	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	3		3	2	1.5	1					1	1.75	3

Prerequisites: Nil

Course content:

1. **Sugar industry in India:** Chemical and physical properties of sucrose and reducing sugars. Sources of sucrose, formation of sucrose plants, non sugar

compounds of sugarcane, inorganic constituents of sugar cane juices and sugars analytical used in sugar industry. **8 Hrs.**

2. **Purification:** Technology of the purification process, fundamental reactions and physical chemistry aspects of clarification, liming, Sulphitation and carbonation process, filtration of sugar juices. **12 Hrs.**
3. **Unit operations:** Evaporation of sugar juice, heat transfer in evaporators, evaporation equipment and auxiliaries. Crystallography: solubility of sucrose, theoretical aspects of crystal growth, factors influencing rate of crystallization, control methods and equipment in sugar crystallization, technology of sugar crystallization, boiling scheme of crystallization Centrifugation: theory of the centrifugal process, centrifugal operation, engineering principles of sugar centrifugals, and the centrifugal equipment and auxiliaries, grading of sugar. **14 Hrs.**
4. **Distillery:** Production of final molasses and molasses's utilization and storage. Molasses characteristics for alcohol. Fermentation methodology for alcohol production, factors influencing the production. Distillation methods used in separation process, Design consideration for distillation column. **6 Hrs.**
5. **Co-generation:** Types of co-generation methods, quality of bagasse used, different types of boilers used and efficiency, factors influencing the operation, methods of obtaining steam, and quality of steam **6 Hrs.**
6. **Environmental management plan:** Pollution control measures for water, air, solid waste, noise in sugar industries. **6 Hrs.**

Reference Books:

1. Honing P (Ed), "Principles of Sugar Technology", Vol I to III, Elsevier publishing company, 1953.
2. Jenkinos. G.H., "Introduction to cane sugar Technology", Elsevier, 1966.
3. Mathur.R.B.L, "Handbook of cane Sugar Technology", 2/e, Oxford and I.B.H. Publishing Co., 1997.
4. R.K. Rajputh, "A text book on Power Plant Engineering", 2/e, Laxmi publications (p) Ltd., New Delhi, 2001.
5.

15UCHE806	Bioprocess Engineering	(4-0-0)4: 52 Hrs.

Course Learning Objectives:

- To provide the students with the basics of bioreactor engineering.
- To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

Course Outcomes:

COs	Description: At the end of the course	Mapping to POs and PSOs

	student will be able to	**Introductory 1**	**Moderate 2**	**Substantial 3**
CO1	Select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts and cell lines and other process criteria.	2	3, 4, 7	
CO2	Apply modelling and simulation of bioprocesses so as to reduce costs and to enhance the quality of products and systems.		3, 4, 7	5
CO3	Plan a research career or to work in the biotechnology industry with strong foundation about bioreactor design and scale-up.	3, 4, 7		13
CO4	Integrate research lab and Industry; identify problems and seek practical solutions for large scale implementation of Biotechnology.		3, 6	15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		1	1.7	1.6			1.6						3		3

Prerequisites: Biochemical Engineering
Course content:

1. **Operational Modes of Bioreactors**: Fed batch cultivation, Cell recycle cultivation, Cell recycle cultivation in waste water treatment, two stage cultivation. Packed bed reactor, airlift reactor, fluidized bed reactor and bubble column reactor. **10 Hrs**.
2. **Bioreactor Scale – Up:** Regime analysis of bioreactor processes, oxygen mass transfer in bioreactors microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. **12 Hrs.**
3. **Bioreactor Consideration in Enzyme Systems** : Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors. **10 Hrs.**
4. **Modelling And Simulation of Bioprocesses** :Study of structured models for analysis of various bioprocess – compartmental models, models of cellular energetics and metabolism, single cell models, plasmid replication and plasmid stability model. Dynamic simulation of batch, fed batch, steady and transient culture metabolism. **10 Hrs**

5. **Recombinant Cell Cultivation**: Different host vector system for recombinant cell cultivation strategies and advantages. E.coli, yeast Pichia pastoris/ Saccharomyces cereviseae, Animal cell cultivation, plant cell cultivation, Insect cell cultivation. High cell density cultivation, process strategies, reactor considerations in the above system. **10 Hrs.**

Reference Books:

1. Jens Nielson, John Villadsen and Gunnar Liden, "Bioreaction engineering principles", 2nd Edition, Kulwer Academic, 2002
2. Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc
3. James E. Bailey & David F. Ollis, "Biochemical Engineering Fundamentals", McGraw Hill.
4. Atkinson, B, Mavituna, F, "Biochemical Engineering and Biotechnology Handbook" Macmillan Publishers Ltd, New York, 1992.

15UCHE807 Unit Processes in Organic Synthesis (4-0-0) 4:52 Hrs.

Course Learning Objectives:

1. To study the fundamental concepts of Industrial Chemistry and their applications.
2. To have knowledge on various reaction mechanisms, preparation of organic compounds, classification of the compounds etc.

Course Outcomes:

COs	Description: At the end of the course student will be able to	Mapping to POs and PSOs		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	To apply basic knowledge of chemical processes and equations to solve numerical problems.	5	3	2
CO2	To develop appropriate techniques in industrial scales for the preparation of value added products.	7	2	1
CO3	To converge the concepts of chemical processes like sulfonation and sulfation for industrial products	1	5	3,13
CO4	To elaborate halogenations its process, kinetics and interpret it for	6	1	5,13

	modern industrial processes.			
CO5	To correlate oxidation and analyse various unit processes of many organic compounds for improvement of existing techniques for the preparation of better yield and quality,	3	2	1
CO6	To evaluate hydrogenation reaction and processes with mechanisms for innovative industrial products.	1	3	2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.25	2.25	2.5	-	1.75	1	1	-	-	-	-	-	3	-	-

Prerequisites: Chemistry, Thermodynamics and Unit processes.

Course content:

1. **Introduction**: Unit processes and principles of thermodynamics and kinetics related to unit processes. **6 Hrs.**
2. **Nitration:** Introduction, nitrating agents, aromatic nitration, thermodynamics kinetics and mechanism, nitration of paraffin hydrocarbon, other nitration. Mixed acid for nitration, process equipment for technical nitration typical industrial nitration processes (nitrobenzene). **10 Hrs.**
3. **Sulfonation and sulfation:** Introduction sulfonating and sulfation agents and their application, chemical and physical factors, kinetics mechanism and thermodynamics od sulfonation, industrial equipments for batch and continuous processes industrial processes (Monosulphonation of benzene, detergent alkylate). **10 Hrs.**
4. **Halogenation:** Introduction survey of halogenation processes thermodynamics and kinetics, chlorination in presence of catalyst, photo halogenation, industrial equipment for halogenation, typical processes (Chorobenzene). **9 Hrs.**
5. **Oxidation:** Types of oxdative reactions oxidizing agents. Typical liquid phase oxidation processes, vapor phase oxidation of alpha-tic and aromatic compounds. Industrial processes (strene from ethyl benzene, acetaldehyde to acetic acid.) **9 Hrs.**
6. **Hydrogenation:** Introduction, methods of hydrogen production, general principles relating to hydrogenation catalysts, kinetics and thermodynamics, industrial apparatus for hydrogenation and typical examples of hydrogenation processes (Hydrogenation of oils and fats). **8 Hrs.**

Reference Books:

1. P. H. Groggins. "Unit Processes in Organic Synthesis ", 5/e, Tata Mc Graw Hill, 1995.
2. Kirk R. E. Othmer D. F. "Encyclopedia of Chemical Technology", Inter Science Publishers.

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Academic Program: UG

Academic Year 2019-20

Syllabus

III & IV Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465Fax:** **0836-2464638 Web:** www.sdmcet.ac.in

SDM College of Engineering & Technology, Dharwad

Date:18-7-2019

It is certified that the scheme and syllabus for III& IV semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2019-20 till further revision.

Principal Chairman BoS&HoD

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SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and Mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes(POs) and Program Specific outcomes(PSOs)

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

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Scheme for III Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC300	BS	Engineering Mathematics – III	3-0-0	3	50	100	3	-	-
18UCHC300	PC	Chemical Process Calculations	4-0-0	4	50	100	3		-
18UCHC301	PC	Technical Chemistry**	3-0-0	3	50	100	3	-	-
18UCHC302	PC	Fluid Mechanics	4-0-0	4	50	100	3	-	-
18UCHC303	PC	Particulate Technology	4-0-0	4	50	100	3	-	-
18UCHC304	PC	Chemical Engineering Drawing	2-0-2	3	50	100	3	-	-
18UCHL305	PC	Particulate Technology Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL306	PC	Technical Analysis Laboratory	0-0-3	1.5	50	-	-	50	3
Total			**20-0-8**	**24**	**400**	**600**		**100**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

** To be handled by the Chemistry department faculty

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Scheme for IV Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC400	BS	Engineering Mathematics – IV	3-0-0	3	50	100	3	-	-
18UCHC400	PC	Process Heat Transfer	4-0-0	4	50	100	3	-	-
18UCHC401	PC	Chemical Reaction Engineering-I	4-0-0	4	50	100	3		
18UCHC402	PC	Chemical Engineering Thermodynamics	3-2-0	4	50	100	3	-	-
18UCHC403	PC	Pollution Control Engineering	3-0-0	3	50	100	3	-	-
18UCHC404	PC	Energy Technology and Management	3-0-0	3	50	100	3	-	-
18UCHL405	PC	Computational Methods & Simulation Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL406	PC	Fluid Mechanics Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL407	PC	Introductory Project	0-0-2	1	50	-	-	-	-
Total			**20-2-8**	**25**	**450**	**600**		**100**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the Second year: 49

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18UMAC300 Engineering Mathematics III (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

To have an insight into Laplace transforms, Fourier series, Fourier transforms, Difference equations andZ-transforms. To develop the proficiency in variational calculus and solving ODE’s arising inengineering applications, using numerical methods.

Course Outcomes (COs):

COs	**Description of the course outcomes:** At the end of course the students will be able to	**Mapping to POs (1-12)**		
		Mastering 3	**Moderate 2**	**Introductory 1**
CO-1	Transform the given function using Laplace /Fourier transforms depending on the nature of engineering applications.			1
CO-2	Express periodic function as a Fourier series and obtain the various harmonics of the Fourier series expansion for the given numerical data.			1,2
CO-3	Solve difference equations using Z-transform.			1
CO-4	Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numericalmethods.		1,2	
CO-5	Determine the extremalsof functional using calculus of variations and solve problems arising in engineering.			1,2

POs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mapping Level	1.2	1.3													

Contents:

1) Laplace Transforms: Definition and Properties. Laplace transform of elementary functions. Laplace transforms of Periodic functions and unit-step function – problems.

Inverse Laplace Transforms: Inverse Laplace transform - problems, Convolution theorem(without proof) to find the inverse Laplace transform and problems, solution of linear differentialequations using Laplace transform.
8 Hrs.

2) Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions of period 2π and arbitrary period. Half- range Fourier series. Practical harmonic analysis, examples from engineering field.
8 Hrs.

3) Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Simple problems.

Z-Transforms and Difference Equations : Z-transform- definition, Standard Z-transforms, Damping and shifting rules, Initial value and Final value theorems (without proof) with problems. Inverse Z-transform.Simple problems.Difference equations-basic definition. Application of Z-transform to solve Difference equation.
8 Hrs.

4) Numerical Solutions of Ordinary Differential Equations (ODE's): Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Runge –Kutta method of fourth order, Milne's predictor and corrector method (Noderivations of formulae). Problems.**7 Hrs.**

5) Numerical Solution of Second Order ODE's: Runge-Kutta method and Milne's predictor and Corrector method. (No derivations of formulae). Calculus of Variations: Variation of function and functional, variational problems, Euler's equation (without proof), Geodesics(plane), hanging chain problems.
8 Hrs.

Text Books:

1) B.S. Grewal: HigherEngineeringMathematics, KhannaPublishers, 44thEd.,2017.

2)E. Kreyszig: Advanced EngineeringMathematics,John Wiley&Sons, 10thEd. (Reprint).2016.

3)Srimanta Pal et al: Engineering Mathematics, Oxford University Press, 3rdEdition, 2016.

ReferenceBooks:

1)C. RayWylie,LouisC. Barrett:"Advanced EngineeringMathematics",6th Edition, McGraw-Hill Book Co.,New York, 1995.

2) S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, 4th Edition 2010.

3)B. V. Ramana:"HigherEngineeringMathematics"11th Edition,TataMcGraw-Hill, 2010.

4)N. P. Bali and Manish Goyal : ATextBook ofEngineeringMathematics, LaxmiPublishers, 7th Ed., 2014.

5)VeerarajanT., "EngineeringMathematicsfor Firstyear", TataMcGraw-Hill, 2008.

6)Thomas G.B. and FinneyR.L."Calculusand Analytical Geometry" 9th Edition,Pearson, 2012.

Web links and Video Lectures:

http://nptel.ac.in/courses.php?disciplineID=111.

http://www.class-central.com/subject/math(MOOCs).

http://academicearth.org/.

VTU EDUSAT PROGRAMME –20.

18UCHC300	Chemical Process Calculations	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To study the analysis of chemical processes through calculations and also to develop systematic problem-solving skills.
2. To formulate and solve material and energy balances in processes with and without chemical reactions.

Course Outcomes (COs):

COs	Description: At the end of course the student will able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline the fundamentals of units and dimensions and Psychrometry.	13	2, 3	1
CO2	Categorize methods of expressing chemical compositions.	1	2, 3	13
CO3	Evaluate problems on steady state			

	material balance with and without chemical reactions.	1	2, 3	13
CO4	Compute ultimate and proximate analysis of fuels and Perform calculations on energy balances.	1	2, 3	13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2.0	2.0										2.5		

Course content:

1. **Units and dimensions:** Fundamental and derived units, Conversion. Dimensional consistency of equations. Dimensionless groups and constants. Conversion of equations. Psychrometry: absolute humidity, molal humidity, dry bulb and wet bulb thermometry, humidity chart, humidification and dehumidification, air conditioning. **8Hrs.**
2. **Basic chemical calculations:** Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases. Concept of normality, molarity, molality, ppm. Ideal gas law calculations. **8 Hrs.**
3. **Material balance without reaction:** General material balance equation for steady and unsteady state. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying, mixing and evaporation. Elementary treatment of material balances involving bypass, recycle and purging. **12 Hrs.**
4. **Steady state material balance with reaction:** Principles of stoichiometry, Concept of limiting and excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, related problems. Ultimate and proximate analyses of fuels, Calculations involving burning of solid, liquid and gaseous fuels, excess air, air-fuel ratio calculations. **12 Hrs.**
5. **Energy Balance:** General steady state energy balance equation, Heat capacity. Enthalpy, Heat of formation, Heat of reaction, Heat of combustion. Heat of mixing. Determination of Heat of formation at Standard and Elevated temperatures, Theoretical flame temperature and adiabatic flame temperature. **12 Hrs.**

Reference Books:

1. Hougen, O.A., Waston, K.M. and Ragatz, R.A., “Chemical Process Principles Part – I, Material and Energy Balances”, 2/e, CBS publishers and distributors, New Delhi, 1995.

2. Himmelblau, D.M., “Basic Principles and Calculations in Chemical Engineering”, 6/e, Prentice Hall Of India, New Delhi, 1997.
3. Bhatt, B.L. and Vora, S.M., “Stoichiometry”, SI Units, 3/e, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
4. K.V. Narayanama B. Lakshmikutty, “Stoichiometry and Process calculations” Prentice Hall India Limited, New Delhi, 2006. ISBN: 978-81-203-2992-8

18UCHC301	**Technical Chemistry**	**(3-0-0) 3**

Contact Hours: 39

Course Learning Objectives:

1. Acquisition of knowledge and development of scientific attitude among the learners.
2. Development of intellectual abilities and skills.
3. To inculcate social virtues among students so as to contribute significantly towards the progress of society.

Course Outcomes(COs):

Cos	**Description: At the end of course the student will able to**	**Mapping to POs(1-12) and PSOs(13-15)**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	To interpret the complex problems with an approach to its chemical nature and chemical bonding.	3	7	4
CO2	Apply the knowledge of inorganic polymers and applicability in material use, optimization and in various engineering applications.	6	8	1
CO3	Implement the reaction mechanisms and the rate of chemical reactions, factors affecting for designing of various industrial processes.	4	5	2 , 13
CO4	To emphasize on modern technologies and the use of Nanotechnological tools for synthesis and engineering activities.	1	4	5
CO5	To converge and design the			

	vibrant mechanisms and correlate the reactions generating critical thinking for specified products for the benefit of society with environmental considerations.	8	2	3 , 13
CO6	To demonstrate the parameters, theory and mathematical approach of catalysts to formulate the process and product formation in chemical engineering processes.	1	3	2 , 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.67	2.67	2	1.67	1.67	1	2	1.5	-	-	-	-	3	-	-

Course Content:

1. **Chemical Bonding:** Introduction, Ionic bond – Definition, steps involved in the formation of ionic bond, conditions and factors affecting the formation of ionic bond; Ionic solids- lattice energy, Barn-Haber cycle, lattice defects; semiconductors. Covalent bond - Definition, Lewis concept; Types of covalent bonds – sigma, pi, polar and non-polar. Valence bond theory (VBT) – postulates and explanation, Limitations of VBT; Molecular orbital theory – comparison between atomic orbitals and molecular orbitals, Linear combination of atomic orbitals (LCAO), conditions for effective combination of atomic orbitals. Molecular orbital configuration of simple molecules (H_2 and He); Comparison between valence bond theory and molecular orbital theory. Hydrogen bond- consequences of hydrogen bonding, boiling points of binary hydrogen compounds, solubility; unique properties of water. Hybridization-geometry of molecules- VSEPR theory; geometry of molecules of bonding pairs (BF3, CH4), geometry of molecules of nonbonding pairs (H_2O, NH_3).
8 Hrs.
2. **Inorganic Polymers:** Introduction, preparation, properties and applications of Phosphorous-based polymers-polyphosphonitrilic chlorides and ultraphosphate glasses. Sulphur-based polymers-polymeric sulphur nitride and chalcogenide glasses. Silicon-based polymers-fluid polysiloxanes gums and silicone resins.
5 Hrs.

3. **Nano-Technology:** Introduction, Nanoscale; Nanomaterials-Introduction, properties and applications of-one dimensional nanomaterials-Thin films, two dimensional nanomaterials-Carbon Nanotubes and Nonowires, three dimensional nanomaterials- Fullerens, Dendrimers; Construction of Nanomaterials-Top down and Bottom up methods. **6 Hrs.**
4. **Catalysis:** Introduction, General Characteristics, Types of catalysis with examples, Homogeneous catalysis-acid-base catalysis with mechanism, Enzyme catalysis with mechanism and kinetics; effect of temperature on Enzyme catalysis; Heterogeneous catalysis - explanation with examples;effect of temperature; Autocatalysis. **6 Hrs.**
5. **Organic Reactions and their Mechanisms:** Types of reactions – (a) Substitution – free radical; nucleophilic - S_{N1} and S_{N2}, Electrophilic – halogenation; nitration; sulphonation; Friedel-Craft's alkylation and acylation, Electronic interpretation of orienting influences of substituents in aromatic electrophilic substitution of toluene,chlorobenzene, benzoic acid and nitrobenzene, (b) Addition – free radical; electrophilic and nucleophilic, (c) Elimination – unimolecular and bimolecular, (d) Rearrangement – intra and inter molecular. **10 Hrs.**
6. **Introduction to Spectroscopy:** Study of chromatography,FTIR and UV-visible spectroscopy and their applications in analysis of organic compound. **4 Hrs.**

Reference Books:

1. J.D. Lee "Concise Inorganic Chemistry",5/e, Wiley's Publication,2012.
2. Wahid U. Malik; G.D. Tuli; R. D. Madan,"Selected Topics in Inorganic Chemistry" ,Publisher: S Chand & Co Ltd, 2010,ISBN 10: 8121906008
3. B.R. Puri, L.R. Sharma and M.S. Pathania, "Physical Chemistry", S. Chand and Co., New Delhi.ISBN 10:9382956018
4. Samuel Glasstone "Text book of Physical chemistry", Published by D. Van Nostrand company, inc
5. Er. RakeshRathi S, "Nanotechnology", Chand & Company Ltd., Ram Nagar, New Delhi,2010.
6. Peter Sykes, "Organic Reactions Mechanism", ULBS Publishers, New Delhi.
7. I. L. Finar "Organic Chemistry" Vol I & II, 5/e,Pearson Publication.

18UCHC302	Fluid Mechanics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To introduce the concepts, principles, laws, observations and models of fluids at rest and in motion.
2. To provide the basis for understanding the fluid behaviour, engineering design and control of fluid systems.

Course Outcomes(COs):

COs	Description: At the end of course the student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify the nature of fluids along with the properties and its measuring devices.		3	1
CO2	Interpret and analyze the parameters of fluid flow and understand the mechanical energy equations	1	2	3, 13
CO3	Derive and interpret the equations of fluid flow for liquids	1	2	3, 13
CO4	Derive and interpret the equations of fluid flow for gases	1	2	3, 13
CO5	Explain and characterize the different pipe fittings, pumps and flow measuring devices.	1	2	3, 13
CO6	Interpret and solve the fluid flow problems using dimensional analysis.	1	3	5

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.3	2	2.6		3								3		

Course Content:

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1. **Fluid Statics and Applications:** Introduction to momentum transfer and unit operations. Nature of fluids, pressure and its measurements. Hydrostatic equilibrium, barometric equation, measurement of fluid pressure-manometers (U tube manometer, Inverted manometer, differential manometer), continuous gravity decanter, centrifugal decanter. **8 Hrs.**
2. **Fluid Flow Phenomena:** Newtonian and Non-Newtonian fluids, types of flows, Shear rate, Shear stress, Rheological properties of fluids. Flow in boundary layer-Boundary layer separation and wake formation. Basic Equations of Fluid Flow: Macroscopic momentum balances, Mechanical energy equations. **10 Hrs.**
3. **Incompressible Fluids:** Laminar flow of incompressible fluids in pipes and conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy equation. Turbulent flow of incompressible fluids in pipes and conduits-Universal velocity distribution equation. Friction factor and Reynolds number relationship and friction factor chart. Nikuradse and Karman equation-Blasius equation, Prandtl one seventh power law. Changes in velocity or direction-Sudden expansion and contraction. **10 Hrs.**
4. **Compressible Fluids:** Continuity equation, Mach number, total energy balance, velocity of sound, Ideal gas equation, adiabatic and isothermal flow equations, Flow through convergent-divergent sections. **8 Hrs.**
5. **Transportation and Metering of Fluids:** Pipes, fittings and valves. Performance characteristics of Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors, Measurement of flowing fluids - full bore meters, area meter, insertion meters with flow rate equations. **10 Hrs.**
6. **Dimensional Analysis:** Dimensional homogeneity, Rayleigh's and Buckingham-Pi methods, dimensionless numbers, models and prototypes. **6 Hrs.**

Reference Books:

1. McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGraw Hill chemical engineering series. ISBN-10: 0072848235
2. Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1 and 2, 5/e. Butterworth publications. ISBN-10: 0750644451
3. Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4. R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

18UCHC303	Particulate Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objective:

1. To study the basic principles of the unit operations and to study the construction, working and applications of the equipments involved in each of the unit operations.

Course Outcomes(COs):

COs	Description: At the end of course the student will able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Explain the characteristics of particulate solids and equipments dealing with them.	3	13	1,2
CO2	Explain and evaluate drag and pressure drop through a bed of solids immersed in fluid.	4	13	1,2
CO3	Evaluate the terminal velocity of particles moving in a fluid under different regimes.	4	13	1,2
CO4	Comprehend and analyze gravity and centrifugal sedimentation.	13	2	1
CO5	Categorize and explain the industrial filters.	13	2	1
CO6	Describe the types of impellers, mixers and calculate the power consumption in different agitation systems.	13	2	1

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	2.5	1	1									1.5		

Course Content:

1. **Particle Technology:** Particle shape, particle size, sphericity, mixed particles size analysis. Screens – ideal and actual screens, standard screens, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture. Industrial screening equipments, grizzly, gyratory screen, vibrating screen, trommels. Sub sieve analysis – Air permeability method, sedimentation and elutriation methods.

Size Reduction: Introduction, types of forces and criteria for communition, characteristics of communited products, laws of size reduction, open and closed circuit grinding. Equipments for size reduction – jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, impactors, attrition mill, ball mill, fluid energy mill, knife cutter. **12Hrs.**

2. **Flow of Fluids Past Immersed Bodies:** Drag, drag coefficient. Pressure drop – Ergun's, Kozeny – Carman and Burke – Plummer equations. Fluidization - conditions for fluidization, minimum fluidization velocity, types of fluidization, applications of fluidization, pneumatic conveying. **9 Hrs.**
3. **Motion of Particles Through Fluids**: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, motion of spherical particles in Stoke's region, Newton's region and intermediate region. Criterion for settling regime, centrifugal separators, cyclones and hydro cyclones. **9 Hrs.**
4. **Sedimentation:** Batch settling test, application of batch settling test to design of continuous thickener. Coe and Clevenger theory, Kynch theory. Thickener design, determination of thickener area**.** **6 Hrs.**
5. **Filtration:** Introduction, classification of filtration, cake filtration, batch and continuous filtration, pressure and vacuum filtration, constant pressure filtration, characteristics of filter media. Industrial filters - sand filter, filter press, leaf filter, rotary drum filter. Filter aids, application of filter aids. Principles of cake filtration, modification of Kozeny – Carman equation for filtration. **9 Hrs.**
6. **Agitation and Mixing:** Application of agitation, agitation equipment, types of impellers – propellers, paddles and turbines, flow patterns in agitated vessels, prevention of swirling, standard turbine design, power correlation and power calculation. Mixing of solids, types of mixers- change can mixer, Muller mixer, mixing index, ribbon blender, internal screw mixer, tumbling mixer. **Sampling, Storage and Conveying of Solids:** Sampling of solids, storage of solids, open and closed storage, bulk and bin storage. Conveyors – belt conveyor, chain conveyor, apron conveyor, bucket conveyor, bucket elevators, screw conveyor. **7Hrs.**

Reference Books:

1. McCabe and Smith, "Unit Operation of Chemical Engineering", 4/e, McGraw Hill International, Singapore, 2001.
2. Badger, W.L. and Banchero J.T., "Introduction to Chemical Engineering", 3/e, McGraw Hill International, Singapore, 1999.

3. Coulson, J.M. and Richardson, J.F., "Chemical Engineering Vol.2", 5/e, Particle Technology and Separation Processes, 1998.
4. Foust, A.S. et.al, "Principles of Unit Operation", 3/e, John Wiley and Sons, New York, 1997.

18UCHC304 Chemical Engineering Drawing (2-0-2) 3

Contact Hours: 52

Course Learning Objective:

1. To increase competency in drawing through various conventions, equipments and sectional view in engineering drawing

Course Outcomes(COs):

COs	Description: Description: At the end of course the student will able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify Symbols, Valves, and Equipment	10		
CO2	Analyze sectional views and assembly drawing.	13		10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO 15
Mapping Level										2			1		

Course Content:

1. **Conventions:** Equipment and piping, colour codes, materials, nuts and bolts. **4 Hrs.**
2. **Process Flow Diagram**: with conventions and blocks, P&ID. **5 Hrs.**
3. **Proportionate Drawing of Process Equipment**: Jackets-types, Vessel Supports, Storage vessel, Reaction vessel, Heat Exchanger, Evaporator, Distillation column. **4 Hrs.**
4. **Sectional views:** Representation of the sectional planes, Sectional lines and hatching, Selection of section planes and types of sectional views. **6 Hrs.**
5. **Assembly Drawings:**

i. Shaft Joints: Cotter joint with sleeve, Gib and Cotter joint, Socket and Spigot joint. **8 Hrs.**

ii. Pipe joint: Flanged type, Union Joint, Expansion joint **8Hrs.**

iii. Valves: Stop valve, Lever safety valve, Rams Bottom safety valve, Non-return valve, Plug valve **17 Hrs.**

Note:

- First angle projection to be followed.
- Drafter to be used for all drawings.

Reference Books:

1. Gopal Krishna, K.R., "Machine Drawing," 2/e. Subhash Publication
2. Joshi, M.V., "Process Equipment Design" 3/e, Macmillan India publication.
3. Bhat N.D., "Machine Drawing". Charotar Publishing, 50/e, 2011
4. Vilbrantand Dryden., "Chemical Engineering Plant Design" Publisher: New York, ***McGraw-Hill***, 1959.

18UCHL305	**Particulate Technology Laboratory**	**(0-0-3) 1.5**

Contact Hours: 30

Course Learning Objectives:

1. To get hands on experience on various unit operations by conducting experiments on size separation, size reduction, filtration etc.
2. To analyze experimental data and project in the form of a report and oral presentation.

Course Outcomes(COs):

COs	**Description: At the end of the course student will be able to**	**Mapping to POs (1-12) PSOs(13-15)**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Determine the average particle diameter by sieve and sub-sieve analysis experiments.	9	10	4, 15
CO2	Evaluate the energy consumed for the size reduction of solid samples by applying size reduction laws.	9	10	4, 15
CO3	Calculate the medium and cake resistance in filtration equipments.	9	10	4, 15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15

Mapping Level				3				2	1.25	2.25					3

List of Experiments:

1. Ball mill
2. ICI sedimentation
3. Beaker decantation
4. Cyclone separator
5. Drop weight crusher
6. Jaw crusher
7. Leaf filter
8. Plate and frame filter
9. Screen effectiveness
10. Sieve analysis
11. Thickener
12. Batch sedimentation
13. Air elutriation

Note: Minimum 10 experiments to be conducted

Reference Books:

1. McCabe and Smith, "Unit Operations of Chemical Engineering" 6/e, McGraw Hill International
2. Foust A.S. et al., "Principles of Unit Operations", John Wiley and Sons.

18UCHL306 Technical Analysis Laboratory (0-0-3)1.5

Contact Hours: 30

Course Learning Objectives:

1. To get hands on experience on various analysis of materials
2. To analyze experimental data and understand the importance of Chemical analysis

Course Outcomes(COs):

Cos	Description: At the end of course the student will able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Determine the various properties of the fluids and solids given.	9	10	4, 15
CO2	Estimation and characterization of the given material.	9	10	4, 15
CO3	Analysis of various fluids with the measuring techniques used.	9	10	4, 15
CO4	Compile the data from the experiments conducted and discuss		8,9	10

	the results obtained with justification and conclusion in a report			

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3					1.25	2.25					3

List of Experiments:

1. Conductometric titration an Acid vs Base.
2. Standardization of potassium permanganate.
3. Determination of percentage of available chlorine present in bleaching power sample.
4. Determination of moisture content of soil and ash content of coal.
5. Determination of calorific value of solid &liquid fuels by bomb colorimeter.
6. Estimation of hardness, calcium and chlorides in water sample.
7. Determination of optimum dosage of alum of raw water.
8. Determination of bulk density, porosity and specific surface area of a sample.
9. Estimation of oil in seeds by solvent extraction method.
10. Qualitative analysis of proteins and aminoacids.
11. Qualitative analysis of carbohydrates and lipids.
12. Estimation of total loss on ignition of cement sample.
13. Estimation of reducing sugar by DNS method.
14. Estimation of sulphates and nitrates ina given water sample.

Note: Minimum 10 experiments to be conducted.

Reference Books:

1. Jaffery, G.H., Basset, J., et al., “Vogel's Text book of Quantitative Inorganic Analysis” 5/e, ELBX. 1998
2. Skoog, D.A., “Principles of Instrumental Analysis” 3/e, Saunders College publishing 1985.

IV Semester

18UMAC400	Engineering Mathematics-IV	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs): To provide an insight into applications of conformal mapping, integration of complex functions and application of probabilitydistributionsin Engineering.

Course Outcomes (Cos):

COs	**Description of the course outcomes:** At the end of course the students will be able to	Mapping to POs (1-12)		
		Mastering 3	**Moderate 2**	**Introductory 1**
CO-1	Construct and use the concepts of analytic function to solve the problems arising in Engineering field.			1
CO-2	Utilize conformal transformation and complex integral to transform irregular domain onto a relatively simple domain.		1	
CO-3	Apply discrete and continuous probability distributions in analyzing the probability models arisingin engineeringfield.		1	
CO-4	Make use of the correlation and regression analysis to fit a suitable mathematical model forthe statisticaldata.		1,2	
CO-5	Estimate the correlation, covariance using joint probability distributions. Also use student's t-distribution, Chi-square distribution as a test of goodness offit.		1,2	

POs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Mapping Level	1.8	2														

Contents:

1) **Calculus of complex functions**: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms. Construction of analytic functions: Milne-Thomson method-Problems. **7 Hrs.**

2) **Conformal transformations**: Introduction. Discussion of transformations: $w = e^z; w = z^2, w = z + \frac{1}{z}, z \neq o)$. Bilinear transformations- Problems. Complex integration: Line integral of a complex function, Cauchy's theorem and Cauchy's Integral theorem. **8 Hrs.**

3) **Probability Distributions**: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions.Binomial, Poisson, exponential and normaldistributions- problems (No derivation for mean and standard deviation)-Illustrative examples. **8 Hrs.**

4) **Statistical Methods**: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation-problems. Regression analysis- lines of regression–problems.

   Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form $= ax + b; y = ax^2 + bx + c; y = ax^b$ **.8 Hrs.**

5) **Joint probability distribution:** Joint Probability distribution for two discrete random variables, expectation and covariance.

Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-IIerrors.Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness offit. **8 Hrs.**

Text Books:

1) E. Kreyszig:AdvancedEngineeringMathematics,John Wiley&Sons, 10th Ed.(Reprint) 2016.

2) B.S. Grewal: HigherEngineeringMathematics, KhannaPublishers, 44th Ed.,2017.

3) Srimanta Pal et al: Engineering Mathematics, Oxford University Press, 3rd Edition, 2016.

ReferenceBooks:

1. C. RayWylie,LouisC. Barrett:"Advanced EngineeringMathematics",6th Edition, McGraw-Hill Book Co.,New York, 1995.
2. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, 4th Edition 2010.
3. B. V. Ramana:"HigherEngineeringMathematics"11th Edition,TataMcGraw-Hill, 2010.
4. N. P. Bali and Manish Goyal : ATextBook ofEngineeringMathematics, LaxmiPublishers, 7th Ed., 2014.

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111.
2. http://www.class-central.com/subject/math(MOOCs).
3. http://academicearth.org/.

18UCHC400	Process Heat Transfer	(4-0-0)4

Contact Hours: 52

Course Learning Objective:

1. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course Outcomes(COs):

Cos	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Ability to understand and solve conduction, convection and radiation problems.	1	2	13
CO2	Design and analyze cooling systems		2,13	3
CO3	Prevent the heat loss around various equipments		6,13	
CO4	Design and analyze the performance of heat exchangers, evaporators and condensers.	13	2	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	3			2							2		

Course Content:

1. **Conduction Heat Transfer:** Fourier's law, Mechanism of thermal conduction in

solids, liquids and gases, thermal conductivity, steady state unidirectional heat conduction. Fourier's law, Heat transfer through composite walls and cylinders. Analogy with Ohm's law.Individual and overall heat transfer coefficient. **8 Hrs.**

2. **Insulation and Extended Surfaces:** Types of insulating materials, general properties and application of insulators, Critical and optimum thickness of insulation. Extended Surfaces: Fins – types of fins, fin efficiency for longitudinal fins, Fin effectiveness. **8 Hrs.**
3. **Convection:**Newton's law of cooling, Dimensionless Numbers Reynolds No., Prandtl No., Nusselt No.,: Dimensional analysis Empirical correlationsfor heat transfer in plate and tubes., Analogy between momentum and heat transfer – Reynolds, and Coulburn analogies, Natural convection from vertical plates and horizontal cylinders. Grashof No., Rayleigh No. **10 Hrs.**
4. **Heat Transfer with Phase Change:** Film wise and drop wise condensation. Condensation, Nusselt's equation for vertical, horizontal and inclined plate. Condensation outside bank of horizontal tube. Performance of steam heated tubular evaporators-capacity and economy, single effect evaporator and multiple effect evaporators. Evaporators: Natural circulation, Forced circulation. **8 Hrs.**
5. **Heat Exchangers:** Classification of HE, Individual and overall heat transfer coefficient. DPHE, STHE, PTHE-general constructions, temperature profiles in heat exchangers. LMTD and LMTD correction factor. Fouling and types of fouling, fouling factor. Analysis of HE's-LMTD, ε-NTU method. **10 Hrs.**
6. **Radiation:** Radiation laws - Stefan Boltzman's law, Kirchoff's law, Wien's law, Plank"s law. Black body, Grey body. Transmittivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces, radiation shields. **8 Hrs.**

Reference Books:

1. J.P.Holman," Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2. Rao Y.V.C., "Heat Transfer", *Edition*illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3. McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4. Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1.6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

18UCHC401	Chemical Reaction Engineering- I	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To provide basic understanding of kinetic models and mechanisms for homogeneous chemical reactions.
2. To understand the interpretation of reactor data and thereby exploring the rate law for chemical reactions.
3. To provide an understanding and application of rate law in design of Ideal reactors and to assess their performances based on temperature effects.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Calculate rate, rate constant, activation energy and order of reaction.		1	
CO2	Interpret kinetic data to determine the rate equation	1		4
CO3	Calculate operating parameters for single and multiple Ideal reactors and understand the effect of temperature on reactor performance.		2,13	3
CO4	Design/Operate with regard to yield and selectivity for multiple reactions		2,13	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2	3	3									2		

Course Content:

1. **Introduction:** Scope of Chemical Reaction Engineering, classification of reactions, Rate equation and rate of reaction. Factors affecting the rate of reaction. Chemical kinetics, thermodynamics and Equilibrium. Temperature dependency of rate constant from Arrhenius, collision and Transition state theories. Molecularity and order of reaction. Elementary and non-elementary reactions. Kinetic models for non- elementary reactions. **8 Hrs.**
2. **Homogenous reactions**: Interpretation of batch reactor data. Constant volume batch reactor. Analysis of total pressure data in a constant volume system. Integral method of analysis for Irreversible zero, first, second and n^{th} order

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reactions. Reversible first and second order reactions, series, parallel and autocatalytic reactions. Variable volume reactions. Differential method of analysis. Over all order from half-life method. **12 Hrs.**

3. **Design of Ideal Reactors:** Formulations of performance equations for Ideal batch, Plug and mixed flow reactors for both constant and variable volume reactions. Rate equation from data obtained from ideal reactors. Comparison of Ideal reactors. Multiple reactor systems. Series and parallel combinations. Recycle reactors, introduction and qualitative treatment for single reactions only. **12 Hrs.**
4. **Multiple reactions:** Design of Batch, plug and mixed flow reactors for parallel, series reactions. Yield and selectivity. **10 Hrs.**
5. **Non-Isothermal Reactors:** Heat of reactions, equilibrium constant, optimum temperature progression. Conversion in reactors operated under adiabatic and nonadiabatic conditions. Reactor design by solving material and energy balance equations simultaneously. **10 Hrs.**

Reference Books:

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, McGraw Hill, 1981.ISBN:0-07-066574-5
3. H. Scott Fogler, “Elements of Chemical Reaction Engineering”, 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

18UCHC402	Chemical Engineering Thermodynamics	(3-2-0) 4

Contact Hours: 60

Course Learning Objectives:

1. To relate state changes in a system to the quantity of energy in the form of heat and work transferred across its boundaries.
2. Understanding of the laws of thermodynamics and their application in the analysis of chemical and engineering problems.
3. Calculating thermodynamics properties of fluids and fluid mixtures using equation of state.
4. Determining equilibrium compositions of chemical reactions and two-phase liquid/vapor mixtures.

Course Outcomes(COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	State thermodynamic laws, Apply and evaluate heat and work interactions for the flow and non-flow processes.	2, 13		1
CO2	Analyze and evaluate pressure, volume and temperature with equations of state for gases. Evaluate the entropy changes associated with processes.	3	2, 13	1
CO3	Relate measurable and non-measurable thermodynamic properties. Differentiate between ideal and non- ideal solutions and calculate the partial molar properties.			1,2,3,13
CO4	Generate VLE data for solutions using correlations and interpret their consistency.		4	1,2,3,13
CO5	Determine the conversion at equilibrium and predict the effect of controllable variables on conversion.		4	1,2,3,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	2.4	2.5	2									2.4		

Course Content

1. **Basic Concepts and First Law of Thermodynamics:** Types of properties, functions, reversible and irreversible processes, zeroth law of thermodynamics, general statement of first law of thermodynamics, first law for cyclic process and non-flow processes, heat capacity. Derivation for closed system and steady state flow process. **7+2 Hrs.**
2. **P-V-T Behaviour:** P-V-T behaviour of pure fluids, equations of state and ideal gas law, processes involving ideal gas law: Constant volume, constant pressure, constant temperature, adiabatic and polytropic processes. Equations of state for real gases: van der Waals equation, Redlich – Kwong equation, virial equations,

principles of corresponding states, generalized compressibility charts, thermodynamic diagrams. **7+1 Hrs.**

3. **Second Law of Thermodynamics**: General statements of the Second law, concept of entropy, Carnot's principle, calculations of entropy change, Clausius Inequality, entropy and irreversibility, third law of thermodynamics. **7+1 Hrs.**
4. **Thermodynamic Properties of Pure Fluids:** Reference Properties, Energy Properties, Derived Properties, Work function, Gibbs free energy. Fundamental property relations: Exact differential equations, Fundamental property relations, Maxwell's equations, equations for U and H, effect of temperature on U, G, H and S, entropy- heat capacity relations, relationship between C_p and C_V, Clapeyron equation, Gibbs-Helmholtz equation, fugacity and fugacity coefficient, determination of fugacity of pure fluids. **8+1 Hrs.**
5. **Properties of Solutions:** Partial molar properties, Gibbs-Duhem equation, chemical potential, fugacity in solutions, Henry's law and dilute solutions, activity in solutions, activity coefficients, property changes of mixing, excess properties. **8+1 Hrs.**
6. **Phase Equilibria:** Criteria of phase equilibria and stability, phase equilibria in single and multicomponent systems, Duhem's theorem, vapor-Liquid equilibria, ideal and nonideal solutions, VLE at low pressures, VLE correlations, G-D equation for VLE, consistency tests, VLE at high pressures, liquid-liquid equilibrium. **8+1 Hrs.**
7. **Chemical Reaction Equilibria**: Reaction stoichiometry, criteria of chemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature and pressure on equilibrium constants and other factors affecting equilibrium conversion, liquid phase reactions, heterogeneous reaction equilibria, phase rule for reacting system. **7+1 Hrs.**

Reference Books:

1. Smith, J.M. and Vanness, H.C., "Introduction to Chemical Engineering Thermodynamics", 7/e, McGraw Hill, New York, 2005.
2. Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.
3. Rao, Y.V.C., "Chemical Engineering Thermodynamics", New Age International Publication, Nagpur, 2000.
4. Sandler and Stanley, "Chemical, Biochemical and Engineering Thermodynamics", 4/e, John Wiley, 2007. ISBN 0471661740

18UCHC403	Pollution Control Engineering	(3-0-0)3

Contact Hours: 39

Course Learning Objectives:

1. To create awareness on the various environmental pollution aspects and issues and give a comprehensive insight into natural resources, ecosystem, and biodiversity.
2. To understand the different parameters, treatment methods and control techniques of various environmental pollution.

Course Outcomes(COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline the importance of the environment on mankind, standards and legislation of different pollution parameters	3, 6, 7	14	
CO2	Interpret various parameters of waste water and explain different methods of treatment in specific industries		14, 15	3, 6, 7
CO3	Identify the sources and effects of different types of air pollutants, their prevention and control techniques in specific industries		3, 6, 7	14
CO4	Understand the different methods for handling and disposal of solid waste and control measures of noise pollution in industries		3, 6, 7	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2			2	2							2.5	2

Course content:

1. **Introduction:** Importance of Environment for Mankind. Engineering, ethics and environment. Ecological systems and pollution, hydrological cycle and nutrient cycle. Damages from environmental pollution. Fundamental definition of

pollution parameters- air, water and soil quality criteria, standards and legislation and acts, EIA, EIS and EMP. Air, water and soil pollution management through waste minimization. **6Hrs.**

2. **Water Pollution and waste water treatment:** Water Resources. Wastewater Classification. Types of Water Pollutants. Waste Water Sampling, Methods of Analysis: DO, BOD, COD, TOC, Nitrogen, Phosphorus, Trace Elements and Alkalinity. Wastewater Treatment: Preliminary, Primary, Secondary and Tertiary. Advanced wastewater Treatment: Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electrodialysis cell. Design of sedimentation tanks and biological treatment processes. Industrial case studies. **14Hrs.**
3. **Air Pollution and treatment:** Definition, Sources, Classification, Properties of air pollutants, Effects of air pollution on health vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling. Analysis of air pollutants. Air pollution meteorology (generation transportation and dispersion of air pollutants). Control methods and Equipment's for particulates and gaseous pollutants. Selection design and performance analysis of air pollution control equipment: gravity settling chambers, cyclone separator, ESPs, filters and wet scrubbers. Industrial case studies. **12Hrs.**
4. **Solid Waste Treatment and Noise pollution:** Sources and Classification, Effect on public health, Methods of Collection, onsite handling, storage and processing techniques, Disposal Methods, Reuse, Recovery and Recycling of Solid Waste.Solids waste disposal– compositing, landfill, briquetting/gasification and incineration.Definition, Sources, Effects of Noise, and Equipment's used for Noise Measurement, Approaches for Noise Control. **7Hrs.**

Reference Books:

1. C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2. S .P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill.
3. Metcalf and Eddy, "Waste Water Engineering Treatment Disposal Reuse" Tata McGraw Hill, 4/e, 2003.
4. Frank Kreith and George Tchobanoglous- "Hand book of Solid waste Management", Tata Mc-Graw Hill, 2/e.

18UCHC404	Energy Technology and Management	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives:

1. Understand the utilization of conventional and non – conventional energy sources and the principle of working of related equipments.
2. Recognize the effects of current energy systems on the environment and society.
3. Study energy costs/waste minimization without affecting production and quality.

Course Outcomes(COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify and comprehend the effects of current energy systems based on solid and gaseous fuels.	3	2,13	1
CO2	Analyze the principles and concepts involved in non – conventional energy sources such as solar, geothermal, wind, biomass, ocean and tidal energy.	3, 14	2, 13	1
CO3	Describe the challenges and problems associated with solar, geothermal, wind, biomass, ocean and tidal energy sources with regards to future energy supply and environmental concern.	1	2,13	3, 14
CO4	Discuss the principles and need of energy audit and management programs.		2,13	1

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.5	2	1.7										2	2	

Course Content:

1. **Introduction to Energy sources:** World energy futures, Indian energy scenario, Conventional and non-conventional energy sources.
   Fuels: Classification, properties and tests and analysis of solid, liquid and gaseous fuels. **5Hrs.**

2. **Solar Energy:** Solar constant, Solar radiation at earth's surface, Solar radiation geometry, Solar radiation measurement. Solar water heating, space cooling, Solar distillation, pumping and Solar cooking- Basic principles, methods, applications, advantages and limitations. **6 Hrs.**
3. **Wind Energy:** Introduction, Basic components of WECS (wind energy conversion system). Classification of WEC Systems. Types of wind energy machines- (wind energy collectors) horizontal axis, vertical axis machines. **5 Hrs.**
4. **Bio–Energy:** Introduction, Biomass conversion technology, Wet and Dry process, Factors affecting Bio digestion or Generation of gases, Classification of Bio gas plants, Floating Drum, Fixed Dome plants -Basic principles, Construction and Working principles, Advantages and disadvantages. **6 Hrs.**
5. **Fuel cells**: Design and Principle of operation, Classification, Types, Advantages and disadvantages, Conversion efficiency, Types of electrodes, Work output and EMF of Fuel Cells, Applications of Fuel Cells. **5Hrs.**
6. **Geothermal and ocean energy:** Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India**.**

   Ocean Energy: Principle of working, performance and limitations of Wave Tidal Energy. Ocean Thermal Energy-Availability, theory and working principle, performance and limitations. **6 Hrs.**
7. **Energy management:** Principles and needs initiating and managing an energy management programs, Energy Audit – Elements and concepts, Types of Energy Audits, Energy Audit of any one chemical industries. **6 Hrs.**

Reference Books:

1. G.D. Rai, "Non-Conventional Energy Sources", 4/e Second Reprint, Khanna Publications", 1997.
2. P.C. Jain and M. Jain, "Engineering Chemistry", 10/e, 3rd Reprint, DhanpatRai and Sons, 1995.
3. S.P. Sukhatme, "Solar Energy", 2/e, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.
4. G.D. Rai, "Solar Energy Utilization", 4/e, Khanna Publications.
5. G.N.Tiwari and M.K.Ghosal, "Renewable Energy Resource: Basic Principles and Applications", Narosa Publishing House, 2004.

18UCHL405 Computational Methods & Simulation Laboratory

(0-0-3) 1.5

Contact Hours: 30

Course Learning Objective:

1. To understand the application of mathematics using computer to solve the simple Chemical Engineering problems.

Course Outcomes(COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Solve Chemical Engineering problems using the analytical methods and programming.	9	10	4, 5,15
CO2	Compute the chemical engineering problems with nonlinear-algebraic equations.	9	10	4, 5,15
CO3	Compute the chemical engineering problems with Numerical Integration	9	10	4, 5,15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	-	8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3	3			2	1.25	2.25					3

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – Simpson's1/3 rule.
6. Curve fitting – Least square method
7. Double pipe heat exchanger (Area, Length)
8. Bubble and dew point calculation.
9. Introduction to Unisim design Software
10. Simulation studies of flash drum
11. Simulation studies of CSTR
12. Simulation studies of Heat Exchanger.
13. Simulation studies of Mixer

Note: Minimum 10 experiments to be conducted.

Reference Books:

1. Jenson, V.J. and Jeffereys, G.V., “Mathematical Methods in Chemical Engineering”, Academic Press, London and New York, 1977.
2. Mickley, H.S., Thomas. K. Sherwood and Road, C.E., “Applied Mathematics in Chemical Engineering”, Tata McGraw-Hill Publications, 1957.
3. S. Pushpavanam, “Mathematical Methods in Chemical Engineering”, PHI
4. E. Balagurusamy, “Programming in ANSI C”, 6/e, TMH 2012.

18UCHL406	Fluid Mechanics Laboratory	(0-0-3) 1.5

Contact Hours: 30

Course Learning Objective (CLOs):

1. To understand the principle, construction, working and analysis of different equipment’s in the fluid flow phenomena.

Course Outcomes(COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Calculate the discharge rate for flow measuring devices and pumps	9	10	4,15
CO2	Distinguish the types of pipe fitting and identify their applications	9	10	4,15
CO3	Identify the flow pattern of the fluid and evaluate the friction factor of the spiral coil	9	10	4,15
CO4	Calculate the minimum fluidization velocity	9	10	4,15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	-	8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3				2	1.2	2.2					3

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List of Experiments:

1. Fluidized bed.
2. Study and development of characteristics for centrifugal pump
3. Local velocity measurement using Pitot tube.
4. Positive Displacement Pump Characteristics
5. Packed Bed
6. Reynolds Experiment
7. Flow through spiral coil
8. Orifice meter and venturimeter characteristics
9. Friction in circular pipes
10. Pipe fittings
11. Weir characteristics
12. Bernoulli’s theorem

Note: Minimum 10 experiments to be conducted.

Reference Books:

1. McCabe and Smith, “Unit operations of Chemical Engineering” 7/e, McGrawHill.
2. Coulson J.H and Richardson J.F, “Chemical Engineering” Vol-1, 5/e. Butterworth publications.
3. Kumar K.L., “Engineering Fluid Mechanics”, 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4. R. K. Bansal, “A textbook of Fluid Mechanics” 2/e, Laxmi Publications. ISBN: 9788131802946s

18UCHL407	Introductory Project	(0-0-2) 1

Contact Hours: 24

Course Learning Objective:

1. To identify and understand the community expectation in terms of possible engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify the problem.	7, 14	12	2,10
CO2	Compare the literature review and select suitable existing solutions.	7, 10,14	8,11,12	3,4,5,15
CO3	Prepare work plan with economic analysis.	9	8,10,12	11,15
CO4	Prepare a precise report with proper guidelines and references.	9	8,15	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3.0	3.0	3.0	3.0		1.0	2.0	1.0	2.25	2.5	2.0		1.0	2.7

Introductory project is introduced with an objective of understanding and identifying the community expectation in terms of possible Engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses. The project shall be engineering oriented in terms of problem definition, related literature survey and existing solutions. The team consisting of 10-12 students shall be asked to identify problems related to community and try to propose a solution. The faculty members handling the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for introductory project.

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Reference Books/Material:

1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field

SDM College of Engineering & Technology, Dharwad

Odd Semester 2019-20

Academic Calendar for UG Programmes

Sl. No.	Particulars	Date
1	Registration	27-07-2019 to 31-07-2019
2	Induction program for First Semester (Tentative)	01-08-2019 to 14-08-2019
3	Teaching Commences for odd semester except I Sem	01-08-2019
4	Last date for registration with late fee	06-08-2019
5	Teaching Commences for I semester	16-08-2019
6	Display of attendance	16-09-2019
7	Internal Assessment – IA– I	18-09-2019 to 20-09-2019
8	Communication of performance to the parents	26-09-2019
9	Last date to drop the course	27-09-2019
10	Display of attendance	02-11-2019
11	Internal Assessment –IA– II	04-11-2019 to 06-11-2019
12	Students Feedback	11-11-2019 to 15-11-2019
13	Communication of performance to the parents	13-11-2019
14	Last date to withdraw the course	13-11-2019
15	Teacher – Parents Meet	16-11-2019
16	Internal Assessment –IA– III	27-11-2019 to 29-11-2019
17	Last day of teaching for Odd Semester	30-11-2019
18	Final Lab Assessments	03-12-2019 to 10-12-2019
19	Display of consolidated Continuous Internal Evaluation (CIE) & Attendance	05-12-2019
20	Communication of performance to the parents	05-12-2019
21	Semester End Examination	13-12-2019 to 27-12-2019
22	Inter Semester Recess	28-12-2019 to 12-01-2020
23	Declaration of Results	09-01-2020
24	Communication of performance to the parents by putting on website	10-01-2020
25	Makeup SEE for odd semesters	11-01-2020 to 18-01-2020
	Commencement of Even Semester :	**13-01-2020**

Dean (Academic Program) PRINCIPAL

Academic Calendar (Tentative) for Even Semester 2019-20

B.E. & M.Tech

Sl. No.	Particulars	Date
1	Registration	09-01-2020 to 11-01-2020
2	Commencement of Teaching	13-01-2020
3	Last date for registration with late fee	18-01-2020
4	Display of attendance	18-02-2020
5	Internal Assessment – IA– I	24-02-2020 to 26-02-2020
6	Communication of performance to the parents	03-03-2020
7	Last date to drop the course	04-03-2020
8	Parents Meet	14-03-2020
9	Insignia – 2020	20-03-2020 & 21-03-2020
10	Display of attendance	30-03-2020
11	Internal Assessment – IA– II	01-04-2020 to 03-04-2020
12	Last date to withdraw the course	08-04-2020
13	Communication of performance to the parents	11-04-2020
14	Feedback by Students	20-04-2020 to 25-04-2020
15	Internal Assessment –IA– III	04-05-2020 to 06-05-2020
16	Last day of teaching for Even Semester	06-05-2020
17	Final Lab Assessments	09-05-2020 to 20-05-2020
18	Display of consolidated Continuous Internal Evaluation (CIE) marks & Attendance for 8th semester	09-05-2020
19	Semester End Examination for 8th semester	11-05-2020 to 19-05-2020
20	Display of consolidated CIE marks & Attendance for 2nd, 4th & 6th semesters (Both for UG & PG)	13-05-2020
21	Communication of performance to the parents	14-05-2020
22	Project exam for 8th semester	21-05-2020 to 26-05-2020
23	Semester End Examination for 2nd, 4th & 6th semesters (Both for UG & PG)	22-05-2020 to 05-06-2020
24	Results for 8th semester	30-05-2020
25	Summer vacation	06-06-2020 to 31-07-2020
26	Announcement of Results for 2nd, 4th & 6th semester (Both for UG & PG)	12-06-2020

Supplementary Semester: 12-06-2020 to 27-07-2020

Commencement of next Academic Year 2020 - 21: 01-08-2020
Dean (Academic Program) **PRINCIPAL**

Supplementary Semester Calendar for B.E./M.Tech/MBA – 2020

Sl. No.	Particulars	VII & VIII Sem (B.E.)	I to VI Sem (B.E.), M.Tech& MBA
1	Registration	01-06-2020 to 03-06-2020	06-06-2020 to 08-06-2020
2	Teaching Commences	01-06-2020	12-06-2020
3	Registration with special permission by Principal	04-06-2020	12-06-2020
4	Internal Assessment (IA) – I	13-06-2020 & 15-06-2020	24-06-2020 & 25-06-2020
5	Internal Assessment (IA) – II	25-06-2020 & 26-06-2020	03-07-2020 & 04-07-2020
6	Internal Assessment (IA) – III	10-07-2020 & 11-07-2020	13-07-2020 & 14-07-2020
7	Display of consolidated Continuous Internal Evaluation (CIE) marks & Attendance	13-07-2020	16-07-2020
8	Supplementary SEE	14-07-2020 to 17-07-2020	18-07-2020 to 23-07-2020
9	Declaration of results	22-07-2020	27-07-2020

Dean (Academic Program) **PRINCIPAL**

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Academic Program: UG

Academic Year 2019-20

Syllabus

V & VI Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002

(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465** **Fax: 0836-2464638** **Web:** www.sdmcet.ac.in

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SDM College of Engineering & Technology, Dharwad

Date:18-7-2019

It is certified that the scheme and syllabus for V & VI semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2019-20 till further revision.

Principal Chairman BoS & HoD

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College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes POs) and Program Specific outcomes(PSOs)

Chemical Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

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Scheme for V Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC500	Chemical Reaction Engineering – II	4-0-0	4	50	100	3		
15UCHC501	Mass Transfer – II	4-0-0	4	50	100	3		
15UCHC502	Chemical Equipment Design	4-0-0	4	50	100	3		
15UCHC503	Chemical Plant Utilities and Safety	4-0-0	4	50	100	3		
15UCHL504	Heat Transfer Laboratory	0-0-3	1.5	50			50	3
15UCHL505	Environmental Engineering Laboratory	0-0-3	1.5	50			50	3
15UCHE50X	Elective-1	4-0-0	4	50	100	3		
15UCHE50X	Elective-2	4-0-0	4	50	100	3		
	Total	**24-0-6**	**27**	**400**	**600**		**100**	
15UCHE506	Process Instrumentation	4-0-0	4	50	100	3		
15UCHE507	Energy Technology and Management	4-0-0	4	50	100	3		
15UCHE508	Solution Thermodynamics	4-0-0	4	50	100	3		
15UCHE509	Food Technology	4-0-0	4	50	100	3		
15UCHE510	Fertilizer Technology	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Scheme for VI Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC600	Management, Entrepreneurship and Protection of Intellectual Property Rights	4-0-0	4	50	100	3		
15UCHC601	Chemical Process Integration	4-0-0	4	50	100	3		
15UCHC602	Process Equipment Design and Drawing	3-0-2	4	50	100	3		
15UCHL603	Mass Transfer Laboratory	0-0-3	1.5	50			50	3
15UCHL604	Chemical Reaction Engineering Laboratory	0-0-3	1.5	50			50	3
15UCHL605	Mini Project	0-0-8	4	50			50	3
15UCHE60X	Elective – 3	4-0-0	4	50	100	3		
15UCHE60X	Elective – 4	4-0-0	4	50	100	3		
	Total	**19-0-16**	**27**	**400**	**500**		**150**	
15UCHE606	Petroleum and Petrochemicals	4-0-0	4	50	100	3		
15UCHE607	Catalyst Technology	4-0-0	4	50	100	3		
15UCHE608	Applied Mathematics in Chemical Engineering	4-0-0	4	50	100	3		
15UCHE609	Polymer Science and Technology	4-0-0	4	50	100	3		
15UCHE610	Composite Materials	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the third year: 54

V Semester

15UCHC500 Chemical Reaction Engineering-II (4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To understand Non-Ideal flow behavior in Chemical reactors.
2. To provide the forum to understand the Principles and concepts involved in Catalytic reactions.
3. To understand kinetics of heterogeneous reactions (Non-Catalytic) and apply the same for reactor design.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Define residence time distribution and determine conversion using single parameter models for real reactors.	1		2
CO2	Explain various methods to estimate properties of a given catalyst and evaluate its performance.		1	4
CO3	Develop performance equations for reactors containing porous catalyst and apply the same for reactor design.		4	3,13
CO4	Develop the mechanism and determine the deactivation and regeneration rates in various reactors.		4	3
CO5	Interpret various kinetic regimes for heterogeneous non- catalytic reactions and apply the same for reactor design.	4	2	3,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2.5	3	2									3		

Prerequisites: Chemical Reaction Engineering-I

Course Content:

1. **Basics of non-ideal flow:** Causes for non-ideal flow, the residence time distribution (RTD), E, C and F. Curves, Experimental methods for finding extent of non-ideal behavior, Micro and macro mixing, conversion in non-ideal flow reactors from tracer information, dispersion model and tanks-in-series model. **12 Hrs.**
2. **Fluid-Particle reactions:** Introduction to heterogeneous non-catalytic reactions, industrial examples, overall rate expression, Ideal contacting

patterns, progressive conversion and shrinking core model, overall rate expression for various controlling mechanisms from shrinking core model, conversion – time expressions, Design of reactors for particles of single size and different sizes under ideal flow patterns. **10 Hrs.**

3. **Fluid – Fluid reactions:** Industrial examples, Rate equations for straight mass transfer and mass transfer with chemical reaction, various kinetic regimes, liquid film enhancement factor, Role of Hatta number, Design of reactors for fluid-fluid reactions under co current and counter current operations based on ideal flow patterns. **10 Hrs.**
4. **Fluid – Solid Catalytic reactions:** The nature and mechanism of catalytic reactions, Adsorption isotherms, physical, chemical dynamic and mechanical properties of solid catalyst and their determination, catalyst preparation, overall rate expressions for various controlling mechanisms. **10 Hrs.**
5. **Catalyst deactivation:** Causes for deactivation, mechanisms of deactivation, Experimental methods to find deactivation kinetics using Batch- solids and Batch-fluids, Batch solids and Mixed constant and variable flow of fluid, Batch solids and plug constant and variable flow of fluid. **10 Hrs.**

Reference Books:

1. Octave Levenspiel, "Chemical Reaction Engineering", 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2. J. M. Smith, "Chemical Engg Kinetics", 3/e, McGraw Hill, 1981. ISBN:0-07-066574-
3. H. Scott Fogler, "Elements of Chemical Reaction Engineering", 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

15UCHC501	Mass Transfer - II	(4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To understand the principles and mechanism of diffusion mass transfer in applying to various separation processes viz. distillation, absorption, extraction and leaching.
2. To propose and evaluate the performance of the related equipment for separations involving diffusion.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline the principles of different			

	mass transfer equipment.	13	1	1, 2
CO2	Interpret and analyze the concept and mechanism of gas absorption, and sizing of absorption column	1	2	3, 13
CO3	Explain the phenomena of vapor-liquid equilibria, principle and types of distillation process	1	2	3, 13
CO4	Calculate the no of stages for distillation process by different methods	1	2	3, 13
CO5	Explain the extraction and leaching concepts and processes and to determine the no of stages required.	1	2	3, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	1.2	2.2	3										2.6		

Prerequisites: Mass Transfer-I

Course Content:

1. **Gas Liquid Contacting Systems:** Types, construction and working of equipment – Distillation, Absorption, Humidification & Drying.
   Gas Absorption: Mechanism of gas absorption, equilibrium in gas absorption, Choice of solvent, Equilibrium concept in absorption, application of mass transfer theories to absorption, calculation of HETP, HTU, NTU, calculation of height of packing. Absorption and stripping factors, tray efficiencies, absorption with chemical reaction. **14 Hrs.**
2. **Distillation:** Vapor-liquid equilibria, Relative volatility, Ideal Solutions, Relative volatility, Azeotropic mixtures, Raoult's law, Types of distillation, extractive, azeotropic, flash, differential distillation, low-ressure distillation; steam distillation, **8 Hrs.**
3. **Continuous Distillation:** multistage continuous rectification, Total reflux, minimum reflux ratio, optimum reflux ratio. Design calculations by McCabe-Thiele and Ponchon-Savarit methods; Murphree, stage and overall efficiency, calculation of actual number of stages, Multicomponent distillation . **12 Hrs.**

4. **Liquid-Liquid Extraction** Liquid-Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Different types of extractors: Selection, construction, and operation **10 Hrs.**

5. **Leaching operation:** Solid-liquid extraction (Leaching), various types with application, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages Leaching equipment: Selection, construction, and operation **8 Hrs.**

Reference Books:

1. Robert. E. Treybal, "Mass Transfer Operation", 3/e, McGraw Hill, 1981.
2. McCabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/ e, Mc Graw Hill, 2001.
3. Coulson and Richardson, "Chemical Engg Vol. 2 and Vol 4, 4/e. Pergamon press, 1998.
4. Geankoplis, C.J., "Transport Processes and Unit Operations", 3/e, Prentice Hall (I).

15UCHC502 Chemical Equipment Design (4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To develop key concepts and techniques with relevant codes and standard procedures of different equipments.
2. To study the detailed design considerations of different types of equipments used in chemical industries.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Congregate the data from relevant code books and identify the standard procedures for the design of chemical plant equipment.	3	1	14
CO2	Design and evaluate the components of the reaction and pressure vessels.	1	2	3, 13
CO3	Design and evaluate the components of the storage and tall vertical vessels.	1	2	3, 13
CO4	Estimate the pipe size; pump rating with accessories to provide the valid conclusions for their use.		3	13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	1.3	2	2.25										3	3	

Course Content:

1. **Introduction:** Design procedure, equipment classification and components, design parameters, pressure vessel codes. Design considerations: Material selection, factors affecting design, stresses due to static and dynamic loads (Internal and External), temperature effects, and economic considerations **8 Hrs.**
2. **Design of Pressure Vessels:** Design parameters, conditions and stresses. Design of shell and other vessel components. Vessel at low and high operating temperatures. Design of components, supports and selection of vessels accessories and mountings. Numerical problems. **12 Hrs.**
3. **Design of Reaction Vessels:** Design of reaction tanks-agitators, baffles, jackets, tank dimensions. Power calculations. Drive calculations and accessories. Support calculations for the system. Numerical problems **10 Hrs.**
4. **Design of Tall Vertical Vessels:** Vessels subjected to wind loads. Multi shell constructions. Determination of shell thickness. Supports for columns. Numerical problems **8 Hrs.**
5. **Pipe Line Design:** Pipe thickness, pipe diameter. Optimum size of delivery line in pumping operations. Pump rating. Numerical problems. **8 Hrs.**
6. **Introduction to Design of Storage Vessels:** Process conditions and design parameters for storage of volatile, nonvolatile fluids and gases. Design of components, supports and selection of vessels accessories and mountings. Roofs for vessel. Numerical problems. **6 Hrs.**

Note: IS code book 2825 for pressure vessel design is permitted in the exams for reference.

Reference Books:

1. V V Mahajani & S B Umarji, "Joshi‟s Process Equipment Design" – Trinity Press, Delhi, India 4 th edition.
2. S. D. Dawande, "Process Design of Equipment", Vol 1, Central Techno Publications. 3rd edition, 2003.
3. Brownell & Young, "Process equipment design" Willy student, 1 st edition, 2009
4. Don W. Green & Robert H. Perry, "Chemical Engineers Handbook", 6 th edition, McGraw Hill, 2014.
5. Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, , New Delhi, 1969.

15UCHC503	Chemical Plant Utilities and Safety	(4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To understand the utilities in a chemical process plant, types, role and their selection.
2. To understand the principles of safety with insight of safety analysis techniques and application of safety devices.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	List and comprehend the selection and role of utilities in a chemical plant.	5	3	14
CO2	Appraise the generation, handling and role of water, steam and air in a chemical plant.	3,5	14	
CO3	Assess refrigerants, evaluate the performance and apply refrigeration.	3,5	7,14	
CO4	Prioritize safety aspects, plan and use safety devices in defiant situations in a chemical plant.	3,5	6,8	14
CO5	Interpret safety analysis tools and techniques and translate to hazardous conditions.	3	5,7	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			1.2		1.2	2	2	2						2.5	

Course Content:

1. **Water and Steam:** Resources, Cooling water-requirements and treatments, Process water-Ion Exchange, Water softening methods-Ion exchange, Reverse osmosis, Electro dialysis, Water pretreatment, recycle and reuse, various pumps. Generators, Efficiency, Feed water Treatment and Steam quality, Steam consumption, Steam distribution, Condensate removal, condensate recovery,. **12 Hrs.**
2. **Air:** Compressed air for process and instruments, Blowers and Fans-Characteristics, Compressed- Positive displacement and Centrifugal features, Multistage Compression-features, Vacuum pumps, Air Drying-Pressure swing **9 Hrs.**

3. **Refrigeration:** Carnot Cycle and Reverse Carnot Cycles, Tonnage, Primary and Secondary refrigerants, Vapor Compression Refrigeration; various refrigerants, Tonnage. Vapor Absorption Refrigeration- Characteristics, Comparison. **9 Hrs.**
4. **Process Safety and Devices:** Safety aspect, safe design, Intrinsic and Extrinsic safety, Hazards, Risk, Toxicity, Flammability, Fire, Explosion, TLV, Sources of ignition, Hazardous materials and conditions, Reactive chemicals, Combustion and Flammability, Gas explosion, Dust Explosion, UCVCE, Static Electricity, Vacuum Hazards, Inert Gas Hazards, Gas Dispersion, Safety Devices; Pressure Relief Systems, Emergency relief devices, Flame arrestors, storage and handling. **12 Hrs.**
5. **Safety Analysis & Case studies:** Hazard Analysis (HAZAN), Hazard and Operability studies (HAZOP), Comparison, Risk Analysis and Estimation, Safety check list. Case Studies: Bhopal, Jaipur, Flixborough, Seveso, Piper Alpha, Mexico [LPG Fire] **10 Hrs.**

Reference Books:

1. Perry's "Handbook of Chemical Engineers" 7/e, Mc-Graw Hill Publications.
2. Frank P. Lees, "Loss Prevention", Vol 1 and Vol 2.
3. Jack Broughton, "Process Utilities", I Chem publications.

15UCHL504	Heat Transfer Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives:

1. To study the phenomena of conduction, convection and radiation effects in different equipments and know the rate of heat transfer.
2. To study the working, construction and analyse the efficiency and performance of heat exchangers.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify the different modes of heat transfer and evaluate the rate of heat transfer coefficient.	9	10	4,15
CO2	Determine the thermal conductivity of solids and liquids.	9	10	4,15
CO3	Distinguish the different types of heat exchangers and identify their applications.	9	10	4,15

CO4	Evaluate the performance and efficiency of the heat exchangers using the steam and recognize the boiler characteristics.	9	10	4, 15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report.		8, 10	9

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level				3				2	1.4	2					3

List of Experiments:

1. Double pipe heat exchanger
2. Cross flow heat exchanger
3. Thermal conductivity of liquids
4. Heat transfer through lagged pipe
5. Emissivity determination
6. Stefan - Boltzmann apparatus
7. Extended surfaces
8. Packed bed vertical condenser
9. Heat transfer through helical coil
10. Unsteady state heat transfer
11. Natural and forced convection in a jacketed vessel
12. Evaporator
13. Solar heater
14. Heat transfer through fluidized bed

Note: Minimum 10 experiments to be conducted

Reference Books

1. J.P.Holman, “Heat Transfer”, 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2. Rao Y.V.C., “Heat Transfer”, Edition illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3. McCabe and Smith “Unit Operations of Chemical Engineering”.7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4. Coulson and Richardson, “Unit Operations of Chemical Engineering” Vol.1. 6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

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15UCHL505 Environmental Engineering Laboratory (0-0-3)1.5

Contact Hours: 30

Course Learning Objective:

1. To understand the employability of instruments in determining various parameters of solid, liquid and gas samples to analyze completely and present a good technical report.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Reproduce theory and apply into practice for using high precision instruments for analysis.	9	10	4,15
CO2	Characterize the samples through the use of pollution indicators and report the results.	9	10	4,15
CO3	Comprehend the use of instruments in projects.	9	10	4,15
CO4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report.		8, 10	9

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3				2	1.5	2					3

.

List of Experiments:

1. Analysis of effluents for pH, alkalinity and turbidity
2. Determination of COD and BOD
3. Volatile, Fixed, Filterable and Dissolved solid analysis
4. Analysis by ion selective electrode (any two anions)
5. Measurements of particulate matter in Air
6. Analysis of exhaust by Orsat Apparatus.
7. Dissolved Oxygen Measurement
8. KF Auto Titrator
9. Flame Photometer
10. Turbidometer
11. Viscometer
12. mV Titrator

Note: Minimum 10 experiments to be conducted

Reference Books

1. C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2. Metcalf and Eddy - "Waste Water Engineering Treatment Disposal Reuse" 4/e, Tata McGraw Hill, 2003.
3. Jaffery, G.H., Basset, J., et. al., " Vogel's Text book of Quantitative Inorganic Analysis" 5/e, ELBX, 1998
4. Skoog, D.A., "Principles of Instrumental Analysis" 3/e, Saunders College publishing 1985.

15UCHE506	Process Instrumentation	(4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To make students understand the Identification, classification construction, working principle and application of various transducers used for Displacement, Temperature, Level, flow and Miscellaneous measurement.

Course Outcomes (COs):

COs	**Description: At the end of the course student will be able to**	**Mapping to POs(1-12) and PSOs(13-15)**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Comprehend the fundamentals of instrumentation to control chemical processes.	3	1,13	
CO2	Explain process control instrumentation with principles and theory	3,13	1	
CO3	Apply correct practice to installation, calibration of instrument and analyze limitations of each measuring instruments.	1,13	3	
CO4	Troubleshoot, isolate and fix electronic instrumentation problems.		1,3,13	
CO5	Design a simple instrumentation system.	13	1	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.8		1.8										1.4		

Course content:

1. **Introduction:** classification, characteristics of instruments- static and dynamic. Sensor and Transducer: Definition, classification (active, passive, primary, secondary, mechanical, electrical, analog, digital).Transducer

specifications. Transmitters, Converters, Control panel, Recorders and monitors. Error: definition, classification. **5 Hrs.**

2. **Flow Measurement:** Head Type: orifice, venturi, nozzle, pitot tube. Variable Area Type: Rotameter type. Other flow meters: Turbine, electromagnetic, ultrasonic, positive displacement, anemometers, solid flow measurements. **7Hrs.**
3. **Pressure Measurement:** Pressure scales, units and relations, classification, U-tube types, well type, inclined type manometer, micro manometer, bellows, diaphragm, bourdon tube,. Vacuum Measurement Units and relations, McLeod gauge, Pirani gauge, thermocouple gauge, hot cathode ionization gauge, Knudsen gauge. **5 Hrs.**
4. **Level Measurement:** Need for Level Measurement, Classification of Level Measurement Techniques. Construction and working of Dipstick, displacer, float system, bubbler, capacitive devices for level measurement, ultrasonic level gauge, DP cell, vibrating type, radar, radioactive type level gauges, LASER type transducers, fiber optic level sensors. **6 Hrs.**
5. **Temperature Measurement:** Temperature scales, classification of Temperature Sensors, a) Thermometers: Classification, Construction and working of glass thermometers, liquid expansion thermometer, gas thermometer (filled system thermometer), bimetallic thermometer, Specifications. b)Resistance temperature detector (RTD):Principle, types, Configurations, construction and working of RTD, Material for RTD, Lead wire Compensation in RTD, Specifications, advantages, disadvantages and applications of RTD. c) Thermistors: Principle, types (NTC and PTC), characteristics, Construction and working, materials, specifications of Thermistor, applications. **10 Hrs.**
6. **Thermocouples:** Principle, thermoelectric effect, See beck effect, Peltier effect, laws of thermocouple, types of thermocouple with characteristic curve, thermocouple table, Sensitivity, constructional features of Thermocouples, Thermo couple specifications, cold junction Compensation method, thermopile, thermocouple emf measurement method, Thermo well. Pyrometers: Principle, Construction and working of Radiation and optical pyrometers and its Applications. **6 Hrs.**
7. **Displacement Measurement:** a) Resistance potentiometer: piezo-resistive effect, ultrasonic transducer. LVDT, RVDT. Selection and properties of materials for LVDT, and general electromagnetic sensors. b) Capacitance type transducers: with applications, materials for capacitive, ultrasonic and elastic transducers. c) Digital transducer: translational and rotary encoders, Optical and magnetic pickups. d) Pneumatic transducer: flapper- nozzle transducer. **6 Hrs.**

8. **Miscellaneous Transducers:** Transducers for Position, speed, acceleration, humidity, and moisture measurement. Electronic measuring instruments, Electronic voltmeters, Principle of A/D and D/A converters. **7 Hrs.**

Reference Books:

1. Donald Eckman, “Automatic Process Control”, Wiley Eastern Limited
2. John P. Bentley, “Principles of Measurement Systems”, 3/e, Addison Wesley Longman Ltd., UK, 2000.
3. Doebelin E.O, “Measurement Systems - Application and Design”, 4/e, McGraw-Hill International Edition, New York, 1992.
4. Stephanopoulos George, “Chemical Process Control”.

15UCHE507	**Energy Technology and Management**	**(4-0-0) 4**

Contact Hours: 52

Course Learning Objectives:

1. Understand the utilization of conventional and non – conventional energy sources and the principle of working of related equipments.
2. Recognize the effects of current energy systems on the environment and society.
3. Study energy costs/waste minimization without affecting production and quality.

Course Outcomes (COs):

COs	**Description: At the end of the course student will be able to**	**Mapping to POs(1-12) and PSOs(13-15)**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and comprehend the effects of current energy systems based on solid and gaseous fuels.	3	2,13	1
CO2	Analyze the principles and concepts involved in non – conventional energy sources such as solar, geothermal, wind, biomass, ocean and tidal energy.	3, 14	2, 13	1
CO3	Describe the challenges and problems associated with solar, geothermal, wind, biomass, ocean and tidal energy sources with regards to future energy supply and environmental concern.	1	2,13	3, 14
CO4	Discuss the principles and need of energy audit and management programs.		2,13	1

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.5	2	1.7										2	2	

Course Content:

1. **Introduction to Energy sources:** World energy futures, Indian energy scenario, Conventional and non-conventional energy sources.
   Fuels: Classification, properties and tests and analysis of solid, liquid and gaseous fuels. **6 Hrs.**
2. **Solar Energy:** Solar constant, Solar radiation at earth's surface, Solar radiation geometry, Solar radiation measurement. Solar water heating, space cooling, Solar distillation, pumping and Solar cooking- Basic principles, methods, applications, advantages and limitations. **10 Hrs.**
3. **Wind Energy:** Introduction, Basic components of WECS (wind energy conversion system). Classification of WEC Systems. Types of wind energy machines- (wind energy collectors) horizontal axis, vertical axis machines. **6 Hrs.**
4. **Bio – Energy (Thermal Conversion):** Introduction, Biomass conversion technology, Wet and Dry process,Factors affecting Bio digestion or Generation of gases, Classification of Bio gas plants, Floating Drum, Fixed Dome plants -Basic principles, Construction and Working principles, Advantages and disadvantages, Thermal gasification of biomass. Classification of Bio gasifiers. **10 Hrs.**
5. **Fuel cells**: Design and Principle of operation, Classification, Types, Advantages and disadvantages, Conversion efficiency, Types of electrodes, Work output and EMF of Fuel Cells, Applications of Fuel Cells. **6Hrs.**
6. **Geothermal and ocean energy:** Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India.
   Ocean Energy: Principle of working, performance and limitations of Wave Tidal Energy. Ocean Thermal Energy-Availability, theory and working principle, performance and limitations. **8 Hrs.**
7. **Energy management:** Principles and needs initiating and managing an energy management programs, Energy Audit – Elements and concepts, Types of Energy Audits, Energy Audit of any one chemical industries.**6 Hrs.**

Reference Books:

1. G.D. Rai, "Non-Conventional Energy Sources", 4/e Second Reprint, Khanna Publications", 1997.
2. P.C. Jain and M. Jain, "Engineering Chemistry", 10/e, 3rd Reprint, Dhanpat Rai and Sons, 1995.
3. S.P. Sukhatme, "Solar Energy", 2/e, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.

4. G.D. Rai, “Solar Energy Utilization”, 4/e, Khanna Publications.
5. G.N.Tiwari and M.K.Ghosal, “Renewable Energy Resource: Basic Principles and Applications”, Narosa Publishing House, 2004.

15UCHE508	Solution Thermodynamics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To calculate thermodynamic properties of fluids and fluid mixtures using equations of state.
2. To determine the equilibrium compositions of chemical reactions and two-phase Liquid /vapor mixtures.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Classify thermodynamic properties of pure fluids and derive equations which relate them to non measurables.			1,2,3,13
CO2	Differentiate between ideal and non- ideal solutions and calculate the partial molar properties.			1,2,3,13
CO3	Generate VLE data for solution using various correlations and interpret their consistency.		4	1,2,3,13
CO4	Determine the conversion at equilibrium and predict the effect of controllable variables on conversion.		4	1,2,3,13
CO5	Explain the important refrigeration cycles and list the properties of refrigerants.	3,13,15		1,2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	3	2.6	2									2.6		1

Prerequisites: Chemical Engineering Thermodynamics

Course Content:

1. **Thermodynamic Properties of Pure Liquids:** Reference Properties, Energy properties, Derived properties, Work function, Gibbs free energy, Relationships among thermodynamic Properties: Exact differential equations,

Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, Modified equations for U and H, Effect of temperature on U, H and S, Relationships between C_p and C_v, Gibbs-Helmholtz equation, Fugacity: Fugacity, Fugacity coefficient, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: effect of temperature and pressure, Thermodynamic diagrams. **10 Hrs**.

2. **Properties of Solutions:** Partial molar properties, Chemical potential, Fugacity in solutions, Henry's law and dilute solutions, Activity and Activity coefficients, Gibbs-Duhem equation, Property changes of mixing, excess properties. **10 Hrs.**
3. **Phase Equilibria:** Criteria of phase Equilibria, and stability, Duhem's theorem, Vapor-Liquid Equilibria, ideal and nonideal solutions, Consistency test for VLE data, Calculation of Activity coefficients using Gibbs-Duhem equation, Liquid-Liquid Equilibrium diagrams. **10 Hrs.**
4. **Chemical Reaction Equilibrium:** Reaction stoichiometry, Criteria of chemical reaction equilibrium, Equilibrium constant-temperature and pressure effect, standard free energy change, factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous reaction Equilibria, phase rule. **12 Hrs.**
5. **Refrigeration:** Carnot Refrigerator, Vapor compression cycle, choice of refrigerants. **10 Hrs**.

Reference Books:

1. Smith J.M and Vanness H.C. and Abbot, "Introduction to Chemical Engineering Thermodynamics", 5/e & 6/e, McGraw Hill, New York, 1996.
2. Rao, Y.V.C., "Chemical Engineering Thermodynamics" New Age International Publication, Nagpur, 2000.
3. Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.

15UCHE509	**Food Technology**	**(4-0-0) 4**

Contact Hours: 52

Course Learning Objectives:

1. To understand the basic principles of Food Science and Technology and applying this understanding to the growing and dynamic needs of the Food Industries.
2. To study the application of unit operations and modern trends in food processing industries.

Course Out comes (COs):

COs	Description: At the end of the	Mapping to POs(1-12) and PSOs(13-15)

	course student will be able to	Introductory 1	Moderate 2	Substantial 3
CO1	Understand the quality attributes and the chemistry of food	2		14
CO2	Apply unit operations and modern techniques for food processing	1	5	3
CO3	Identify and analyse the different food preservative, enzymes and additives required	14	2	6,7
CO4	Assess the impact of environmental concern and food safety	14	8	6, 7

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	1.5	3		2	3	3							1.6	

Course Content:

1. **Introduction and Quality Attributes of Food:** Function of foods. Food in relation to health. Aim of food science and technology. Quality attributes – Appearance factors, Textural factors, Flavour factors. Visual and objectively measurable attributes. Aroma of foods –introductory ideas, formation, chemistry and analysis. Taste – introductory ideas, formation and chemistry. Additional quality; quality standards, quality control. Introduction to sensory evaluation of foods and beverages. **6 Hrs.**
2. **Formation and Chemistry of Food:** Carbohydrates. Proteins. Lipids. Vitamins. Minerals. Water. Biotin. Choline. Phytochemicals. **4 Hrs.**
3. **Food Processing and Preservation:** Food deterioration – Causes. Aims and objectives of preservation and processing. Unit operations in processing. Different methods of food preservation – low temperature, high temperature, preservatives, osmotic pressure, dehydrations. Food irradiation; processing and preservations of milk and dairy, vegetables and fruits, cereals, legumes and nuts, meat and meat products, fats and oils, beverages, sugars, sweeteners, honey and confectionary, salt and spices. **8 Hrs.**
4. **Enzymatic and Non-Enzymztic reactions during storages:** Introduction to enzymes. Nature and function of enzymes. Classification of enzymes. Hydrolases – Esteraus, amylases, pectic enzymes. Proteases. Oxidoreductases – phenolases, glucose oxidase, catalose, peroxidase, lipoxygenase, xantine oxidase. Immobilized enzymes. Uses and suggested uses of enzyme in food processing. Non-enzymatic reactions. **8 Hrs.**
5. **Food Additives:** Introduction and need for food additives. Types of additives –antioxidants, chelating agents, coloring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and antichoking

agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives – types and applications. Stabilizers and thickeners, other additives. Additives and food safety. **9 Hrs.**

6. **Food Contamination and Adultration:** Types of adulterants and contaminants. Intentional adulterants. Metallic contamination. Incidental adulterants. Nature and effects. Food laws and standards. **9 Hrs.**
7. **Environmental Concerns and Food Safety:** Water in food production. Properties and requirements of processing water. Environmental concerns – solid waste disposal, waste water properties, wastewater treatment. Safety hazards and risks. Food related hazards. Processing and handling. Cleaning and sanitizing. **4 Hrs.**
8. **Modern Trends in Food Science:** Biotechnology in food. Biofortification. Nutraceuticals. Organic foods. Low cost nutrient supplements. Packaging of foods and nutrition label in. Careers in food science and food industries. **4 Hrs.**

Reference Books:

1. N. Shakuntala Manay and M. Shadaksharamurthy, "Foods (facts and principles)", 3/e, New Age International, 2016.
2. Heid, J.L. and Joslyn, M.A., Fundamentals of Food Processing Operation, The AVI Publishing Co., Westport, 1967.
3. Heldman, D.R., Food Process Engineering, The AVI Publishing Co., Westport, 1975.
4. Hall, C.W., Farall, A.W. and Rippen, A.L., Encyclopedia of Food Engineering, Van Nostrand, Reinhold, 1972.

15UCHE510	Fertilizer Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. It is needed to provide comprehensive and balanced understanding of essential link between chemistry and the synthetic fertilizer industry. It is therefore vital for chemical engineers to understand the fertilizer production and technology.
2. To study the different reaction and separation steps of the different fertilizers and application of unit operations in fertilizer industries.

Course Out comes (COs):

COs	Description: At the end of the	Mapping to POs(1-12) and PSOs(13-15)

	course student will be able to	Introductory 1	Moderate 2	Substantial 3
CO1	Use reactions and unit operations steps in manufacturing of various fertilizers	1	2	13
CO2	Characterize fertilizers on the basis of different properties		3	14
CO3	Identify engineering problems in fertilizer manufacturing	3	13	6,7
CO4	Handle the fertilizers	7,8	14	
CO5	Select appropriate synthesis fertilizer	7,8		14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	1.5			3	1.66	1						2.66	

Course Content:

1. **Overview of Fertilizer:** Synthetic fertilizers, Classification of fertilizers, Role of essential Elements in plant Growth, Macro elements and Micro elements, Application of fertilizers considering Nutrient, Balance and types of crop. Development of fertilizer industry; Fertilizer production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers. **8 Hrs.**
2. **Nitrogenous Fertilizers:** Introduction to Ammonia: Physical &chemical properties, applications, Synthesis gas by Catalytic partial oxidation Steam Hydrocarbon reforming, Ammonia converters: Design aspect of Single bed and multi-bed converter, Kellogg process and Haldor Topsoe process, Storage and Transportation of Ammonia. Introduction to Nitric acid: Chemical, physical properties and applications, Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process, Concentration of Nitric acid by $Mg(NO_3)_2$. Physical, chemical properties of Urea. Manufacturing of Urea by Stamicarbon's CO2 stripping process, Montecatini Solution recycle process Toyo-Koatsu total recycle process **16 Hrs.**
3. **Phosphate Fertilizers:** Physical, chemical properties and applications of Phosphorus and Phosphoric acid. Manufacturing of elemental phosphorous by Electric furnace method. Manufacturing phosphoric acid by Wet Process. Strong Sulphuric Acid Leaching Hydrochloric Acid Leaching Electric Furnace Process. **8 Hrs.**
4. **Potassium Fertilizers:** Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate, Manufacturing of potassium

chloride from sylvinite, Preparation of Potassium nitrate, Potassium sulphate. **10 Hrs.**

5. **Miscellaneous Fertilizer and Bio Fertilizers:** Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate(CAN), Biofertilizers, Types of Biofertilizers, Nitrogen fixing biofertilizers, Phosphate-solubilizing biofertilizers, Preparation of a biofertilizers. **10 Hrs.**

Reference Books:

1. Collings, G.H., "Commercial Fertilizers", 5/e, Mcgraw Hill, New York, 1955.
2. Editorial board, "Handbook of Fertilizer Technology", The Fertilizer Association of India, New Delhi, 1977.
3. Slacks, A.V., "Chemistry and Technology of Fertilizers", Interscience, New York, 1966.

VI Semester B.E.

15UCHC600 Management, Entrepreneurship and Protection of Intellectual Property Rights (4–0–0)4

Contact Hours: 52

Course Learning Objective:

1. To understand the development and function of management, the concept of entrepreneurship, intellectual property rights and legal issues.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Explain historical development of management and Engineering; Defend the synthesis of Engineering and Management.	6		
CO2	Explain the five functions of management in modern organization structures.		9, 10	7, 8
CO3	Explain foundation of entrepreneurship, role of entrepreneurs in economic development.		9, 10	7, 8
CO4	Asses impact of liberalization, privatization and globalization on small scale industries.		9, 10	7, 8
CO5	Identify Institutional support to small scale industries and prepare project report and its feasibility studies.		9, 10, 14	8, 11
CO6	Explain forms of intellectual property rights and procedure for registration, infringements and penalties.		6,7,8	10,12

Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level						1.5	2.75	2.8	2	2	3	3		2	

Course Content:

Management:

1. **Introduction:** Development and evolution of management thoughts, Modern management approaches, Scope and characteristics of management, tools of management, management and administration,

levels of management, principles of management, roles of management **4 Hrs.**

2. **Planning:** Nature and importance of planning, types of planning, steps of planning, essential of planning, planning process, planning tools and techniques. **5Hrs.**
3. **Organizing and staffing:** Steps and nature of organizing, organization structure, purpose of organization, types and principles of organization, Departmentation, span of control, authority, power and responsibility, delegation, centralization and decentralization, management by objectives, nature and importance staffing, recruitment and selection. **5Hrs.**
4. **Directing and controlling:** Nature of direction, principles of direction, leadership and styles, motivation, communication, types and forms of communication, coordination and cooperation, managerial control, steps in control process, control methods. **4Hrs**

Entrepreneurship:

1. **Entrepreneurship:** Evolution and Meaning of entrepreneur, characteristics of entrepreneur, entrepreneur and manager, functions and types of entrepreneur, Intrapreneur, role of entrepreneurship in economic development, barriers of entrepreneurship. **5 Hrs.**
2. **Small Scale Industry:** Definition, characteristics, objects, role of SSI in economic development, advantages of SSI, steps to start a SSI, impact of liberalization, privatization, and globalization on SSI, impact of WTO/GATT on SSI, definition of ancillary and tiny industry. **5 Hrs.**
3. **Institutional Support:** Nature of support of government, objectives and functions of NSIC, SIDO, SISI, SSIB, SSIDC, SIDBI, DIC, KIADB, KSSIDC, KSFC. **4 Hrs.**
4. **Preparation of Project:** Meaning of project identification, project report, contents and formulation, identification of business opportunities, feasibility studies, types and purpose **4 Hrs.**

Protection of Intellectual Property:

1. Introduction: Meaning and forms of intellectual property right, competing rationale for protection, international conventions, world court. **3 Hrs.**
2. Copyright: Meaning of copyright, content of copy right, ownership and rights, period of copyright, assignment and relinquishment of copyright, license, infringement of copy right, fair use, offenses and penalties. **4 Hrs.**
3. Patents: Concept of patent, patentable inventions, procedure for obtaining patent, rights and obligations of patent holders, infringements and remedies, offenses and penalties. **4 Hrs.**

4. Industrial Designs and Trademarks: Definition of design, procedure for registration, rights conferred by registration, infringements. Concept of trademarks, procedure of registration, duration and fees of trademark.

5Hrs.

Reference Books:

1. Thomas W. Zimmerer, "Essentials of Entrepreneurship", PHI, 2005.
2. Veerabhadrappa Havinal, "Management and Entrepreneurship", 1/e, ISBN (13): 978-81-224-2659-5, New Age International, 2009.
3. Peter Drucker, "The Practice of Management", ISBN-10: 0060878975 Harper Business Reissue edition, 2006
4. N.K. Acharya, "Text book on Intellectual Property Rights", 4/e, Asia Law House.

15UCHC601	**Chemical Process Integration**	**(4-0-0) 4**

Contact Hours: 52

Course Learning Objectives:

1. To teach students basic principles and methodologies for energy, mass and material integration for sustainable process synthesis and design.
2. It helps in understanding the usage of material, Heat and Mass effectively for the profit of Industry using pinch analysis.
3. It helps in formulating the design and optimizing the process in plant for the integrated approach.

Course Outcomes (COs):

COs	**Description: At the end of the course student will be able to**	**Mapping to POs(1-12) and PSOs(13-15)**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Identify and explain the importance of process integration.	14	3	6,7
CO2	Evaluate and analyze the direct recycle strategy through material balance, graphical and algebraic approach.	1	2,3	13
CO3	Predict and evaluate the visualization strategies of mass integrated system through graphical and algebraic approach	1	2,3	13
CO4	Illustrate and develop heat exchange network by pinch diagram with screening of exchangers along with combined heat and power integration	1	2,3	5,13
CO5	Formulate and optimize the different process integration networks	1,2		5,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	1.75	2		3	3	3						3	1	

Course Content:

1. **Introduction to Process Integration:** Categories of process integration. Mass targeting for minimum discharge of waste and minimum purchase of fresh utilities. **6 Hrs.**
2. **Direct recycle strategies.** Source-Sink mapping diagram, Multicomponent source sink mapping. Graphical and algebraic approach for direct recycle strategies. Property based pinch diagram. **14 Hrs.**
3. **Heat Integration**. Design and synthesis of heat exchange network (HENs). Heat exchange pinch diagram and algebraic approach for pinch point. Grand composite curves (GCC). Combined heat and power integration (Heat Pumps and Engines). Cogeneration process targeting. **14 Hrs.**
4. **Mass Integration**. Synthesis of mass exchange network (MEN). Design and cost optimization of mass exchangers. Visualization strategies for the development of mass integrated system. Algebraic and graphical approach to targeting mass exchange (Mass Integration) **12 Hrs.**
5. **Optimization.** Overview of optimization, classification and formulation of optimization programs. Different methods of optimization programming. Approach for direct recycle and synthesis of mass and heat exchange network using a programming language. **6 Hrs.**

Reference Books:

1. Mahmoud Halwagi, “Process Integration”, 1/e, Elsevier, 2006.
2. I. C. Kemp, “Pinch analysis and process Integration” 2/e, Butterworth, 2006.
3. Robin smith, “Chemical Process Design and Integration”, 1/e, Wiley, 2005

15UCHC602	Process Equipment Design and Drawing	(3-0-2)4

Contact Hours: 52

Course Learning Objectives:

1. To develop key concepts and techniques to design process equipment in a process plant.
2. To expose students to the practices followed in the design of chemical equipment’s and their drawing.

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Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Congregate and analyze the data from the hand book, code book and literature.			1, 2
CO2	Design and evaluate the heat transfer equipment: DPHE, STHE condenser.	1	2	3, 13
CO3	Design and evaluate mass transfer equipment: Distillation column and absorption tower.	1	2	3, 13
CO4	Design and evaluate the simultaneous heat and mass transfer equipment: calendria evaporator and rotary dryer.	1	2	3,13
CO5	Sketch the equipment as per the design.			3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	2.25	3										3		

Prerequisites: Process Heat Transfer, Chemical Engineering Drawing, Mass Transfer I and II

Course Content:

- Detailed Chemical Engineering Process Design of the following equipment.
- Necessary aspects studied in “Chemical Equipment Design” is to be applied for mechanical design.
- Use of standard code books to be taught.
- The detailed Sketch shall include sectional front view

NOTE:

1. The question paper to contain two full design problems (100 Marks each contains 80 Marks for Design and 20 Marks for sketch) for the equipment from the above list and **student to answer any One full question.**
2. Perry’s Chemical Engineer’s Handbook shall be allowed in the examination as reference. IS Code 4503 for Heat Exchangers (if required) shall be permitted.

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3. The answer shall include detailed process design steps using the data given in the problem, mechanical design for component dimensions and sketch Sectional Front View.

1. Double Pipe Heat Exchanger
2. Shell and Tube Heat Exchanger.
3. Condenser
4. Distillation Column.
5. Evaporator
6. Absorption Column.
7. Rotary Dryer.

Reference Books:

1. R. H. Perry and D. W. Green "Chemical Engg Hand Book", 6/e, McGraw Hill, 1998.
2. Donald Q. Kern, "Process Heat Transfer", McGraw Hill, 1997.
3. Robert E. Treybal, "Mass Transfer Operations", 3/e, McGraw Hill, 1981.
4. J. M. Coulson & J. F. Richardson, "Chemical Engineering", Vol. 6 Pergamon Press, 1993.

15UCHL603	**Mass Transfer Laboratory**	**(0-0-3)1.5**

Contact Hours: 30

Course Learning Objectives:

1. To provide an understanding of extending the theory into practice through various experiments related to diffusion, both molecular and convective; transfer coefficients and other diffusion based separation processes.
2. To analyze experimental data from the experiment conducted and present a good technical report, thereby demonstrating skills in communication through mandatory oral presentations.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Evaluate Rayleigh's equation, vaporization and thermal efficiencies using distillation principles.	9	10	4, 15
CO2	Estimate the percentage recovery for types of Extraction equipments.	9	10	4, 15
CO3	Calculate the Diffusion coefficient for Diffusion of organic vapour experiment, and height of cooling tower	9	10	4, 15
CO4	Explain the temperature dependency on ternary phase diagram.	9	10	4, 15
CO5	Evaluate Freundlich equation using adsorption principles	9	10	4, 15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3.0					1.0	2.0					3.0

List of Experiments:

1. Diffusion of organic vapors in Air
2. Steam distillation
3. Distillation - Simple (Differential) distillation
4. Solid - liquid leaching
5. Surface evaporation
6. Adsorption studies
7. Liquid - Liquid / Vapor - Liquid equilibrium
8. Liquid extraction - (Cross current: single and 2 or 3 Stage)
9. Wetted wall column
10. Cooling tower
11. Solid dissolution

Note: Minimum 10 experiments to be conducted.

Reference Books:

1. Robert E. Treybal, "Mass Transfer Operation" 3/e, Mc Graw Hill.
2. Coulson and Richardson, "Chemical Eng Vol. 1 and Vol. 2", 4/e.
3. Geankoplis C.J, "Transport Processes and Unit Operations", 3/e,Prentice Hall (I).
4. Mc Cabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/e Mc Graw Hill

15UCHL604	Chemical Reaction Engineering Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives:

1. To study the reaction kinetics for lab scale reactors by applying the knowledge of chemistry and engineering into practice.
2. To analyze and interpret the experimental data to find the rate law and project in the form of a report and oral presentation.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Determine the kinetics of the reaction for batch, semi batch and flow reactors	9	10	4, 15
CO2	Evaluate the activation energy of the reaction	9	10	4, 15
CO3	Characterize the non ideal behavior in the reactors	9	10	4, 15
CO4	Analyse and interpret the data for reactor design	9	10	4, 15
CO5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report		8,9	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				3				2	1.2	2.2					3

List of Experiments

1. Batch Reactor
2. Isothermal plug flow reactor
3. Semi Batch Reactor
4. Mixed flow reactor
5. Heterogeneous catalytic reactor
6. Segregated flow reactor
7. Adiabatic reactor
8. Packed Bed Reactor
9. RTD Studies in Tubular reactor
10. Effect of temperature on Rate of reaction
11. RTD Studies in mixed flow reactor
12. CSTRs in series
13. RTD studies on spouted bed reactor

Note: Minimum10 experiments to be conducted.

Reference Books

1. Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley and Sons, 1999.
2. J. M. Smith, “Chemical Engg Kinetics”, 3/e, Mc Graw Hill, 1984.

15UCHL605	Mini Project	(0-0-8) 4

Contact Hours: 40

Course Learning Objectives:

1. To carry out the experimental/design tasks of relatively minor intensity and scope as compared to the major project and in line with the guidelines formulated by the DUGC.
2. To see that this project could be a prologue for the upcoming major projects in the final year.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify the topic of chemical engineering or integrated problems (allied fields).	7, 14	8, 12	2,10
CO2	Compare the literature review and select suitable materials and methodologies for selected topic.	7, 10,14	8,11,12	3,4,5,15
CO3	Plan and carry out the experimental work and economic analysis.	9	8,10,12	11,15
CO4	Prepare a precise report on the work done with proper guidelines and references.	9	8,15	10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3.0	3.0	3.0	3.0		1.0	2.0	1.0	2.25	2.5	2.0		1.0	2.66

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VI semester. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VI semester. After getting the approval from DUGC, the project work should be carried out in VI semester. The project report should be submitted along with the presentation on the work carried out at the end of VI semester

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:

1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field.

15UCHE606 Petroleum and Petrochemicals (4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. Studying this subject the students will learn about the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline the Indian petroleum industry and world scenario	6		
CO2	Apply the basic procedure and role of all fundamental system used in petroleum and petrochemical industry	6		1
CO3	Identify and characterize the different products of hydrocarbon	14	2	
CO4	Analyze the measuring parameters to be measured according to the operational conditions	13	1	4
CO5	Analyze the key issues in the design and optimization of petroleum and petrochemical production system	1	2, 13,	3

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	2	3	3		1							1.5	1	

Course Content:

1. **Indian Petroleum Industry:** prospects & future, major companies, world production, markets, offshore & onshore, oil well technology. **4 Hrs.**
2. **Petroleum crude characterization**: Composition and classification, UOP K factor, TBP analysis, EFV Analysis, Average Boiling points, ASTM Curves, Thermal properties, Pour Point. **4 Hrs.**
3. **Product properties and test methods:** Characterization -Flash point, Fire point, Reid vapor pressure Analysis, Octane Numbers, Cetane Index, smoke point, Burning quality, Carbon Residue, Viscosity Index, Softening point, Penetration Index, Oxidation Stability, Volatility, Aniline point, Pour point . Various Petroleum products & Additives for Naphtha, Gasoline, Gas, ATF, LPG, Kerosene, Diesel, Lubricating oils, Bitumen. **12 Hrs.**
4. **Crude pretreatment**: Pumping, dehydration, comparison, petroleum furnaces and comparison, Refining of petroleum – Atmospheric and vacuum distillation. **6 Hrs.**
5. **Treatment techniques**: Removal of sulphur compounds, storage and stability, product treatment using solvent, dewaxing, clay treatment and hydro refining. **6 Hrs.**
6. **Thermal cracking:** Visbreaking, Coking, Catalytic cracking (FCC), Hydro cracking, Air blowing of bitumen. Catalytic reforming, Extraction of Aromatics. **6Hrs.**
7. **Petrochemicals:** Definition, importance and growth potential of the field, raw materials for petrochemical industries, sources, economics and advantages. Production of petrochemicals like dimethyl terephathalate (DMT), ethylene glycol, synthetic glycerin, LAB, acrylonitrile, methyl methacrylate (MMA), phthalic anhydride, maleic anhydride, phenol acetone, formaldehyde, production of carbon black. **14 Hrs.**

Reference Books:

1. K. Bhaskar Rao, “Modern Petroleum Processes”, 3/e, Oxford IBH publisher.
2. Ram Prasad , “Petroleum Refining Technology”, Khanna Publishers, 2000.
3. W.L. Nelson, “Petroleum Refinery Engineering” 4/e, McGraw Hill, 1985.
4. B.K.Bhaskar Rao, “A text book on petrochemicals” 1/e, Khanna Publishers, New Delhi, 1987.

15UCHE607	Catalyst Technology	(4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To under stand controlling mechanisms in solid catalyzed reactions, characterization of catalyst properties and is preparation.
2. To provide catalytic reactor design concepts involving solid catalyzed reaction and catalyst deactivation

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Explain the various methods to estimate properties of given catalyst and its preparation.			1,2
CO2	List controlling mechanisms and formulate overall rate expressions.			1,2
CO3	Formulate performance equations for reactors containing porous catalyst and apply the same for reactor design.		14	1,2,3
CO4	Explain various causes and mechanisms of catalyst deactivation and experimental methods to determine catalyst deactivation kinetics.		14	1,2,3

POs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mapping Level	3	3	3											2	

Course Contents:

1. **Fundamentals of catalytic phenomena:** Brief history of catalyst technology development and its economic importance. Various controlling mechanisms involved in solid catalyzed reactions, overall rate expressions. **10 Hrs.**
2. **Catalyst materials and properties:** Makeup of a typical heterogeneous catalyst and their functions. Molecular sieves and zeolites. Physical, Chemical, Dynamic and Mechanical properties of solid catalyst and their characterization. **10 Hrs.**
3. **Catalyst preparation and forming:** Various catalyst preparation methods and equipments used, catalyst activation and forming**.** **8 hrs.**
4. **Reactor design**: Basic approaches to reactor design, performance equations, collection of data form laboratory reactors, experimental methods to find rate equations and reactor design. **12 Hrs.**

5. **Catalyst deactivation:** Causes and mechanisms of catalyst deactivation, prevention and regeneration. Experimental methods to find rate of deactivation, design and operation strategies with deactivating catalysts.

12 Hrs.

Reference Books:

1. Prof. I.P. Mukhlyonov, " Catalyst Technology", MIR Publishers.
2. R.P. Farrauto and C.H. Bartholomew, "Fundamentals of Industrial Catalytic Processes".
3. Hamid Al-Mergen and Tian Cum Xiao, " Petrochemical Catalyst Materials, Processes and Emerging Technologies", IGI Global Series Book, 2016, ISBN:97814666699755.

15UCHE608	Applied Mathematics in Chemical Engineering	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To understand the Computational techniques and use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand calculations for application in Chemical Engineering.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify and apply mathematical methods to solve chemical engineering problems	3	2	1
CO2	Evaluate and analyse different chemical engineering problems using different mathematical techniques		2	3, 13
CO3	Interpret and develop the relationship in chemical engineering using different techniques		2	3, 13
CO4	Formulate and optimize with different methods to solve chemical engineering problems unit operation and process.	1	2	3, 5, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	2	2.5		3								3		

Course content

1. **Computation and Error Analysis:** Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation. Linear Systems and Equations Matrix representation, Calculation of Eigen Values and Eigen vectors, Solution by Cramer's rule; Iterative Method-- Jacobi iteration; Gauss-Seidel Method, Chemical Engineering Examples: Material and energy balance problems involving at least 3 simultaneous equations Non-linear Algebraic Equations (single and multivariable) Secant, Multivariate Newtons method Chemical Engineering Examples: Equation of state (van der Waals, Beattie-Bridgeman, etc.), Friction factor equation etc. **14 Hrs**
2. **Regression and Interpolation:** Polynomial regression, Newtons Difference Formulae, Cubic Splines Chemical Engineering Examples: Free settling velocity of particles, Arrhenius Equation, Specific heat w.r.to temperature etc. **8 Hrs**
3. **Numerical differentiation:** Numerical differentiation; higher order formulae. Integration and Integral Equations Two and Three point Gaussian quadrature formula Chemical Engineering Examples: Rayleighs equation, Rate equation. **8 Hrs**
4. **ODEs:** Initial Value Problems Runge – Kutta method for second order differential equations, Explicit Adams-Bashforth technique, Implicit Adams-Moulton technique, Predictor-Corrector technique. Stiffness of ODE"s ODEs: Boundary Value Problems: Orthogonal Collocation, shooting techniques. Chemical Engineering Examples: Rate equation, Steady-state material or energy balance equations etc. **10 Hrs**
5. **Solution of partial differential equations:** Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, implicit and explicit methods, Cranks Nicolson Method, Chemical Engineering Examples: unsteady-state one dimensional heat conduction. Use of Matlab with chemical engineering examples. **12 Hrs**

Reference Books

1. Gupta S.K , “Numerical Methods for Engineers”, 3/e, ISBN : 978-81-224-3359-3, New Age International, 1995
2. Alkis Constantinides and Navid Mostoufi, “Numerical Methods for Chemical Engineers with MATLAB Applications”, ISBN-10: 0130138517, Prentice Hall, 1999.
3. Steven Chapra and Raymond Canale, “Numerical Methods for Engineers.”, 6/e, McGrew Hill Publication, 2010.
4. M. K. Jain, S. R. K. Iyengar, and R. K. Jain, “Numerical Methods”, 6/e New Age International Publishers, New Delhi, 2012

15UCHE609	Polymer Science and Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To provide a broad and fundamental knowledge of the polymers and their chemical, physical and mechanical behavior.

Course Out comes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Classification, chemistry, kinetics, characteristics and types of polymers.	1	2	13
CO2	Comprehend polymer properties, their testing procedures and methods of polymerization.		1,4	
CO3	Explain different polymer processing techniques.	1	3	
CO4	Comprehend manufacturing processes and frontiers of polymers	2	1	
CO5	Polymer recycling, challenges and engineering applications.	2	7	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.5	1.3	2	2			2						3	3	

Course Content:

1. **Polymer science:** Introduction, IUPAC names, Classification of polymers (source, occurrence, elemental composition, geometry and tacticity, stereo regularity), Definition of polymerization, characterization, Chain polymerization (free radical, ionic and co-ordination polymerizations), Step (condensation) polymerization, copolymerization. **6 Hrs.**
2. **Polymerization kinetics:** Definition of reaction rate, order, molecularity, kinetics of step reaction polymerization, kinetics of addition polymerization. **5 Hrs.**
3. **Methods of Polymerization*:*** Bulk, solution, Suspension, Emulsion, solid phase, gas phase polymerizations (formulation, mechanism, properties of the polymer produced, advantages and disadvantages). **8 Hrs.**
4. **Polymer properties:** Tensile strength, Impact strength, glass transition temperature, melting temperature, testing: sample preparation, testing standards & methods, analysis of polymer **6 Hrs.**

5. **Processing Technology:** Extrusion, Injection moulding, blow moulding Compression moulding, rotational moulding, thermoforming, Calendering, Compounding. **7 Hrs.**
6. **Polymer manufacturing:** Industrial production methods of PE, PP, PS, PVC, UF,PF, PU, Poly butadiene, Nylon 6 and Nylon 66. **8 Hrs.**
7. **Frontiers of polymer materials:** biodegradable polymers, biomedical polymers, conducting polymers, polymers for space. **5 Hrs.**
8. **Problems of polymer:** Thermoxidative degradation, fire hazards, toxicity, effluent disposal. **4 Hrs.**
9. **Recycle:** Recycle and Reuse of polymers. **3 Hrs.**

Reference Books:

1. R.J.Young and P.A.Lovell, "Introduction to polymers", Chapman and Hall, London.
2. Fried W. Billmeyer, "Text book of Polymer Science", J.R.John Wiley and Sons, New York.
3. F. Rodrignek, "Principles of Polymer Systems", McGraw Hill, N.Y.
4. Gowarikar, "Polymer Science", Wiley Eastern Ltd. New Delhi.

15UCHE610	Composite Materials	(4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To understand the nature, properties, structure and processing of composite materials and their engineering applications.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs(1-12) and PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Characterize and explain the different synthesis of advanced and future materials for industrial application		6	2,14
CO2	Analyse and compile the different techniques for preparing the materials	7	2	14
CO3	Compare and assess the different processing techniques for advanced materials	7	2	14
CO4	Distinguish between mechanical and chemical techniques for fabrication and synthesis of	7	2	14

	composite materials			

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		2.25				2	1							3	

Course Content:

1. **Synthesis and Fabrication of advanced and future material:** emphasis on ceramic, Semi-conducting and Super-conducting materials with superior structural, optical and electrical properties. **10 Hrs.**
2. **Techniques for preparation of ultra-pure, ultrafine powders:** of oxides, nitrides, carbides etc., with very well defined characteristics and superior properties. **12 Hrs.**
3. **Processing Techniques:** Sintering, hot pressing, hot isostatic pressing, tape-casting sol-gel processing for the formation of monolithic ceramics, composites (ceramic, ceramic metal, as well as metal matrix), SiO_2, Glasses from above powders. **10 Hrs.**
4. **Processing Techniques based on reaction methods:** Chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI), self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibers and semi conducting materials such as Si and gallium arsenide. **12 Hrs.**
5. **Synthesis and processing**: mixed ceramic oxides with high temperature super conducting properties. Comparison of properties of such advanced materials with conventional materials such as metals and polymers. **8 Hrs.**

Reference Books:

1. W.D. Kingery “Introduction to Ceramics”.
2. Chawla “Advanced Composites”.
3. James.T.Schockel Ford, “Introduction to Material Science for Engg”, McMillan publications.
4. L.H. Vanvlack, “Material Science and Engineering”.

SDM College of Engineering & Technology, Dharwad

Odd Semester 2019-20

Academic Calendar for UG Programmes

Sl. No.	Particulars	Date
1	Registration	27-07-2019 to 31-07-2019
2	Induction program for First Semester (Tentative)	01-08-2019 to 14-08-2019
3	Teaching Commences for odd semester except I Sem	01-08-2019
4	Last date for registration with late fee	06-08-2019
5	Teaching Commences for I semester	16-08-2019
6	Display of attendance	16-09-2019
7	Internal Assessment – IA– I	18-09-2019 to 20-09-2019
8	Communication of performance to the parents	26-09-2019
9	Last date to drop the course	27-09-2019
10	Display of attendance	02-11-2019
11	Internal Assessment –IA– II	04-11-2019 to 06-11-2019
12	Students Feedback	11-11-2019 to 15-11-2019
13	Communication of performance to the parents	13-11-2019
14	Last date to withdraw the course	13-11-2019
15	Teacher – Parents Meet	16-11-2019
16	Internal Assessment –IA– III	27-11-2019 to 29-11-2019
17	Last day of teaching for Odd Semester	30-11-2019
18	Final Lab Assessments	03-12-2019 to 10-12-2019
19	Display of consolidated Continuous Internal Evaluation (CIE) & Attendance	05-12-2019
20	Communication of performance to the parents	05-12-2019
21	Semester End Examination	13-12-2019 to 27-12-2019
22	Inter Semester Recess	28-12-2019 to 12-01-2020
23	Declaration of Results	09-01-2020
24	Communication of performance to the parents by putting on website	10-01-2020
25	Makeup SEE for odd semesters	11-01-2020 to 18-01-2020
	Commencement of Even Semester :	**13-01-2020**

Dean (Academic Program) **PRINCIPAL**

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Academic Calendar (Tentative) for Even Semester 2019-20
B.E. & M.Tech

Sl. No.	Particulars	Date
1	Registration	09-01-2020 to 11-01-2020
2	Commencement of Teaching	13-01-2020
3	Last date for registration with late fee	18-01-2020
4	Display of attendance	18-02-2020
5	Internal Assessment – IA– I	24-02-2020 to 26-02-2020
6	Communication of performance to the parents	03-03-2020
7	Last date to drop the course	04-03-2020
8	Parents Meet	14-03-2020
9	Insignia – 2020	20-03-2020 & 21-03-2020
10	Display of attendance	30-03-2020
11	Internal Assessment – IA– II	01-04-2020 to 03-04-2020
12	Last date to withdraw the course	08-04-2020
13	Communication of performance to the parents	11-04-2020
14	Feedback by Students	20-04-2020 to 25-04-2020
15	Internal Assessment –IA– III	04-05-2020 to 06-05-2020
16	Last day of teaching for Even Semester	06-05-2020
17	Final Lab Assessments	09-05-2020 to 20-05-2020
18	Display of consolidated Continuous Internal Evaluation (CIE) marks & Attendance for 8th semester	09-05-2020
19	Semester End Examination for 8th semester	11-05-2020 to 19-05-2020
20	Display of consolidated CIE marks & Attendance for 2nd, 4th & 6th semesters (Both for UG & PG)	13-05-2020
21	Communication of performance to the parents	14-05-2020
22	Project exam for 8th semester	21-05-2020 to 26-05-2020
23	Semester End Examination for 2nd, 4th & 6th semesters (Both for UG & PG)	22-05-2020 to 05-06-2020
24	Results for 8th semester	30-05-2020
25	Summer vacation	06-06-2020 to 31-07-2020
26	Announcement of Results for 2nd, 4th & 6th semester (Both for UG & PG)	12-06-2020

Supplementary Semester: 12-06-2020 to 27-07-2020

Commencement of next Academic Year 2020 - 21: 01-08-2020

Dean (Academic Program) **PRINCIPAL**

Supplementary Semester Calendar for B.E./M.Tech/MBA – 2020

Sl. No.	Particulars	VII & VIII Sem (B.E.)	I to VI Sem (B.E.), M.Tech & MBA
1	Registration	01-06-2020 to 03-06-2020	06-06-2020 to 08-06-2020
2	Teaching Commences	01-06-2020	12-06-2020
3	Registration with special permission by Principal	04-06-2020	12-06-2020
4	Internal Assessment (IA) – I	13-06-2020 & 15-06-2020	24-06-2020 & 25-06-2020
5	Internal Assessment (IA) – II	25-06-2020 & 26-06-2020	03-07-2020 & 04-07-2020
6	Internal Assessment (IA) – III	10-07-2020 & 11-07-2020	13-07-2020 & 14-07-2020
7	Display of consolidated Continuous Internal Evaluation (CIE) marks & Attendance	13-07-2020	16-07-2020
8	Supplementary SEE	14-07-2020 to 17-07-2020	18-07-2020 to 23-07-2020
9	Declaration of results	22-07-2020	27-07-2020

Dean (Academic Program) **PRINCIPAL**

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Academic Program: UG

Academic Year 2019-20

Syllabus

VII & VIII Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002

(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465** **Fax: 0836-2464638** **Web:** www.sdmcet.ac.in

SDM College of Engineering & Technology, Dharwad

Date: 18-7-2019

It is certified that the scheme and syllabus for VII & VIII semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2019-20 till further revision.

Principal   Chairman BoS & HoD

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SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs):

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs) and Program Specific outcomes (PSOs):

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for VII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC700	Process Dynamics and Control	4-0-0	4	50	100	3		
15UCHC701	Chemical Technology	4-0-0	4	50	100	3		
15UCHC702	Biochemical Engineering	3-0-0	3	50	100	3		
15UCHL703	Major Project-Phase 1	0-0-6	4	50			50	3
15UCHL704	Process Control Laboratory	0-0-3	1.5	50			50	3
15UCHL705	Computer Applications in Chemical Engineering and Simulation Laboratory	0-0-3	1.5	50			50	3
15UCHE70X	Elective – 5	4-0-0	4	50	100	3		
15UCHE70X	Elective – 6	4-0-0	4	50	100	3		
Total		**19-0-12**	**26**	**400**	**500**		**150**	
Electives								
15UCHE706	Pilot Plant and Scale up Methods	4-0-0	4	50	100	3		
15UCHE707	Transport Phenomena	4-0-0	4	50	100	3		
15UCHE708	Process Modeling and Simulation in Chemical Engineering	4-0-0	4	50	100	3		
15UCHE709	Novel Separation Techniques	4-0-0	4	50	100	3		
15UCHE710	Wastewater Treatment and Engineering	4-0-0	4	50	100	3		

Scheme for VIII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC800	Process Engineering Economics and Management	4-0-0	4	50	100	3		
15UCHL801	Seminar	0-0-3	2	50				
15UCHL802	Major Project- Phase 2	0-0-12	10	50			50	3
15UCHE80X	Elective – 7	4-0-0	4	50	100	3		
15UCHE80X	Elective – 8	4-0-0	4	50	100	3		
Total		**12-0-15**	**24**	**250**	**300**		**50**	
15UCHE803	Solid Waste Management	4-0-0	4	50	100	3		
15UCHE804	Instrumental Methods of Analysis**	4-0-0	4	50	100	3		
15UCHE805	Sugar Technology	4-0-0	4	50	100	3		
15UCHE806	Bioprocess Engineering	4-0-0	4	50	100	3		
15UCHE807	Unit Processes in Organic Synthesis**	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

** To be handled by the Chemistry department faculty

Total credits offered for the Fourth year: 50

Interdisciplinary Elective open for all Engineering Branches:
15UMAE875 Applied Numerical Methods (VIII Sem)
15UPHE876 Nanotechnology (VIII Sem)

VII Semester B. E.

15UCHC700 Process Dynamics and Control (4-0-0)4

Contact Hours: 52

Course Learning Objective:

The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to:	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Comprehend the fundamentals of process controls	13	1,10	
CO2	Derive transfer function models for dynamic processes and study the transient response characteristics.	2	3,4	
CO3	Predict the closed-loop behavior using block diagram and evaluate the stability of the system.	2	4,13	
CO4	Analyse the principles involved in selecting a control value and understand the interaction with other process components.	5	2,13	
CO5	Analyse controllers to achieve desired performance.	2	3,5,13	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	1.25	2	2	1					2			1.75		

Course Content:

1. **Introduction:** Classification of variables, control configuration, classification of control systems. Laplace Transform, types of inputs- step, impulse, linear and sinusoidal **6 Hrs.**
2. **Process dynamics:** First order systems, transfer functions - mercury in glass thermometer, level, mixing tanks, stirred tank reactors, I order system in Series-interacting and non interacting systems, response equations, linearization of non-linear system. **12 Hrs.**
3. **Second order systems:** U-tube manometer, damped oscillator, response equations, terms of second order under damped system. **7 Hrs.**
4. **Block diagram:** Importance, reduction rules, steps, problems **6 Hrs.**
5. **Final control element:** control valves, types, actuators, positioners, valve plugs, characteristics. **5 Hrs.**

6. **Controllers:** Proportional, Proportional +Integral (P+I), Proportional + Integral + Derivative (P+I+D), On-Off controller, servo and regulator control system. **7 Hrs.**
7. **Stability:** Stability of linear control system, Routh –Hurwitz, Root Locus methods. **9 Hrs.**

Reference Books:

1. Coughanour and Koppel, “Process System Analysis and Control”, 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2. Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2/e, McGraw Hill, 1990.
3. Coulson and Richardson, “Chemical Engineering” Vol, III, 3/e, Pengeman Press.
4. George Stephanopoules, “Chemical Process Control” An Introduction to Theory and Practical, Prentice Hall, New Delhi, 1998.

15UCHC701	Chemical Technology	(4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To understand the industry protocols used in the manufacture of chemicals both inorganic and organic with the use of reference flow sheets.
2. Identify major engineering problems associated with manufacturing processes.
3. Overcoming bottlenecks and trouble shooting.
4. Appraise of themselves as industry ready chemical engineers.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline the impetus of Chemical Industry globally	8	12	6,7
CO2	Apply the concepts of unit operations and processes, reaction kinetics, thermodynamics, stoichiometry, transport processes, materials engineering etc. and translate to develop a process flow sheet.	12	14	13
CO3	Describe the technology of manufacturing chemicals.		5	13,14
CO4	Prioritize trouble shooting to overcome the bottlenecks in a process and develop the technology within realistic constraints.		14	6,7

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level					2	3	3	1				1.5	3	2.3	

Course contents:

Introduction to Chemical Process Industries: Chemical Industry in this millennium

1. **Industrial and Fuel gases**: H_2, O_2, N_2, CO_2, Water gas, Producer gas. **6 Hrs.**
2. **Chlor-Alkali Industry**: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder **6 Hrs.**
3. **Acids:** Sulfuric, Nitric, Hydrochloric and Phosphoric acids. **7 Hrs.**
4. **Fertilizer Industry**: Ammonia, Urea, Ammonium Nitrate, Ammonium Sulfate, DAP, Potash fertilizers, Bio-fertilizers. **8 Hrs.**
5. **Phosphorous Industry**: Red and White phosphorous, Phosphorous pentoxide, Phosphate fertilizers, Super phosphate and Triple super phosphate. **7 Hrs.**
6. **Pulp and Paper Industry**: Raw materials, manufacture of pulp and paper, recovery of chemicals. **6 Hrs.**
7. **Fermentation & Distillery**: Manufacture of alcohol, beer, wine, vinegar. **6 Hrs.**
8. **Oils, Fats and Soaps Industry**: Manufacture of oils (vegetable and industrial) processing and refining, essential oils and uses, soaps, fatty acid purification and types. **6 Hrs.**

Reference Books:

1. George T Austin: Shreves, “Chemical Process Industries”, Mc Graw Hill International ltd.
2. Gopal Rao and Marshall, “Dryden’s Outlines of Chemical Technology”, East-West Press.
3. S.D. Shukla and G.N. Pandey, “Text book of Chemical Technology” Vol.1 and 2, Vikas Publishing House Pvt. Ltd. New Delhi.
4. S.C. Bhatia, “Chemical Process Industries”, Vol.1 and 2, CBS Publishers, New Delhi

15UCHC702	Biochemical Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives:

1. To provide the forum to understand the principles and concepts of microbiology, cell biology and biochemistry and thereby apply chemical engineering principles to asses and evaluate the cell as a reactor.
2. To incorporate the principles of chemical engineering in understanding the upstream and downstream processing techniques in a biochemical industry.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Outline and identify the microorganisms in the context of industrial and environmental microbiology.	2	7	
CO2	Characterize and explain the chemicals of life with the properties and their derivate.		2	
CO3	Interpret and evaluate the enzyme kinetic parameters with different effects of the reactors.	2	3	13
CO4	Explain the various configurations of bioreactors along with fermentation technology	2	3	12,13
CO5	Identify and explain the methods involved in product recovery and purification	2	3	12,14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		1.2	2				2					3	3	3	

Course content:

1. **Microbiology:** Scope, structure of cells: Prokaryotic and Eukaryotic, characterization and classification of microorganisms - Taxonomy and Whitaker's 5-Kingdom concept, environmental and industrial microbiology, control of microorganisms. **4 Hrs.**
2. **Biochemistry:** Chemicals of life - Lipids, sugars and polysaccharides; amino acids, proteins and enzymes; vitamins, biopolymers, nucleic acids and their derivatives. **6 Hrs.**
3. **Enzyme catalyzed reactions:** Enzyme Nomenclature and classification, enzyme kinetics, Mechanism and kinetics of enzymatic reactions, evaluation of kinetic parameters, factors affecting enzyme activity, Inhibitors and inhibition kinetics, Industrial enzymes and applications, methods of

immobilization of enzymes. **10 Hrs.**

4. **Biomass production in cell cultures:** Ideal reactors for kinetic measurements - batch and continuous reactors, Monod's growth kinetics, Transient growth kinetics, Cell growth and kinetic patterns, Reactors and their configurations. **10 Hrs.**
5. **Fermentation technology:** Ideal bioreactors, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations. **4 Hrs.**
6. **Downstream processing:** Steps involved in product recovery, operations involved - centrifugation, chromatography and emerging technologies including membrane separation techniques. **5 Hrs.**

Reference Books:

1. Jay Bailey, James Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill, 1986.
2. Michael L. Shuler and Fikret Kargi, "Bioprocess Engineering - Basic Concepts", 2/e, Prentice Hall of India (2003).
3. Michael J. Pelczar, E. C.S. Chan and Noel R. Krieg, "Microbiology Concepts and Applications", 5/e, McGraw Hill reprint 2001.
4. Syed Tanveer Ahmed Inamdar, "Biochemical Engg: Principles and Concepts" 3/e, Prentice Hall of India Learning Pvt. Ltd. (2012), New Delhi.

15UCHL703	Major Project – Phase 1	(0-0-6) 4

Contact Hours: 72

Course Learning Objectives:

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Analyse and compare the literature review of the topic chosen in chemical engineering	7, 14	8,12	2,10
CO2	Identify the challenges related to the process industries or society with multidisplanery facets	10, 14	8,12, 11	6,7,9
CO3	Select the suitable material, methodology and carry out the computation and economic analysis			3,4,5,15
CO4	Formulate, design and report the approaches to carry out the experiments with feasibility solutions	9	8,10,12	11,15
CO5	Outline the precise project report with appropriate guidelines and references	9	8,15	10
CO6	Discuss the results obtained with proper justification and conclusion		10,11	15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3	3	3	3	3	2	2	1.6	2.2	2.3	2		1	2.75

Course Content:

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VII semester or project of VI semester can also be extended here. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VII semester. After getting the approval from DUGC, the project work should be carried out in VII and VIII semester. The project report should be submitted in VII semester which includes literature survey, plan of work and any progress of the work. The final project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:

Literature survey- 20%

Synopsis (plan of work and PERT charts)-10%

Project Topic/Work-35%

Presentation-15%

Conclusion and Final report-20%

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Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

15UCHL704	Process Control Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objective:

1. The purpose of this laboratory is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Apply fundamentals of industrial processes, process measurement and process control theory.		9,10	1
CO2	Analyse transient behavior of simple systems.		9,10	2
CO3	Analyse data from experiments and prepare well organized laboratory report.		9,10	4

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	3	3		3					2	2					

List of Experiments:

1. Time constant determination for first order systems (step input)
2. Single Tank System -I Order System (step input)
3. Non Interacting tanks - I Order system in series (step/impulse input)
4. Interacting tanks - I Order system in series (step/impulse input)
5. Simple level Control – P, PI,PD,PID action
6. Temperature Control – ON/OFF, P, PI,PD,PID action
7. Valve Characteristics
8. Study of temperature sensors characteristics – RTD , Thermocouple, Thermistor
9. Study of Temperature Transmitter
10. Study of I/P and P/I converter
11. Control system in stirred tank heater
12. Study of Flapper-Nozzle

Note: Minimum 10 experiments to be conducted.

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Reference Books:

1. Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.

15UCHL705 Computer Applications in Chemical Engineering and Simulation Laboratory (0-0-3)1.5

Contact Hours: 30

Course Learning Objectives:

1. To make the students understand physical systems in chemical engineering and using C program to develop models and solutions for these models.
2. The students will also learn to use the commercial process simulations using simulation software.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Solve some problems related to chemical engineering using C-program	4,5, 10	15	
CO2	Demonstrate the model solving ability of various process/unit operations involved in chemical engineering.	10,5, 15	9	4
CO3	Analyse and optimize the parameters of a chemical process using simulation software.	4, 9, 5		15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				1.66	1				1.5	1					2

List of Experiments:

C – Programming:

1. Flash Vaporization for multi-component system
2. Design of Adiabatic Batch Reactor, PFR
3. Bubble and Dew temperature.
4. Double pipe Heat Exchanger (Area, Length and Pressure drop)
5. Distillation column (Bubble cap)

Simulation:

1. Introduction to suggested software available (flow sheeting)
2. Simulation Studies of flash drum, Distillation Column, CSTR, PFR, Heat Exchanger.
3. Simulation Studies of pump, compressor, cyclone, heater
4. Process simulation study of the following process:
   a. Ethylene Glycol from Ethylene oxide
   b. Atmospheric distillation of crude oil
   c. Phthalic anhydride process
   d. Aromatic stripper with Toluene, Xylene
   e. Styrene from Ethyl Benzene
5. Introduction to E-Fluent Software.

Reference Books:

1. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.
2. William L. Luyben, "Process modeling, simulation and control for Chem. Engg.", Mc. Graw Hill, 1990.
3. Asghar Hussain, "Chemical process simulation", Wiley Eastern Ltd, 1986.
4. Roger G.E Franks, "Modeling and Simulation in Chemical Engineering" Wiley Inter science. New York, USA, 1972.

15UCHE706	Pilot Plant and Scale up Methods	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results, and apply process scale-up methods.
2. To study proper designs, modeling and processing and the importance of the process geometry.

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Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify and explain the need for pilot plant and its demonstration	13	3	2
CO2	Interpret and analyse different approaches for scale up studies in chemical engineering system.	2	3	13
CO3	Predict and assess different challenges and techniques for scaling up the given system.	2	3	14
CO4	Illustrate and develop the different mathematical models for scale up methods	5	2	1, 3,13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping level	3	1.75	2.25		1								2.3	3	

Course contents:

1. **Introduction to Pilot plant and scale up studies**. Major issues, approaches to scale up, describing process system. Need for Pilot plant. Concepts of prototype and models. **8 Hrs.**
2. **Mathematical modeling**- Major issues, fundamental principles. Dimensional analysis and Principles of similarity. **8 Hrs.**
3. **Pilot plants and demonstration**- Major issues, fundamental considerations, rules of thumb, predicting commercial performance. Regime concept. **8 Hrs.**
4. **Scale up of chemical reactor systems**. Mixing process: Principles scale up relations, guidelines for scale up. Agitated vessel. **10 Hrs.**
5. **Stage wise mass transfer process**. Principles, Vapour-Liquid systems. Distillation. Absorption and stripping. Extraction. **10 Hrs.**
6. **Scale up of Momentum and Heat Transfer systems**. Environmental challenges of scale up. **8 Hrs.**

Reference Books:

1. Attilio Bisio, Robert L. Kabel, "Scale up of Chemical Processes", John Wiley Interscience publication, 1985.
2. Ibrahim and Kuloor, "Pilot plant and Scale up Studies".
3. Johnstone and Thring, "Pilot Plants Models and scale up method in Chemical Engineering", McGraw Hill, 1962.
4. Marko Zlokarnik, "Dimensional Analysis and Scale-up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986.

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15UCHE707	Transport Phenomena	(4-0-0)4

Contact Hours: 52

Course Learning Objectives:

1. To provide basic understanding of laws governing transport processes and effect of various parameters.
2. To provide an understanding of steady state shell balances for velocity, temperature and concentration distribution under laminar flow.
3. To deal with equations of change and analogies amongst transport processes along with their applications

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	State laws of momentum, energy and mass transport. Discuss effect of temperature and pressure on transport properties of fluid.			1
CO2	Formulate velocity, temperature and concentration distributions under laminar flow conditions and solve transport problems.	1	2, 3, 13	
CO3	Derive equations of change for isothermal systems. Apply these equations in solving steady state problems	1	2, 3, 13	
CO4	Write analogies between momentum, heat and mass transport problems.		1	2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1.75	2.3	2										2		

Course contents:

1. **Introduction:** Momentum, Energy and Mass transport, Newton's law of viscosity, Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction, Ficks law of diffusion, effect of temperature and pressure on transport properties of fluids. Numerical problems using all law. **6 Hrs.**
2. **Velocity distribution in laminar flow:** Steady state shell momentum balance, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through circular tube, flow through annulus, flow

between parallel plates and slit. Numerical problems using the equation derived above. **12 Hrs.**

3. **Temperature distribution in laminar flow**: Steady state shell balance, boundary conditions applicable to energy transport problems, heat conduction through compound walls, heat conduction with internal generation by electrical source, nuclear and viscous energy sources. Heat conduction in a cooling fin, Forced and free convection heat transfer. Numerical problems using equation derived above. **12 Hrs.**
4. **Concentration distribution in laminar flow:** Steady state shell balance, Boundary conditions applicable to mass transport problems, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion, Diffusion into falling film, Forced convection mass transfer, Diffusion with homogeneous and heterogeneous reaction. Numerical problems using the equation derived above. **10 Hrs.**
5. **Equation of change of Isothermal systems**: Non isothermal systems and Multicomponent systems. Application of these equations in solving steady state problem. **6 Hrs.**
6. **Analogies and Navier Stokes equation:** Simple numerical problems on it. Analogies between Momentum, Heat and mass transport and their numerical problems. **6 Hrs.**

Reference Books:

1. Bird, Stewart and Lightfoot, "Transport Phenomena", John Wiley, 1994.
2. Robert Brodkey and Henry C. Hershey, "Transport Phenomena Unified Approach", International Edition- 1988.
3. Bennet and J. E., "Momentum Heat and Mass Transfer", Myer- McGraw Hill-1982.
4. Suryavanshi and Dongre, "Transport Phenomena", Nirali Prakashan, 2012. ISBN: 978-81962-56-5.

15UCHE708	**Process Modeling and Simulation in Chemical Engineering**	**(4-0-0)4**

Contact Hours: 52

Course Learning Objectives:

1. To study basic concepts of modeling and formulation of mass and energy balance relationships and thereby it helps for the development of complex models.
2. To understand the advanced technologies in simulation field and the applicability in industries.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Explain and apply the different fundamentals to develop the models for chemical engineering system.		2	1,3
CO2	Interpret and develop different mathematical methods for chemical engineering system.		1, 2	3,13
CO3	Apply and assess different relevant software for simulation of chemical engineering models.		2,3	5, 15
CO4	Demonstrate and analyse the different model solving ability for various chemical engineering process.		2,3	5, 13

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2.5	2	2.5		3								3		3

Course content:

1. **Modeling in Chemical Engineering**: Introduction, Principles of Formulation, Fundamental laws; Continuity Equation, Energy Equation, Equation of motion, Transport Equations, Equation of States, Equilibrium, Chemical Kinetics, Classification of Mathematical models. **10 Hrs.**
2. **Numerical techniques:** Iterative convergence methods like bisection and secant method, Newton raphson method, Numerical integration of ordinary differential equations like Euler and Runge Kutta method. Numerical solution of partial differential equations of first order approximation with examples. **12 Hrs.**
3. **Models in Chemical engineering:** Introduction, Series of Isothermal, Constant-Holdup CSTRs, CSTRs with Variable Holdups, Two Heated Tanks, Gas-Phase, Pressurized CSTR, Non-isothermal CSTR, Single-Component Vaporizer, Multicomponent Flash Drum, Batch Reactor, Reactor With Mass Transfer, Ideal Binary Distillation Column, Multicomponent Non-ideal Distillation Column Batch Distillation With Holdup. **14 Hrs.**
4. **Computer simulation**: Introduction to Simulation, Role of Computers and Numerical Methods in simulation, Iterative convergence methods, Explicit Convergence methods, Explicit Numerical Integration algorithm, Implicit Methods, Numerical examples. **8 Hrs.**

5. **Specific simulation/ Model development:** Batch reactor, CSTR, Bioreactor, activity coefficient models, Distillation and equilibrium Flash vaporization.

8 Hrs.

Reference Books:

1. William L. Luyben, "Process modeling, simulation and control for Chem. Engg.", Mc. Graw Hill, 1990.
2. Edger TF and Himmelblau D M, "Optimization of chem. Process" Mcgraw Hill, 1989.
3. Asghar Hussain, "Chemical process simulation", Wiley Eastern Ltd, 1986.
4. Roger G.E Franks, "Modeling and Simulation in Chemical Engineering" Wiley Inter science. New York, USA, 1972.

15UCHE709	**Novel Separation Techniques**	**(4-0-0) 4**

Contact Hours: 52

Course Learning Objectives:

1. To provide an understanding of novel/newer separations using mass transfer and thermodynamic considerations.
2. To provide an understanding of their applications at different levels in industry, viz. refineries, biochemical processing, pharmaceuticals, gaseous separations, metallurgical etc.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	**Mapping to POs (1-12) PSOs(13-15)**		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Outline continuous adsorption and advanced chromatographic techniques.		12	5
CO2	Classify membrane based separations and explain their mass transfer and thermodynamic considerations with applications.	12	13	5
CO3	Explain the surfactants based, micellar and foam separations with applications.		12	5
CO4	Describe Super Critical Fluid Extraction process with applications.		12,14	5
CO5	Explain the processes of thermal diffusion, electrophoresis.		12	5

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level					3							1.8	2	2	

Course content:

1. **Adsorptive separations:** Thermal swing adsorption, gradient chromatography and counter current separations etc. **12 Hrs.**
2. **Membrane separation processes:** Classification, structure and characteristics of membranes, mass transfer considerations, R.O., U.F, Pervaporation, and gaseous separations. **12 Hrs.**
3. **Surfactant based separations:** Fundamentals of surfactants at surfaces and in solutions. Liquid membrane permeation, foam separations, micellar separations. **8 Hrs.**
4. **External field induced separations**: Electric and magnetic field separations. Centrifugal separations. **6 Hrs.**
5. **Super critical fluid extraction:** Physicochemical principles, thermodynamics, process description. Applications and case study. **8 Hrs.**
6. **Separation**: Thermal diffusion, electrophoresis . **6 Hrs.**

Reference Books:

1. P.C. Wankat, "Large scale adsorption chromatography" CRC Press, 1986.
2. R.W. Rousseu, "Handbook of separation process technology", John Wiley and sons 1987.
3. S.Sourirajan and T. Matsura, "Reverse osmosis and Ultra filtration process principle", NRC publication Ottawa, 1985.
4. Richard Baker, "Membrane Technology and Applications", 2/e, , John Wiley and Sons Ltd.

15UCHE710 Wastewater Treatment and Engineering (4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To create awareness on the water pollution aspects and understand the kinetics and the designing system of the plant.
2. To understand the different parameters, treatment methods and control techniques of water pollution.

Course Outcomes (COs):

COs	Description: At the end of course the student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	**Moderate 2**	**Substantial 3**
CO1	Cognize the different regulatory standards with design criteria for environmental parameters	3, 6, 7	14	
CO2	Learn the wastewater treatment criteria based on the regional requirement.		14, 15	3, 6, 7
CO3	Comprehend the reaction kinetics, reactor selection and its process analysis.		3, 6, 7	14
CO4	Design the treatment plant based on the fundamentals studies, bench scale and pilot plant studies		3, 6, 7	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2			2	2							2.5	2.0

Course Content:

1. **Objectives of wastewater treatment**: Flow measurements and Composition. Characterization -properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central. **8 Hrs.**
2. **Microbiology of waste treatment**: Growth and inhibition of bacteria. Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization. Effects of endogenous metabolism & kinetics Manod's and Michaclis menton kinetics and their applications. Determination of kinetic coefficients. **10 Hrs.**
3. **Sewerage System- Design of sanitary sewer**: Sewerage System- Design of storm water sewers, Physical and Chemical treatment of wastewater, Screens, Comminuters, Grit chambers, Sedimentation Chemical treatment. **10 Hrs.**
4. **Biological treatment process**: Activated sludge process standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds Treatment disposal of sludge- Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation. **12 Hrs.**
5. **Advanced Waste Water Treatment**: Introduction, Need of Advanced Waste Water Treatment, Purpose of Advanced Waste Water Treatment. Nitrogen & Phosphorus Nitrogen Removal: Nitrification , Denitrification Simultaneous

nitrification and denitrification Phosphorus Removal. Membrane Bioreactor with Membrane Module Submerged in the Bioreactor. Electro-coagulation: Factors affecting Electrocoagulation, Electrode materials, Reactor configurations. **12 Hrs**.

Reference Books:

1. Metcalf and Eddy. Waste water Engineering: Treatment and disposal
2. Gaudy and Gaudy- Microbiological for environmental Scientist and engineers McGraw Hill 1980. 4.
3. G. Tchobanoglous and F.I. Biston Waste water Engineering Treatment and Reuse: Mc Graw Hill, 2002.
4. McGhee. Water Supply and Sewerage, McGraw Hill.

VIII Semester B.E.

15UCHC800	Process Engineering Economics and Management	(4–0–0) 4

Contact Hours: 52

Course Learning Objective:

1. Prepare the students to analyse cost/revenue data and carry out economic analyses in the decision making process to justify alternatives/projects on an economic basis and prepare students to function in the business and management side of professional engineering practice.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Comprehend the concepts of plant location, layout.	12	7	3
CO2	Apply economic concepts viz. cost estimation, depreciation, cash flow etc. in solving chemical engineering problems.		9	11
CO3	Apply economic tools viz. profitability, replacement, breakeven analysis to appraise chemical engineering processes.	9	11	12
CO4	Interpret production, material and marketing management with their virtues applied to a chemical industry.		6,9	8,11

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			3			2	2	3	1.6		2.6	2			

Course Contents:

1. **Cost estimation.** Factors involved in project cost estimation, methods employed for the total cost estimation. Plant location and Layout. **10 Hrs.**
2. **Depreciation,** Taxes and Insurance. Different methods of Depreciation. Time value of money and its equivalence. Cash flow diagram s **8 Hrs.**
3. **Profitability and methods of evaluation**. Replacement and Break even analysis. **8 Hrs.**
4. **Production Management**. Types of production and planning, manufacturing planning, factory planning, production planning, schedule, work study, method study, systems of wage payments. Bonus. Automation. Organization of production. Planning and control department. **10 Hrs.**

5. **Material Management**. Functions of purchasing. Quality standards and Inspection. Sources of supply. Inventory management. ABC analysis. EOQ model. Value analysis and engineering. **8 Hrs.**
6. **Marketing Management.** Functions of marketing. Market research. Product life cycle. Promotion of sales. Pricing. **8 Hrs.**

Reference Books:

1. Peter and Timmerhaus, "Plant design and Economics for Chemical Engineers", McGraw Hill, 1991.
2. Banga and Sharma, "Industrial Organization and Engineering economics", Khanna Publications, 1999.
3. Tripathi and Reddy, "Principles of Management", 5/e, Tata McGraw-Hill Education, 2004.

15UCHL801 Seminar (0-0-3)2

Contact Hours: 40

Course Learning Objectives:

1. To provide platform to focus on knowledge of technical data collection, communication skills and report writing.
2. To develop intellectual and professional competence and work on the chosen topic to improve skills in writing and oral presentation.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Review and acquire knowledge on the chemical engineering topic outside the scope of curriculum	4,5	6,7,8,9,12	14
CO2	Outline and consolidate the required information on chosen topic		6,7,8	9
CO3	Organize the technical matter in the required format and compile the same		9	12
CO4	Interpret and communicate the topic with proper justification and conclusion			9, 10

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level				1	1	2	2	2	2.5	3		2.5		3	

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Course content:

Seminar should be based on a detailed study of any topic related to Chemical Engineering (preferably the advanced areas / application) and the topic should preferably be relevant to the curriculum. Students may undertake studies in research survey, literature review and analysis, synthesis, design and development, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of the work.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. It is expected that the student collect information from reference books, standard journals. The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow. The discussion and conclusions shall form the last part of the text.

The seminar shall be evaluated with due weightage on:

Topic-10%

Literature survey-25%

Report-20%

Presentation-25%

Conclusion and querries-20%

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.

Books in the area of chemical engineering and its related field.

15UCHL802	**Major Project – Phase 2**	**(0-0-12)10**

Contact Hours: 100

Course Learning Objectives:

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Analyse and compare the literature review of the topic chosen in chemical engineering	7, 14	8,12	2,10
CO2	Identify the challenges related to the process industries or society with multidisplanery facets	10, 14	8,12, 11	6,7,9
CO3	Select the suitable material, methodology and carry out the computation and economic analysis			3,4,5,15
CO4	Formulate, design and report the approaches to carry out the experiments with feasibility solutions	9	8,10,12	11,15
CO5	Outline the precise project report with appropriate guidelines and references	9	8,15	10
CO6	Discuss the results obtained with proper justification and conclusion		10,11	

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level		3	3	3	3	3	2	2	1.6	2.2	2.3	2		1	2.66

Course Content:

The project has been assigned at the beginning of the VII semester. The project group would have carried out the preliminary literature survey, plan of project and submitted the synopsis in the VII semester. After the approval from DUGC, the left project work should be carried out and completed in the VIII semester. The detailed project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:

Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.

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Books in the area of chemical engineering and its related field.

15UCHE803	Solid Waste Management	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To provide students with a comprehensive understanding of integrated solid waste management from an environmental and public health perspective.
2. To study the detailed engineered system of solid waste management system.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Characterize the solid waste, management, planning and policies.	4	3,14	6,7,
CO2	Explain the process of collection, handling, storage and disposal techniques of solid waste and hazardous waste.	4	3,	6,7,14
CO3	Categorize different processing methods of solid waste used for recovery of resources.	4	3,	6,7,14
CO4	Apply different techniques of solid waste management for chemical industries through case studies.	4	3,14	6,7

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level			2.0	1.0		3.0	3.0							2.5	

Course content:

1. **Introduction to solid waste.** Definition, Characteristics, Types and properties. Organization and status of SWM, Components of integrated waste management strategy. Overview of materials flow in society and 4R concept of solid waste management. Evolution of SWM, Effect on health and environment. Legislation and government agencies, planning of SWM progress. **8 Hrs.**
2. **Engineered systems for solid waste management**. Generation of solid waste, Onsite handling, Storage and Processing, Transfer and transport, Collection system and devices, processing techniques and equipment. **10 Hrs.**
3. **Disposal of solid wastes.** Source reduction, Ocean dumping, Land filling, Composting and Thermal Incineration. **10 Hrs.**

4. **Recovery of resources,** physical, chemical and biological methods. Details of energy recovery system, heat recovery, gasification, pyrolysis and refuse derived fuels (RDFs). **8 Hrs.**
5. **Hazardous waste** and their management issues and planning methods. Origin, reduction at source, collection and handling. E-waste handling and disposal. **8 Hrs.**
6. **Case studies** on major industrial solid waste generation units- Coal fired power plant, Textile industry, Brewery, Oil refinery, Radioactive generation units, Spills, Sludge lagooning and Incineration. **8 Hrs.**

Reference Books:

1. George Tchobanoglous, "Integrated Solid waste Management-Engineering Principles and Management issues", McGraw Hill, 1993.
2. Howard Peavy, "Environmental Engineering", McGraw Hill,1986.
3. Dutta, "Industrial Solid waste Management and landfilling practice", Narose Publication, 1999.

15UCHE804	Instrumental Methods of Analysis	(4-0-0) 4

Contact Hours: 52

Course Learning Objective:

1. To understand the principles and concepts behind the qualitative and quantitative analysis of molecules and compounds using instrumental methods with their applications.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Identify the concepts for analysis of molecules and compounds using instrumental methods.	2	1	5
CO2	Interpret and analyse the different spectroscopic techniques.	5	3	1
CO3	Explain and analyse Flame photometry and AAS techniques and its application.	2	3	1
CO4	Explain and analyse the electrochemical techniques and its application.	3	1	2
CO5	Explain and analyse the chromatography technique and its applications.	1	2	5

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15

Mapping Level	2.2	1.75	1.67		2.33											

Course Content:

1. **Spectroscopy:** General introduction; Nature and interaction of electromagnetic radiations, Energies corresponding to various kinds of radiations, Atomic and molecular transitions, factors influencing positions and intensity of spectral line, introduction to UV-Vis spectroscopy. **6 Hrs.**
2. **Infrared spectroscopy:** Introduction, Theory, types of vibrations, fundamental modes of vibrations and group frequencies, factors affecting the group frequencies and band shapes, instrumentation FTIR. Instrument and its advantages, Sample handling techniques, Qualitative applications of IR, Applications of IR to structural elucidation of simple organic molecules. **6 Hrs.**
3. **Nuclear Magnetic Spectroscopy:** Introduction, Chemical shifts, Mechanism of shielding and deshielding. Types of nuclei, Theory of population of nuclear magnetic energy levels, , Spin –spin coupling, Rules of governing the interpretation of first order spectra, Low and high resolution NMR, Instrumentation and application to structure elucidation of simple organic molecules. **6 Hrs.**
4. **Mass Spectroscopy:** Introduction, theory, Instrumentation of mass spectrometer, Methods of generation of positively charged ions, Mass analyzers, Resolving power, Molecular ion peak, Base peak, Metastable peak, Modes of fragmentations, Application of mass spectrometry in Qualitative and Quantitative analysis. Structural elucidation of simple organic molecules **6 Hrs.**
5. **Flame Photometry and Atomic Absorption Spectroscopy:** Introduction, Principle, Flame and flame spectra, variation of emission intensity with flame, Metallic spectra in flame, flame ground, Role of temperature on absorption emission and fluorescence. Comparative study of Flame Emission Spectroscopy (FES) and Atomic Absorption Spectroscopy (AAS) Instrumentation and Applications. Qualitative and quantitative determination of alkali and alkaline earth metals. Nephelometry and Turbidometry Introduction, Theory, effect of concentration, Particle size and wavelength on scattering. Instrumentation and applications of Nephelometry and Turbidometry. **10 Hrs.**
6. **Electrochemical Techniques:** Introduction to Electrochemistry, Electrode Potential, Nature, Measurement, sign convention, Effect of concentration, Standard electrode potential, Cell Potential: Thermodynamic, Liquid junction potential, Effect of current. Polarization: Sources, over voltage, concentration polarization, Mechanism of mass transport. Potentiometric Methods: reference

electrodes- calomel electrode Ag- Agcl (s) electrode, Hydrogen electrode, Potentiometric titrations and applications. Membrane Electrodes: Classification of properties, Principle design, theory of ion selective electrodes Membrane potential, Selectivity, Crystalline liquid membrane and electrodes. **10 Hrs.**

7. **Chromatography:** Introduction to chromatographic techniques, General descriptions, definitions, terms and parameters used in chromatography. Classification of chromatographic methods, working principles, Instrumentation and applications of Thin layer chromatography (TLC), Gas chromatography(GC), High pressure liquid chromatography (HPLC). **8 Hrs.**

Reference Books:

1. Jaffery, G.H., Basset, J., et. al., “Vogel’s Text book of Quantitative Inorganic Analysis” ,5/e, ELBX, 1998.
2. Skoog, D.A., “Principles of Instrumental Analysis”, 3/e, Saunders College publishing, 1985.
3. W.H. Willard, “Instrumental Methods of analysis”, 7/e, L.L., Merritt and J.A. Dean, 1988.
4. B.K. Sharma ,“Instrumental Methods of Chemical Analysis”, Goel Publishing House Meerut, 2000.

15UCHE805	Sugar Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. Studying this subject the students will understand the different processing methods practiced for production of sugar. Learn about the extraction and production of sugar learn different unit operation and unit process application with practical difficulties encountering during process along with its remedies.

Course Outcomes (COs):

COs	Description: At the end of the	Mapping to POs (1-12) PSOs(13-15)

	course student will be able to	Introductory 1	Moderate 2	Substantial 3
CO1	Relate the Indian Sugar industry and World scenario	7, 14	6	
CO2	Analyze Working, operation and performance of sugar production process.	1	2	
CO3	Identify various equipments for sugar production.		14	
CO4	Design a system to meet the needs considering the constraints of economics, safety and environmental problems associated with sugar industry.		7	3, 14,6
CO5	Identify the various means of cogeneration and its importance on economy of sugar industry.	13	2	14

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	1	2	3			2.5	1.5						1	2.25	

Course contents:

1. **Sugar industry in India:** Chemical and physical properties of sucrose and reducing sugars. Sources of sucrose, formation of sucrose plants, non sugar compounds of sugarcane, inorganic constituents of sugar cane juices and sugars analytical used in sugar industry. **8 Hrs.**
2. **Purification:** Technology of the purification process, fundamental reactions and physical chemistry aspects of clarification, liming, Sulphitation and carbonation process, filtration of sugar juices. **12 Hrs.**
3. **Unit operations:** Evaporation of sugar juice, heat transfer in evaporators, evaporation equipment and auxiliaries. Crystallography: solubility of sucrose, theoretical aspects of crystal growth, factors influencing rate of crystallization, control methods and equipment in sugar crystallization, technology of sugar crystallization, boiling scheme of crystallization Centrifugation: theory of the centrifugal process, centrifugal operation, engineering principles of sugar centrifugals, and the centrifugal equipment and auxiliaries, grading of sugar. **14 Hrs.**
4. **Distillery:** Production of final molasses and molasses's utilization and storage. Molasses characteristics for alcohol. Fermentation methodology for alcohol production, factors influencing the production. Distillation methods used in separation process, Design consideration for distillation column. **6 Hrs.**

5. **Co-generation:** Types of co-generation methods, quality of bagasse used, different types of boilers used and efficiency, factors influencing the operation, methods of obtaining steam, and quality of steam **6 Hrs.**
6. **Environmental management plan:** Pollution control measures for water, air, solid waste, noise in sugar industries. **6 Hrs.**

Reference Books:

1. Honing P (Ed), "Principles of Sugar Technology", Vol I to III, Elsevier publishing company, 1953.
2. Jenkinos. G.H., "Introduction to cane sugar Technology", Elsevier, 1966.
3. Mathur.R.B.L, "Handbook of cane Sugar Technology", 2/e, Oxford and I.B.H. Publishing Co., 1997.
4. R.K. Rajputh, "A text book on Power Plant Engineering", 2/e, Laxmi publications (p) Ltd., New Delhi, 2001.

15UCHE806 Bioprocess Engineering (4-0-0)4

Contact Hours: 52

Course Learning Objectives:

- To provide the students with the basics of bioreactor engineering.
- To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	Select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts and cell lines and other process criteria.	2	3, 4, 7	
CO2	Apply modelling and simulation of bioprocesses so as to reduce costs and to enhance the quality of products and systems.		3, 4, 7	5
CO3	Plan a research career or to work in the biotechnology industry with strong foundation about bioreactor design and scale-up.	3, 4, 7		13
CO4	Integrate research lab and Industry; identify problems and seek practical solutions for large scale implementation of Biotechnology.		3, 6	15

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15

Mapping Level		1	1.7	1.6			1.6						3		3

Prerequisites: Biochemical Engineering

Course content:

1. **Operational Modes of Bioreactors**: Fed batch cultivation, Cell recycle cultivation, Cell recycle cultivation in waste water treatment, two stage cultivation. Packed bed reactor, airlift reactor, fluidized bed reactor and bubble column reactor. **10 Hrs**.
2. **Bioreactor Scale-Up:** Regime analysis of bioreactor processes, oxygen mass transfer in bioreactors microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. **12 Hrs.**
3. **Bioreactor Consideration in Enzyme Systems** : Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors. **10 Hrs.**
4. **Modelling And Simulation of Bioprocesses** :Study of structured models for analysis of various bioprocess – compartmental models, models of cellular energetics and metabolism, single cell models, plasmid replication and plasmid stability model. Dynamic simulation of batch, fed batch, steady and transient culture metabolism. **10 Hrs**
5. **Recombinant Cell Cultivation**: Different host vector system for recombinant cell cultivation strategies and advantages. E.coli, yeast Pichia pastoris/ Saccharomyces cereviseae, Animal cell cultivation, plant cell cultivation, Insect cell cultivation. High cell density cultivation, process strategies, reactor considerations in the above system. **10 Hrs.**

Reference Books:

1. Jens Nielson, John Villadsen and Gunnar Liden, “Bioreaction engineering principles”, 2nd Edition, Kulwer Academic, 2002
2. Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc
3. James E. Bailey & David F. Ollis, “Biochemical Engineering Fundamentals”, McGraw Hill.
4. Atkinson, B, Mavituna, F, “Biochemical Engineering and Biotechnology Handbook” Macmillan Publishers Ltd, New York, 1992.

15UCHE807 Unit Processes in Organic Synthesis (4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

1. To study the fundamental concepts of Industrial Chemistry and their applications.
2. To have knowledge on various reaction mechanisms, preparation of organic compounds, classification of the compounds etc.

Course Outcomes (COs):

COs	Description: At the end of the course student will be able to	Mapping to POs (1-12) PSOs(13-15)		
		Introductory 1	Moderate 2	Substantial 3
CO1	To apply basic knowledge of chemical processes and equations to solve numerical problems.	5	3	2
CO2	To develop appropriate techniques in industrial scales for the preparation of value added products.	7	2	1
CO3	To converge the concepts of chemical processes like sulfonation and sulfation for industrial products	1	5	3,13
CO4	To elaborate halogenations its process, kinetics and interpret it for modern industrial processes.	6	1	5,13
CO5	To correlate oxidation and analyse various unit processes of many organic compounds for improvement of existing techniques for the preparation of better yield and quality,	3	2	1
CO6	To evaluate hydrogenation reaction and processes with mechanisms for innovative industrial products.	1	3	2

POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13	PO14	PO15
Mapping Level	2	2.5	2		2	1	1						3		

Course content:

1. **Introduction**: Unit processes and principles of thermodynamics and kinetics related to unit processes. **6 Hrs.**
2. **Nitration:** Introduction, nitrating agents, aromatic nitration, thermodynamics kinetics and mechanism, nitration of paraffin hydrocarbon, other nitration.

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Mixed acid for nitration, process equipment for technical nitration typical industrial nitration processes (nitrobenzene). **10 Hrs.**

3. **Sulfonation and sulfation:** Introduction sulfonating and sulfation agents and their application, chemical and physical factors, kinetics mechanism and thermodynamics od sulfonation, industrial equipments for batch and continuous processes industrial processes (Monosulphonation of benzene, detergent alkylate). **10 Hrs.**
4. **Halogenation:** Introduction survey of halogenation processes thermodynamics and kinetics, chlorination in presence of catalyst, photo halogenation, industrial equipment for halogenation, typical processes (Chorobenzene). **9 Hrs.**
5. **Oxidation:** Types of oxdative reactions oxidizing agents. Typical liquid phase oxidation processes, vapor phase oxidation of alpha-tic and aromatic compounds. Industrial processes (strene from ethyl benzene, acetaldehyde to acetic acid.) **9 Hrs.**
6. **Hydrogenation:** Introduction, methods of hydrogen production, general principles relating to hydrogenation catalysts, kinetics and thermodynamics, industrial apparatus for hydrogenation and typical examples of hydrogenation processes (Hydrogenation of oils and fats). **8 Hrs.**

Reference Books:

1. P. H. Groggins. “Unit Processes in Organic Synthesis “, 5/e, Tata Mc Graw Hill, 1995.
2. Kirk R. E. Othmer D. F. “Encyclopedia of Chemical Technology”, Inter Science Publishers.

15UMAE875	Applied Numerical Methods	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:
Study the numerical methods to solve algebraic, transcendental equations, partial differential equations and boundary value differential equations.

<u>Course Outcomes(COs):</u>
At the end of this course, students should meet the learning objectives through following observable and measurable outcomes by undergoing various tests planned by the course teacher as a part of course plan.

COs	Description of the course outcomes
CO-1	Obtain the Solution of algebraic and Transcendental equations.
CO-2	Employ interpolation and extrapolation to Analyze the experimental data and predict.
CO-3	Apply Numerical method to solve boundary valued differential equation.
CO-4	Apply Numerical Integration to Compute Area and Volume.
CO-5	Apply the concept of Rank to solve Engineering Application Problem
CO-6	Apply suitable Numerical methods to solve partial differential equation.

Contents:

1. Numerical solution of Algebraic and Transcendental equations:
Fixed point iteration method, Aitken's process method, Newton-Raphson method for a system of two simultaneous equations. Homer's method, Grafee's root squaring method, Birge-Vietta method. **10 Hrs**

2. Interpolation:
Central differences, central difference interpolation formulae. Gauss's forward interpolation formula. Gauss's backward interpolation formula, Stirling's interpolation formula, Everett's interpolation formula, Bessel's interpolation formula. Hermite and Cubic Spline interpolation. Richardson extrapolation. **12 Hrs**

3. Numerical Differentiation and Integration
Derivatives using Stirling's formula, Bessel's formula.
Romberg integration. Gaussian quadrature, double integration by Trapezoidal and Simpson's $l/3^{rd}$ rules.

4. Numerical solution of ODE:
Picard's method. Taylor's series method for simultaneous first order ordinary differential equations and second order O.D.E's. Runge-Kutta method for simultaneous first order O.D.E and second order O.D.E, Linear Shooting method, Finite difference method and Rayleigh -Ritz method. **10 Hrs**

5. Linear Algebra:
Condition number of a matrix, Matrix inversion method, LU factorization method (Crouts method), Partition method. Relaxation method, Bounds for Eigen values, Jacobi's method. Given's method. **10 Hrs**

6. Numerical solution of PDE:
Numerical solution of one dimensional heat equation. Bendre-Schmidt's method. Crank Nicolsen method. Numerical solution of one dimensional wave equation; explicit method- problems. Numerical solution of two dimensional Laplace equation. Gauss-Seidel method problems. **10 Hrs**

Reference Books:
1. Richard. L. Burden, J. Douglas Faires, Numerical Analysis, Thompson Publishing Company edition - 2001.
2. M.K. Jain, S.R.K. lyengar and R.K. Jain - Numerical methods for scientific and Engineering computation New Age Internationa! Publisher - 5lh edition - 2007.
3. Anthony Ralston, Philip Rabinowitz - A first course in Numerical Analysis - McGraw Hill Publication - 2"J edition – 2001
4. B.S.Grewal-Numerical methods in engineering and science- Khanna Publishers 9th edition- 2010.
5. Thomas G.B. and Finney R.L."Calculus and Analytical Geometry" 9th Edition, Pearson, 2012.

15UPHE876	Nanotechnology	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives:

The students are expected learn about the fundamentals and integrated multidisciplinary nature of nanotechnology and to understand the importance of materials at the nanoscale, size and shape dependent properties, classification of materials, different methods to prepare nanostructures. The course covets the various nanofabrication and hybrid fabrication approaches and characterization techniques. Finally, they are expected to be acquainted with the significance of nanomaterials.

Course Outcome (COs): At the end of the course, the student will be able to **:**

COs	Description of the course outcomes
CO-1	Specify the holistic view of nanoscience, nanotechnology and the effect of quantum confinement in nanostructures.
CO-2	Describe the importance of basic scientific concepts related to the behavior of matter at the nanoscale.
CO-3	To impart the basic knowledge on various preparation techniques involved in nanotechnology and interpret the importance of carbon clusters.
CO-4	Demonstrate the different lithographic techniques and applications of characterization techniques.
CO-5	Evaluate the merit of nanocomposites materials and different applications of nanomaterials.

Course Contents:

1) Basics of Nanoscale Materials:

Introduction: Nanoscale materials, concepts of nanoscience and nanotechnology, importance of nanotechnology. classification of nanomaterials – shape and intrinsic. Physics of nanomaterials – size and surface effects, variation of density of states, size and shape dependent properties of nanomaterials.

Metal and Semiconductor Nanocrystals:

Metal nanocrystals – Plasmons, Surface Plasmon Resonance (SPR) - Gold, silver & iron nanoparticles. Semiconductor nanocrystals (Quantum Dots) and their importance – Variation of energy gap with particle size. Organic capping, core shell structures and self assembly-Intermolecular forces. **12 Hrs.**

2) Carbon Nanoclusters and Synthesis of Nanomaterials:

Carbon clusters: Fullerenes, graphene and carbon nanotubes - types of carbon nanotubes: Synthesis, Properties - electrical, thermal, Mechanical and chemical properties. Importance of carbon clusters.

Top-down and Bottom-up approaches: Chemical vapour deposition (CVD), ion sputtering, laser ablation, molecular beam epitaxy, chemical precipitation, solvothermal synthesis, micelles & green nanotechnology. **12 Hrs.**

3) Fabrication and Characterization of Nanostructures:

Nanolithography: Introduction, photo lithography (Optical, UV & EUV), Electron beam, X- ray lithography, Dip-pen lithography, immersion lithography, Nanoimprint lithography and Soft lithography.

Characterization Techniques: Optical and photoluminescence spectroscopy, field emission scanning electron microscopy (FESEM), Scanning Tunneling Microscopy, transmission electron microscopy (TEM), HR TEM, SAED, EDAX, X-ray diffraction and electron diffraction, Atomic Force Microscopy, Scanning Tunneling Microscopy. **12 Hrs.**

4) Nanocomposite Materials:

Introduction - Ceramic based composites, metal-matrix nanocomposites, polymer-based nanocomposites, graphene and carbon nanotube based nanocomposites. Thermal and electrical properties nanocomposites. **08 Hrs.**

5) Applications of Nanomaterials:

Fundamentals of Charge transport, concept of mobility, self-assembly, assembly components Coulomb Blockade and single-electron tunneling. Hybrid solar cells based on different types of nanostructures. Fuel cells and nanosensors. **08 Hrs.**

Beyond the Syllabus Coverage (Suggestive): Seminars on relevant topics.

References Books:

1. Sulabha K Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Company, 2007.
2. T. Pradeep, “Nano: The Essentials” Tata McGraw Hill Education Pvt Ltd., 2013.
3. James Murday, “Textbook of Nanoscience and Nanotechnology” Universities

Press-IIM, 2012.
4. Charles. P. Poole and F. J. Owens, Introduction to Nanotechnology, John Wiley & Sons, Inc. 2003.
5. P. Mukhopadhyay and R. K. Gupta, Graphite, Graphene and their polymer nanocomposites. CRC Press, Taylor & Francis Group. 2012

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SDM College of Engineering & Technology, Dharwad

Odd Semester 2019-20

Academic Calendar for UG Programmes

Sl. No.	Particulars	Date
1	Registration	27-07-2019 to 31-07-2019
2	Induction program for First Semester (Tentative)	01-08-2019 to 14-08-2019
3	Teaching Commences for odd semester except I Sem	01-08-2019
4	Last date for registration with late fee	06-08-2019
5	Teaching Commences for I semester	16-08-2019
6	Display of attendance	16-09-2019
7	Internal Assessment – IA– I	18-09-2019 to 20-09-2019
8	Communication of performance to the parents	26-09-2019
9	Last date to drop the course	27-09-2019
10	Display of attendance	02-11-2019
11	Internal Assessment –IA– II	04-11-2019 to 06-11-2019
12	Students Feedback	11-11-2019 to 15-11-2019
13	Communication of performance to the parents	13-11-2019
14	Last date to withdraw the course	13-11-2019
15	Teacher – Parents Meet	16-11-2019
16	Internal Assessment –IA– III	27-11-2019 to 29-11-2019
17	Last day of teaching for Odd Semester	30-11-2019
18	Final Lab Assessments	03-12-2019 to 10-12-2019
19	Display of consolidated Continuous Internal Evaluation (CIE) & Attendance	05-12-2019
20	Communication of performance to the parents	05-12-2019
21	Semester End Examination	13-12-2019 to 27-12-2019
22	Inter Semester Recess	28-12-2019 to 12-01-2020
23	Declaration of Results	09-01-2020
24	Communication of performance to the parents by putting on website	10-01-2020
25	Makeup SEE for odd semesters	11-01-2020 to 18-01-2020
	Commencement of Even Semester :	**13-01-2020**

Dean (Academic Program) **PRINCIPAL**

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Academic Calendar (Tentative) for Even Semester 2019-20
B.E. & M.Tech

Sl. No.	Particulars	Date
1	Registration	09-01-2020 to 11-01-2020
2	Commencement of Teaching	13-01-2020
3	Last date for registration with late fee	18-01-2020
4	Display of attendance	18-02-2020
5	Internal Assessment – IA– I	24-02-2020 to 26-02-2020
6	Communication of performance to the parents	03-03-2020
7	Last date to drop the course	04-03-2020
8	Parents Meet	14-03-2020
9	Insignia – 2020	20-03-2020 & 21-03-2020
10	Display of attendance	30-03-2020
11	Internal Assessment – IA– II	01-04-2020 to 03-04-2020
12	Last date to withdraw the course	08-04-2020
13	Communication of performance to the parents	11-04-2020
14	Feedback by Students	20-04-2020 to 25-04-2020
15	Internal Assessment –IA– III	04-05-2020 to 06-05-2020
16	Last day of teaching for Even Semester	06-05-2020
17	Final Lab Assessments	09-05-2020 to 20-05-2020
18	Display of consolidated Continuous Internal Evaluation (CIE) marks & Attendance for 8th semester	09-05-2020
19	Semester End Examination for 8th semester	11-05-2020 to 19-05-2020
20	Display of consolidated CIE marks & Attendance for 2nd, 4th & 6th semesters (Both for UG & PG)	13-05-2020
21	Communication of performance to the parents	14-05-2020
22	Project exam for 8th semester	21-05-2020 to 26-05-2020
23	Semester End Examination for 2nd, 4th & 6th semesters (Both for UG & PG)	22-05-2020 to 05-06-2020
24	Results for 8th semester	30-05-2020
25	Summer vacation	06-06-2020 to 31-07-2020
26	Announcement of Results for 2nd, 4th & 6th semester (Both for UG & PG)	12-06-2020

Supplementary Semester: 12-06-2020 to 27-07-2020

Commencement of next Academic Year 2020 - 21: 01-08-2020

Dean (Academic Program) **PRINCIPAL**

Supplementary Semester Calendar for B.E./M.Tech/MBA – 2020

Sl. No.	Particulars	VII & VIII Sem (B.E.)	I to VI Sem (B.E.), M.Tech & MBA
1	Registration	01-06-2020 to 03-06-2020	06-06-2020 to 08-06-2020
2	Teaching Commences	01-06-2020	12-06-2020
3	Registration with special permission by Principal	04-06-2020	12-06-2020
4	Internal Assessment (IA) – I	13-06-2020 & 15-06-2020	24-06-2020 & 25-06-2020
5	Internal Assessment (IA) – II	25-06-2020 & 26-06-2020	03-07-2020 & 04-07-2020
6	Internal Assessment (IA) – III	10-07-2020 & 11-07-2020	13-07-2020 & 14-07-2020
7	Display of consolidated Continuous Internal Evaluation (CIE) marks & Attendance	13-07-2020	16-07-2020
8	Supplementary SEE	14-07-2020 to 17-07-2020	18-07-2020 to 23-07-2020
9	Declaration of results	22-07-2020	27-07-2020

Dean (Academic Program) **PRINCIPAL**

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Academic Program: UG

Academic Year 2020-21

Syllabus

III & IV Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465** **Fax:** **0836-2464638** **Web:** www.sdmcet.ac.in

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for III& IV semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2020-21 till further revision.

Principal Chairman BoS & HoD

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SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- ✣ In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and Mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

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5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific outcomes (PSOs)

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for III Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC300	BS	Engineering Mathematics – III	3-0-0	3	50	100	3	-	-
18UCHC300	PC	Chemical Process Calculations	4-0-0	4	50	100	3		-
18UCHC301	PC	Technical Chemistry**	3-0-0	3	50	100	3	-	-
18UCHC302	PC	Fluid Mechanics	4-0-0	4	50	100	3	-	-
18UCHC303	PC	Particulate Technology	4-0-0	4	50	100	3	-	-
18UCHC304	PC	Chemical Engineering Drawing	2-0-2	3	50	100	3	-	-
18UCHL305	PC	Particulate Technology Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL306	PC	Technical Analysis Laboratory	0-0-3	1.5	50	-	-	50	3
Total			**20-0-8**	**24**	**400**	**600**		**100**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

** To be handled by the Chemistry department faculty

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Scheme for IV Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC400	BS	Engineering Mathematics – IV	3-0-0	3	50	100	3	-	-
18UCHC400	PC	Process Heat Transfer	4-0-0	4	50	100	3	-	-
18UCHC401	PC	Chemical Reaction Engineering-I	4-0-0	4	50	100	3		
18UCHC402	PC	Chemical Engineering Thermodynamics	3-2-0	4	50	100	3	-	-
18UCHC403	PC	Pollution Control Engineering	3-0-0	3	50	100	3	-	-
18UCHC404	PC	Energy Technology and Management	3-0-0	3	50	100	3	-	-
18UCHL405	PC	Computational Methods & Simulation Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL406	PC	Fluid Mechanics Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL407	PC	Introductory Project	0-0-2	1	50	-	-	-	-
Total			**20-2-8**	**25**	**450**	**600**		**100**	

Total credits offered for the Second year: 49

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Total credits offered for the Second year: 49

III Semester

18UMAC300 Engineering Mathematics-III (3-0-0)3

Contact Hours: 39

Course Learning Objective (CLO):

1. To have an insight into Laplace transforms, Fourier series, Fourier transforms, Difference equations and Z-transforms. To develop the proficiency in variational calculus and solving ODE's arising in engineering applications, using numerical methods.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Transform the given function using Laplace /Fourier transforms depending on the nature of engineering applications.			1
CO-2	Express periodic function as a Fourier series and obtain the various harmonics of the Fourier series expansion for the given numerical data.			1,2
CO-3	Solve difference equations using Z-transform.			1
CO-4	Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.		1,2	
CO-5	Determine the extrenals of functional using calculus of variations and solve problems arising in engineering.			1,2

POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
Mapping Level	1.2	1.33	-	-	-	-	-	-		-	-	-

Pre-requisites: 1. Differentiation of function.
2. Integration of function.

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Course Contents:

Unit-I

Laplace Transforms: Definition and Properties. Laplace transform of elementary functions. Laplace transforms of Periodic functions and unit-step function – problems. Inverse Laplace Transforms: Inverse Laplace transform - problems, Convolution theorem (without proof) to find the inverse Laplace transform and problems, solution of linear differential equations using Laplace transform. **08 Hrs.**

Unit-II

Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions of period 2π and arbitrary period. Half- range Fourier series. Practical harmonic analysis, examples from engineering field. **08 Hrs.**

Unit-III

Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Simple problems. Z-Transforms and Difference Equations: Z-transform- definition, Standard Z-transforms, Damping and shifting rules, Initial value and Final value theorems (without proof) with problems. Inverse Z-transform. Simple problems. Difference equations-basic definition. Application of Z-transform to solve Difference equation. **08 Hrs.**

Unit-IV

Numerical Solutions of Ordinary Differential Equations (ODE's): Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Runge –Kutta method of fourth order, Milne's predictor and corrector method (No derivations of formulae). Problems. **07 Hrs.**

Unit-V

Numerical Solution of Second Order ODE's: Runge-Kutta method and Milne's predictor and Corrector method. (No derivations of formulae). Calculus of Variations: Variation of function and functional, variational problems, Euler's equation (without proof), Geodesics (plane), hanging chain problems. **08 Hrs.**

Reference Books:

1) B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 44/e, 2017.
2) E. Kreyszig: Advanced Engineering Mathematics, John Wiley and Sons 10/e, (Reprint).2016.
3) Srimanta Pal et al: Engineering Mathematics, Oxford University Press, 3/e 2016.

18UCHC300	Chemical Process Calculations	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To study and understand the importance of stoichiometry, material and energy balances and applying these principles to industrial and theoretical problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12) /PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the fundamental and derived units with dimensions and calculate compositions of solutions.	1	2,3	13
CO-2	State ideal gas law and study humidification using psychrometric charts.	2,3	1	-
CO-3	Evaluate problems on steady state material balance without chemical reactions.	13	2,3	1
CO-4	Explain steady state material balance with chemical reaction and determine conversion, yield and selectivity.	13	2,3	1
CO-5	Compute ultimate and proximate analysis of fuels and perform calculations on energy balances.	2,3	1	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.8	2.4	2.4	-	-	-	-	-	-	-	-	-	2.0	-	-

Course content:

Unit-I

Units and Dimensions: Fundamental and derived units, Conversion of units, Dimensional consistency of equations. Dimensionless groups and constants. Conversion of equations.

Basic Chemical Calculations: Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases. Concept of normality, molarity, molality, ppm.

10 Hrs.

Unit-II

Vapour - Gas Concepts: Ideal gas law, vapour pressure concepts and calculation for miscible and immiscible systems. Real gases, Cubic equations of state. Humidification, dry bulb and wet bulb temperature, molal humidity, saturation humidity and psychrometric charts. **09 Hrs.**

Unit-III

Material Balance Without Reaction: General material balance equation for steady and unsteady states. Typical steady state material balances in mixing, evaporation drying distillation, absorption, extraction and Crystallization. Material balances involving bypass, recycle and purging operations. **09 Hrs.**

Unit-IV

Steady State Material Balance with Reaction: Principles stoichiometry, limiting and excess reactants. Effect of inerts, fractional and percentage conversion. Yield and selectivity for multiple reactions. **12 Hrs.**

Unit-V

Fuels and Combustion: Ultimate and proximate analysis of fuels. Calculations involving burning of solid, liquid and gaseous fuels.Excess air, air to fuel ratio calculations.

Energy Balance: General steady state energy balance equation. Heat capacity, enthalpy, heat of formation reaction and combustion. Determination of heat of reaction at standard and elevated temperatures. **12 Hrs.**

Reference Books:

1) Hougen, O.A., Waston, K.M. and Ragatz, R.A., “Chemical Process Principles Part – I, Material and Energy Balances”, 2/e, CBS publishers and distributors, New Delhi, 1995.
2) Himmelblau, D.M., “Basic Principles and Calculations in Chemical Engineering”, 6/e, Prentice Hall Of India, New Delhi, 1997.
3) Bhatt, B.L. and Vora, S.M., “Stoichiometry”, SI Units, 3/e, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
4) K.V. Narayanama B. Lakshmikutty, “Stoichiometry and Process calculations” Prentice Hall India Limited, New Delhi, 2006. ISBN: 978-81-203-2992-8

18UCHC301	Technical Chemistry	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. The students are expected to learn the diffrent types of behaviour of inorganic materials, understand the aspects of inorganic polymers, reaction kinetics of coordinated compounds. Besides they are also expected to understand the basic aspects of nanotechnology and spectroscopy.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the electric, electronic and optical behavior of inorganic materials.	1	-	-
CO-2	Realize the basic knowledge of chemical kinetics	-	2	-
CO-3	Apply the knowledge of inorganic polymers and their applicability in material use, optimization and in various engineering applications.	1	-	-
CO-4	Understand the aspects of nanotechnology and its use for synthesis of engineering materials.	1	-	-
CO-5	Demonstrate the knowledge of different types and the mechanisms involved in spectroscopy and apply them in the analysis of organic compounds	-	1,2	-

PO's/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.75	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisite: Engineering Chemistry

Course content:

Unit-I

Electronic, Electric and Optical Behaviour of Inorganic Materials: Metals, Insulators and Semiconductors, Electronic structure of solid, band theory, band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, the bandgap, synthesis and purification of semi conducting materials, single crystal growth, zone refining, fractional crystallization, semiconductor devices, rectifier transistors, photoconductors, photovoltaic cells, solar batteries. **08 Hrs.**

Unit-II

Inorganic Polymers: Introduction, preparation, properties and applications of Phosphorous-based polymers-polyphosphonitrilic chlorides and ultraphosphate glasses. Sulphur-based polymers-polymeric sulphur nitride and chalcogenide glasses.Silicon-based polymers-fluid polysiloxanes gums and silicone resins.

08 Hrs.

Unit-III

Reaction Kinetics of Coordination Compounds: Introduction, electron transfer reactions: Outer-sphere reactions, ligand-bridged inner sphere reactions doubly bridged inner-sphere transfer, one electron and two electrons transfers, non-complementary reactions. Ligand exchange via electron exchange.Mechanisms of ligand substitution reactions-general considerations, substitution reactions of square planar and octahedral complexes.Base-catalyzed hydrolysis of cobalt (III) ammine complexes.

08 Hrs.

Unit-IV

Introduction to Nano-Technology: Nanoscale; Nanomaterials-Introduction, properties and applications of-one dimensional nanomaterials-Thin films, two dimensional nanomaterials-Carbon Nanotubes and Nonowires, three dimensional nanomaterials-Fullerens, Dendrimers; Construction of Nanomaterials-Top down and Bottom up methods. **08 Hrs.**

Unit-V

Introduction to Spectroscopy: Study of chromatography, Paper, Thin layer and Gas chromatography and their applications. FTIR and UV-visible spectroscopy and their applications in analysis of organic compound. **07 Hrs.**

Reference Books:

1) J.D. Lee “Concise Inorganic Chemistry”,5/e, Wiley’s Publication,2012.
2) Wahid U. Malik; G.D. Tuli; R. D. Madan,“Selected Topics in Inorganic Chemistry”, Publisher: S Chand & Co Ltd, 2010,ISBN 10: 8121906008 .
3) The text book of physical chemistry Samuel Glasstone Mcmillan publications 1st Edition, 1974.
4) Fundamental of Analytical Chemistry D.A. Skoog, D.M. West, Holler and Saunders College Publishing, 8th Edition, 2005.
5) Er. RakeshRathi S, “Nanotechnology”, Chand & Company Ltd., Ram Nagar, New Delhi, 2010.

18UCHC302	Fluid Mechanics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To introduce the concepts, principles, laws, observations and models of fluids at rest and in motion.
2. To provide the basis for understanding the fluid behavior, engineering design and control of fluid systems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the nature of fluids along with the properties and its measuring devices.	1	3	-
CO-2	Interpret and analyze the parameters of fluid flow and understand the mechanical energy equations	3, 13	2	1
CO-3	Derive and interpret the equations of fluid flow for liquids and also use dimensional analysis for solving problems	3, 5, 13	2	1
CO-4	Derive and interpret the equations of fluid flow for gases and also use dimensional analysis for solving problems	3, 5, 13	2	1
CO-5	Explain and characterize the different pipe fittings, pumps and flow measuring devices.	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	2.8	-	3.0	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Fluid Statics and Applications: Introduction to momentum transfer and unit operations. Nature of fluids, pressure and its measurements. Hydrostatic equilibrium, barometric equation, measurement of fluid pressure-manometers (U tube manometer, Inverted manometer, differential manometer), continuous gravity decanter, centrifugal decanter **11 Hrs.**

Unit-II

Fluid Flow Phenomena: Newtonian and Non-Newtonian fluids, types of flows, Shear rate, Shear stress, Rheological properties of fluids. Flow in boundary layer-Boundary layer separation and wake formation. Basic Equations of Fluid Flow: Macroscopic momentum balances, Mechanical energy equations. **10 Hrs.**

Unit-III

Incompressible Fluids: Laminar flow of incompressible fluids in pipes and conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy equation.Turbulent flow of incompressible fluids in pipes and conduits-Universal velocity distribution equation. Friction factor and Reynolds number relationship and friction factor chart. Nikuradse and Karman equation-Blasius equation, Prandtl one seventh power law. Changes in velocity or direction-Sudden expansion and contraction. **11 Hrs.**

Unit-IV

Compressible Fluids: Continuity equation, Mach number, total energy balance, velocity of sound, Ideal gas equation, adiabatic and isothermal flow equations, Flow through convergent-divergent sections, stagnation properties, velocity of sound or pressure wave in ideal gas equation. **Dimensional Analysis:** Dimensional homogeneity, Rayleigh’s and Buckingham-Pi methods, dimensionless numbers, models and prototypes. **10 Hrs.**

Unit-V

Transportation and Metering of Fluids: Pipes, fittings and valves. Performance characteristics of Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors. Measurement of flowing fluids - full bore meters, area meter, insertion meters with flow rate equations. Flow through open channels- weirs and notches. Unsteady state flow- time taken to empty the liquid from the tank.
10 Hrs.

Reference Books

1) McCabe and Smith, “Unit operations of Chemical Engineering” 7/e, McGraw Hill chemical engineering series. ISBN-10: 0072848235
2) Coulson J.H and Richardson J.F, “Chemical Engineering” Vol-1 and 2, 5/e. Butterworth publications. ISBN-10: 0750644451
3) Kumar K.L., “Engineering Fluid Mechanics”, 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4) R. K. Bansal, “A textbook of Fluid Mechanics” 2/e, Laxmi Publications. ISBN: 9788131802946

18UCHC303	Particulate Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To study the basic principles of unit operations and its applications in process industries.

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12) PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply the principles of particle size analysis and unit operations to solve industrial screening problems.	1,2	13	3
CO-2	Classify size reduction equipments and evaluate their performance using laws of size reduction.	1,2	13	3
CO-3	Analyse pressure drop through bed of solids immersed in fluids and demonstrate the knowledge of their application in filtration.	1,2	13	-
CO-4	Analyse and apply the concepts of motion of particles for the design of sedimentation system.	1,2	13	-
CO-5	Demonstrate the knowledge of agitation, mixing, storage and conveying of fluid-solid systems.	1	2	13

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	3.0	2.8	1.0	-	-	-	-	-	-	-	-	-	1.8	-	-

Course content:

Unit-I

Particle Technology: Particle shape, particle size, sphericity, mixed particles size analysis. Screens – ideal and actual screens, standard screens, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture. Industrial screening equipments- grizzly, gyratory screen, vibrating screen, trommels. Sub sieve analysis – Air permeability method, sedimentation and elutriation methods. **09 Hrs.**

Unit-II

Size Reduction: Introduction, types of forces and criteria for communition, characteristics of communited products, laws of size reduction, open and closed circuit grinding. Equipments for size reduction – jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, impactors, attrition mill, ball mill, fluid energy mill, knife cutter. **10 Hrs.**

Unit-III

Flow of Fluids Past Immersed Bodies: Drag, drag coefficient. Pressure drop – Ergun's, Kozeny – Carman and Burke – Plummer equations. Fluidization - conditions for fluidization, minimum fluidization velocity, types of fluidization, applications of fluidization, pneumatic conveying.

Filtration: Introduction, classification of filtration, cake filtration, batch and continuous filtration, pressure and vacuum filtration, constant pressure filtration, characteristics of filter media. Industrial filters - sand filter, filter press, leaf filter, rotary drum filter. Filter aids, application of filter aids. Principles of cake filtration, modification of Kozeny – Carman equation for filtration. **12 Hrs.**

Unit-IV

Motion of Particles Through Fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, motion of spherical particles in Stoke's region, Newton's region and intermediate region. Criterion for settling regime, centrifugal separators, cyclones and hydro cyclones.

Sedimentation: Batch settling test, application of batch settling test to design of continuous thickener. Coe and Clevenger theory, Kynch theory. Thickener design, determination of thickener area**.** **12 Hrs.**

Unit-V

Agitation and Mixing: Application of agitation, agitation equipment, types of impellers – propellers, paddles and turbines, flow patterns in agitated vessels, prevention of swirling, standard turbine design, power correlation and power calculation. Mixing of solids, types of mixers- change can mixer, Muller mixer, mixing index, ribbon blender, internal screw mixer, tumbling mixer. **Sampling, Storage and Conveying of Solids:** Sampling of solids, storage of solids, open and closed storage, bulk and bin storage. Conveyors – belt conveyor, chain conveyor, apron conveyor, bucket conveyor, bucket elevators, screw conveyor. **09 Hrs.**

Reference Books:

1) McCabe, W. L., Smith, J. C. and Harriott, P., "Unit Operation of Chemical Engineering", 4/e, McGraw Hill International, Singapore, 2001.
2) Badger, W.L. and Banchero, J.T., "Introduction to Chemical Engineering", 3/e,McGraw Hill International, Singapore, 1999.

3) Coulson, J.M. and Richardson, J.F., “Chemical Engineering Vol.2”, 5/e, Particle Technology and Separation Processes, 1998.
4) Foust, A.S. et.al, “Principles of Unit Operation”, 3/e, John Wiley and Sons, NewYork, 1997.

18UCHC304	Chemical Engineering Drawing	(2-0-2) 3

Contact Hours: 52

Course Learning Objective (CLO):

1. To increase competency in drawing through. various conventions, equipment’s and sectional view in engineering drawing

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Demonstrate Symbols, proportionate equipment drawings	-	-	10
CO-2	Analyze sectional views and assembly drawing.	10	-	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	-	2.0	-	-	1.0	-	-

Course Content:

1. **Conventions:** Equipment and piping, colour codes, materials, nuts and bolts. **04 Hrs.**
2. **Process Flow Diagram**: with conventions and blocks, P&ID. **05 Hrs.**
3. **Proportionate Drawing of Process Equipment**: Jackets-types, Vessel Supports, Storage vessel, Reaction vessel, Heat Exchanger, Evaporator, Distillation column. **04 Hrs.**
4. **Sectional Views:** Representation of the sectional planes, Sectional lines and hatching, Selection of section planes and types of sectional views. **06 Hrs.**
5. **Assembly Drawings:**
   - **i.** Shaft Joints: Cotter joint with sleeve, Gib and Cotter joint, Socket and Spigot joint. **08 Hrs.**
   - **ii.** Pipe joint: Flanged type, Union Joint, Expansion joint **08 Hrs.**
   - **iii.** Valves: Stop valve, Lever safety valve, Rams Bottom safety valve, Non-return valve, Plug valve **17 Hrs.**

Note:

- First angle projection to be followed.
- Drafter to be used for all drawings.

Reference Books:

1) Gopal Krishna, K.R., "Machine Drawing," 2/e. Subhash Publication
2) Joshi, M.V., "Process Equipment Design" 3/e, Macmillan India publication.
3) Bhat N.D., "Machine Drawing". Charotar Publishing, 50/e, 2011
4) Vilbrantand Dryden., "Chemical Engineering Plant Design" Publisher: New York, McGraw-Hill, 1959.

18UCHL305	Particulate Technology Laboratory	(0-0-3) 1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To get hands on experience on various unit operations by conducting experiments on size separation, size reduction, filtration etc.
2. To analyze experimental data and project in the form of a report and oral presentation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the average particle diameter by sieve and sub-sieve analysis experiments.	4, 15	10	9
CO-2	Evaluate the energy consumed for the size reduction of solid samples by applying size reduction laws.	4, 15	10	9
CO-3	Calculate the medium and cake resistance in filtration equipment's.	4, 15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Performance study of size reduction using Ball mill
2. Particle Size Analysis using ICI sedimentation
3. Particle Size Analysis using Beaker decantation
4. Separation of solids using Cyclone
5. Performance study of size reduction using Drop weight crusher
6. Performance study of size reduction using Jaw crusher
7. Determination of specific cake and medium resistance using Leaf filter
8. Determination of specific cake and medium resistance using Plate and frame filter
9. Screen effectiveness studies
10. Particle Size Analysis using Sieves
11. Batch Sedimentation Test and thickener design
12. Particle Size Analysis using Air Elutriator

Note: Minimum 10 experiments to be conducted

Reference Books:

1) McCabe and Smith, "Unit Operations of Chemical Engineering" 6/e, McGraw Hill International
2) Foust A.S. et al., "Principles of Unit Operations", John Wiley and Sons

18UCHL306	Technical Analysis Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To get hands on experience on various analysis of materials
2. To analyze experimental data and understand the importance of Chemical analysis

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the various properties of the solids and fluids given.	4, 15	10	9

CO-2	Estimation and characterization of the given material.	4, 15	10	9
CO-3	Analysis of various fluids with the measuring techniques used.	4, 15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Conductometric titration an Acid vs Base.
2. Standardization of potassium permanganate.
3. Determination of percentage of available chlorine present in bleaching power sample.
4. Determination of moisture content of soil and ash content of coal.
5. Determination of calorific value of solid &liquid fuels by bomb colorimeter.
6. Estimation of hardness, calcium and chlorides in water sample.
7. Determination of optimum dosage of alum of raw water.
8. Determination of bulk density, porosity and specific surface area of a sample.
9. Estimation of oil in seeds by solvent extraction method.
10. Qualitative analysis of proteins and aminoacids.
11. Qualitative analysis of carbohydrates and lipids.
12. Estimation of total loss on ignition of cement sample.
13. Estimation of reducing sugar by DNS method.
14. Estimation of sulphates and nitrates ina given water sample.

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jaffery, G.H., Basset, J., et al., “Vogel's Text book of Quantitative Inorganic Analysis” 5/e, ELBX. 1998
2) Skoog, D.A., “Principles of Instrumental Analysis” 3/e, Saunders College publishing 1985.

IV Semester

18UMAC400	Engineering Mathematics-IV	(3-0-0)3

Contact Hours: 39

Course Learning Objective (CLO):

1. To provide an insight into applications of conformal mapping, integration of complex functions and application of probability distributions in Engineering.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Construct and use the concepts of analytic function to solve the problems arising in Engineering field.			1
CO-2	Utilize conformal transformation and complex integral to transform irregular domain onto a relatively simple domain.		1	
CO-3	Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.		1	
CO-4	Make use of the correlation and regression analysis to fit a suitable mathematical model for the statistical data.		1,2	
CO-5	Estimate the correlation, covariance using joint probability distributions. Also use student's t-distribution, Chi-square distribution as a test of goodness of fit.		1,2	

POs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
Mapping Level	1.8	2.0	-	-	-	-	-	-		-	-	-

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Pre-requisites: 1. Differentiation of function.
2.Integration of function.
3.Basic probability.
4. Statistical Averages.

Course Content:

Unit-I

Calculus of Complex Functions: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms. Construction of analytic functions: Milne-Thomson method-Problems. **07 Hrs.**

Unit-II

Conformal Transformations: Introduction. Discussion of transformations:$w = e^z; w = z^2, w = z + \frac{1}{z}, z \neq o$). Bilinear transformations- Problems.

Complex integration: Line integral of a complex function, Cauchy's theorem and Cauchy's Integral theorem. **08 Hrs.**

Unit-III

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions- problems (No derivation for mean and standard deviation)-Illustrative examples. **08 Hrs.**

Unit-IV

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation-problems. Regression analysis- lines of regression–problems.

Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form $= ax + b; y = ax^2 + bx + c; y = ax^b$. **08 Hrs.**

Unit-V

Joint Probability Distribution: Joint Probability distribution for two discrete random variables, expectation and covariance.

Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness of fit. **08 Hrs.**

Reference Books:

1) E. Kreyszig: Advanced Engineering Mathematics, John Wiley and Sons, 10/e (Reprint) 2016.
2) B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 44/e, 2017.
3) Srimanta Pal et al: Engineering Mathematics, Oxford University Press, 3/e, 2016.

18UCHC400	Process Heat Transfer	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Ability to understand and solve heat transfer by conduction in solids and extended surfaces for steady state with estimation of critical insulation.	1	2	13
CO-2	Explain and solve heat transfer by forced and natural convection	-	2	13
CO-3	Discuss evaporators and solve heat transfer by radiation.	3	2	13
CO-4	Determine heat transfer in condensation.	13	2	3
CO-5	Analyze the performance of heat exchange equipments.	13	2	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	2.0	1.66	-	-	-	-	-	-	-	-	-	1.8	-	-

Course Content:

Unit-I

Basic Concepts: Modes of heat transfer, conduction, convection and radiation, analogy between heat flow and electrical flow. Conduction: One dimensional steady state heat conduction, the Fourier heat conduction equation, conduction through single and multiple layer plane wall, cylindrical wall, spherical wall, Insulation: Properties of insulation materials, Types of insulation, Critical and Optimum thickness of insulation, Extended surfaces: heat transfer from a fin, fin effectiveness and efficiency. **12 Hrs.**

Unit-II

Convection: Natural and forced convection, the convective heat transfer coefficient. Forced Convection: Correlation equations for heat transfer in laminar and turbulent flows in a Circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer, Natural Convection: Natural convection from vertical and horizontal surfaces, Grashof and Rayleigh numbers. **10Hrs.**

Unit-III

Heat Transfer by Radiation: Basic Concepts of radiation from surface: black body radiation, Planks law, Wien‘s displacement law, Stefan Boltzmann‘s law, Kirchhoff‘s law, grey body, Radiation intensity of black body, View factor, emissivity, radiation between black surfaces and grey surfaces. Solar radiations, combined heat transfer coefficients by convection and radiation, radiation shields.

Evaporation: Types of evaporators, single effect evaporator, multiple effect evaporators: forward, mixed, parallel and backward feeds, capacity and economy of evaporators. **09 Hrs.**

Unit-IV

Condensation: drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal and vertical tube, condensers **09 Hrs.**

Unit-V

Heat Exchangers: Introduction, Industrial use, Types of heat exchangers, Pri1ncipal components of a double pipe & Shell-and Tube Heat Exchanger, Baffles, Tubes and Tube Distribution, Tube sheets, Heat Exchangers with Multiple Shell & tube Passes, Fixed-Tube sheet and Removable-Bundle Heat Exchangers, LMTD, overall heat transfer coefficient, fouling and fouling factor. Analysis of HE’s-LMTD, ε-NTU method

12 Hrs.

Reference Books:

1) J.P.Holman,” Heat Transfer“, 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2) Rao Y.V.C., “Heat Transfer”, Editionillustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3) McCabe and Smith “Unit Operations of Chemical Engineering”.7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4) Coulson and Richardson, “Unit Operations of Chemical Engineering” Vol.1.6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

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18UCHC401	Chemical Reaction Engineering- I	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide basic understanding of kinetic models and mechanisms for homogeneous chemical reactions.
2. To understand the interpretation of reactor data and thereby exploring the rate law for chemical reactions.
3. To provide an understanding and application of rate law in design of Ideal reactors and to assess their performances based on temperature effects.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Calculate rate, rate constant, activation energy and order of reaction.	-	1	-
CO-2	Analyze and interpret batch reactor data	4	-	1
CO-3	Perform reactor design for batch reactor, ideal PFR and MFR	4	2	13
CO-4	Explore the performance of reactors with multiple reactions, recycle reactor	4	2	13
CO-5	Understand the effect of temperature on reactor performance.	-	2	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.5	2.0	-	3.0	-	-	-	-	-	-	-	-	1.0	-	-

Course Content:

Unit-I

Introduction and Kinetics: Scope of Chemical Reaction Engineering, classification of reactions, Rate equation and rate of reaction. Factors affecting the rate of reaction. Chemical kinetics, thermodynamics, and Equilibrium. Temperature dependency of rate constant from Arrhenius, collision, and Transition state theories. Molecularity and order of reaction. Elementary and non-elementary reactions. Kinetic models for non-elementary reactions. **08 Hrs.**

Unit-II

Interpretation of Batch Reactor Data: Constant volume batch reactor. Analysis of total pressure data, Integral method, and Differential method of analysis for constant and variable volumes. Reversible first and second order reactions, series, parallel and autocatalytic reactions. Variable volume reactions of analysis. Overall order from method. **12Hrs.**

Unit-III

Introduction to Reactor Design and Ideal Reactors for Single Reaction: Ideal batch reactor, steady-state mixed flow reactor, steady-state plug-flow reactor, holding and space time for flow reactors, space-time and space velocity. Introduction to semi batch reactor. **12 Hrs.**

Unit-IV

Multiple Reactions: Design of Batch, plug and mixed flow reactors for parallel, series reactions. Recycle reactors, Yield and selectivity. **10 Hrs.**

Unit-V

Non-Isothermal Reactors: Heat of reactions, equilibrium constant, optimum temperature progression. Conversion in reactors operated under adiabatic and nonadiabatic conditions. Reactor design by solving material and energy balance equations simultaneously. **10 Hrs.**

Reference Books:

1) Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2) J. M. Smith, “Chemical Engineering Kinetics”, 3/e, McGraw Hill, 1981.ISBN:0-07 066574-5
3) H. Scott Fogler, “Elements of Chemical Reaction Engineering”, 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

18UCHC402	Chemical Engineering Thermodynamics	(3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To relate state changes in a system to the quantity of energy in the form of heat and work transferred across its boundaries.
2. Understanding of the laws of thermodynamics and their application in the analysis of chemical and engineering problems.
3. Calculating thermodynamic properties of fluids and fluid mixtures using equation of state.
4. Determining equilibrium compositions of chemical reactions and two-phase liquid/vapor mixtures.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	State thermodynamic laws, analyze and evaluate pressure, volume and temperature with equations of state for gases.	1	-	2, 13
CO-2	Evaluate the entropy changes associated with processes and analyse the fundamental equations governing thermodynamics.	1	2, 13	3
CO-3	Differentiate between ideal and non- ideal solutions and calculate the partial molar properties.	1,2,3,13	-	-
CO-4	Generate VLE data for solutions using correlations and interpret their consistency.	1,2,3,13	-	-
CO-5	Determine the conversion at equilibrium and predict the effect of controllable variables on conversion.	1,2,3,13	-	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.4	2.5	-	-	-	-	-	-	-	-	-	2.4	-	-

Course content:

Unit-I

Basic Concepts and First Law of Thermodynamics: Types of properties, functions, reversible and irreversible processes, zeroth law of thermodynamics, general statement of first law of thermodynamics, first law for cyclic process and non-flow processes, heat capacity. Derivation for closed system and steady state flow process.

P-V-T Behaviour: P-V-T behaviour of pure fluids, equations of state and ideal gas law, processes involving ideal gas law, Equations of state for real gases: van der Waals equation, Redlich – Kwong equation, virial equations, principles of corresponding states. **9+2 Hrs.**

Unit-II

Second Law of Thermodynamics: Statements, heat engines, heat pumps, concept of entropy, Carnot's principle, calculations of entropy change, Clausius Inequality, entropy and irreversibility, third law of thermodynamics.

Thermodynamic Properties of Pure Fluids: Types ofthermodynamic Properties, Work function, Gibbs free energy. Fundamental property relations: Exact differential equations, Fundamental property relations, Maxwell's equations, equations for U and H, entropy- heat capacity relations, Clapeyron equation, Gibbs-Helmholtz equation, fugacity and fugacity coefficient, determination of fugacity of pure fluids. **10+2 Hrs.**

Unit-III

Properties of Solutions: Partial molar properties, Gibbs-Duhem equation, chemical potential, fugacity in solutions, Henry's law and dilute solutions, activity in solutions, activity coefficients, property changes of mixing, excess properties. **8+2 Hrs.**

Unit-IV

Phase Equilibria: Criteria of phase equilibria and stability, phase equilibria in single and multicomponent systems, Duhem's theorem, vapor-Liquid equilibria, ideal and nonideal solutions, VLE at low pressures, VLE correlations, G-D equation for VLE, consistency tests, VLE at high pressures, liquid-liquid equilibrium. **8+2 Hrs.**

Unit-V

Chemical Reaction Equilibria: Reaction stoichiometry, criteria of chemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature and pressure on equilibrium constants and other factors affecting equilibrium conversion, liquid phase reactions, heterogeneous reaction equilibria, phase rule for reacting system. **7+2 Hrs.**

Reference Books:

1) Smith, J.M. and Vanness, H.C., "Introduction to Chemical Engineering Thermodynamics", 7/e, McGraw Hill, New York, 2005.
2) Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.
3) Rao, Y.V.C., "Chemical Engineering Thermodynamics", New Age International Publication, Nagpur, 2000.
4) Sandler and Stanley, "Chemical, Biochemical and Engineering Thermodynamics", 4/e, John Wiley, 2007. ISBN 0471661740.

18UCHC403	**Pollution Control Engineering**	**(3-0-0)3**

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To create awareness on the various environmental pollution aspects and issues and give a comprehensive insight into natural resources, ecosystem, and biodiversity.

2. To understand the different parameters, treatment methods and control techniques of various environmental pollution.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the importance of the environment, standards and legislation of environment and interpret various waste water parameters.	-	14	3, 6, 7
CO-2	Explain and design the different methods of waste water treatment techniques.	3, 6, 7	14, 15	-
CO-3	Identify the sources and effects of different types of air pollutants, their prevention and control techniques.	14	3, 6, 7	-
CO-4	Understand the different methods for handling and disposal of solid waste and control measures of noise pollution in industries	14	3, 6, 7	-
CO-5	Identify, interpret and suggest the treatment technology for different pollutants in a typical industry	14, 15	7	-

POs/PSOs	**PO -1**	**PO -2**	**PO -3**	**PO -4**	**PO -5**	**PO -6**	**PO -7**	**PO -8**	**PO -9**	**PO -10**	**PO -11**	**PO -12**	**PSO -13**	**PSO -14**	**PSO -15**
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	-	2.6	2.5

Course content:

Unit -I

Introduction: Importance of Environment for Mankind. Engineering, ethics and environment. Ecological systems and pollution, hydrological cycle and nutrient cycle.Damages from environmental pollution. Fundamental definition of pollution parameters- air, water and soil quality criteria, standards and legislation and acts, EIA, EIS and EMP. Air, water and soil pollution management through waste minimization. **Sources, Sampling and Analysis of Waste Water:** Water Resources. Wastewater Classification.Types of Water Pollutants. Waste Water Sampling, Methods of Analysis: DO, BOD, COD, TOC, Nitrogen, Phosphorus, Trace Elements and Alkalinity. **08 Hrs.**

Unit-II

Waste Water Treatment: Wastewater Treatment: Preliminary, Primary, Secondary and Tertiary. Advanced wastewater Treatment: Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electro dialysis cell. Design of sedimentation tanks and biological treatment processes. **09 Hrs.**

Unit-III

Air Pollution and Treatment: Definition, Sources, Classification, Properties of air pollutants, Effects of air pollution on health vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling. Analysis of air pollutants. Air pollution meteorology (generation transportation and dispersion of air pollutants). Control methods and Equipment's for particulates and gaseous pollutants. Selection design and performance analysis of air pollution control equipment: gravity settling chambers, cyclone separator, ESPs, filters and wet scrubbers. **08 Hrs.**

Unit-IV

Solid Waste Treatment and Noise Pollution: Sources and Classification, Effect on public health, Methods of Collection, onsite handling, storage and processing techniques, Disposal Methods, Reuse, Recovery and Recycling of Solid Waste.Solids waste disposal– compositing, landfill, briquetting/gasification and incineration. Definition, Sources, Effects of Noise, and Equipment's used for Noise Measurement, Approaches for Noise Control. **07 Hrs.**

Unit-V

Case Studies: Industrial case studies – Diary, petroleum refinery, pulp and paper, fertilizer, distillery, textile processing, Cement, Thermal power plants, metallurgical industries **07 Hrs.**

Reference Books:

1) C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2) S. P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill.
3) Metcalf and Eddy, "Waste Water Engineering Treatment Disposal Reuse" Tata McGraw Hill, 4/e, 2003.
4) Frank Kreith and George Tchobanoglous- "Hand book of Solid waste Management", Tata Mc-Graw Hill, 2/e.

18UCHC404	Energy Technology and Management	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. Understand the utilization of conventional and non – conventional energy sources and the principle of working of related equipments.
2. Recognize the effects of current energy systems on the environment and society.
3. Study energy costs/waste minimization without affecting production and quality.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and comprehend the effects of current energy systems based on solid and gaseous fuels.	2	13	1
CO-2	Analyze the principles and concepts and explain basic principles involved in solar and wind energy conversion system.	1	, 13	3, 14
CO-3	Describe the challenges and problems associated with Bio-energy and fuel cell technology, and explain its basic principles and operations.	2	1	3, 14
CO-4	Summarize the basic principle and production process of ocean and tidal energy sources with regards to future energy supply and environmental concern.	3	1,13	2,14
CO-5	Discuss the principles and need of energy audit and management programs.	14	2,13	1

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	1.8	2.25	1.66	-	-	-	-	-	-	-	-	-	2.0	1.5	-

Course Content:

Unit-I

Introduction to Energy Sources: World energy futures, Indian energy scenario, Conventional and non-conventional energy sources. **Fuels:** Classification, properties and tests and analysis of solid, liquid and gaseous fuels. **08 Hrs.**

Unit-II

Solar Energy: Solar constant, Solar radiation at earth's surface, Solar radiation geometry, Solar radiation measurement. Solar water heating, space cooling, Solar distillation, pumping and Solar cooking- Basic principles, methods, applications, advantages and limitations. **Wind Energy:** Introduction, Basic components of WECS (wind energy conversion system). Classification of WEC Systems.Types of wind energy machines- (wind energy collectors) horizontal axis, vertical axis machines. **09 Hrs.**

Unit-III

Bio-Energy: Introduction, Biomass conversion technology, Wet and Dry process, Factors affecting Bio digestion or Generation of gases, Classification of Bio gas plants, Floating Drum, Fixed Dome plants -Basic principles, Construction and Working principles, Advantages and disadvantages. **Fuel Cells**: Design and Principle of operation, Classification, Types, Advantages and disadvantages, Conversion efficiency, Types of electrodes, Work output and EMF of Fuel Cells, Applications of Fuel Cells. **08 Hrs.**

Unit-IV

Geothermal and Ocean Energy: Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India**. Ocean Energy:** Principle of working, performance and limitations of Wave Tidal Energy. Ocean Thermal Energy-Availability, theory and working principle, performance and limitations. **07 Hrs.**

Unit-V

Energy Management: Principles and needs initiating and managing an energy management programs. **Energy Audit**: Elements and concepts, Types of Energy Audits, Energy Audit of any one chemical industries. **07 Hrs.**

Reference Books:

1) G.D. Rai, "Non-Conventional Energy Sources", 4/e Second Reprint, Khanna Publications", 1997.
2) P.C. Jain and M. Jain, "Engineering Chemistry", 10/e, 3rd Reprint, DhanpatRai and Sons, 1995.
3) S.P. Sukhatme, "Solar Energy", 2/e, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.
4) G.D. Rai, "Solar Energy Utilization", 4/e, Khanna Publications.
5) G.N.Tiwari and M.K.Ghosal, "Renewable Energy Resource: Basic Principles and Applications", Narosa Publishing House, 2004.

18UCHL405 Computational Methods and Simulation Laboratory (0-0-3) 1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the application of mathematics using computer to solve the simple Chemical Engineering problems.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Solve chemical engineering problems using the analytical methods and programming.	4, 5,15	10	9
CO-2	Compute the chemical engineering problems with nonlinear-algebraic equations.	4, 5,15	10	9
CO-3	Compute the chemical engineering problems with numerical integration	4, 5,15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	3.0	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – Simpson's1/3 rule.
6. Curve fitting – Least square method
7. Double pipe heat exchanger (Area, Length)
8. Bubble and dew point calculation.
9. Introduction to Unisim design Software
10. Simulation studies of flash drum
11. Simulation studies of CSTR
12. Simulation studies of Heat Exchanger.

13. Simulation studies of Mixer

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jenson, V.J. and Jeffereys, G.V., “Mathematical Methods in Chemical Engineering”, Academic Press, London and New York, 1977.
2) Mickley, H.S., Thomas. K. Sherwood and Road, C.E., “Applied Mathematics in Chemical Engineering”, Tata McGraw-Hill Publications, 1957.
3) S. Pushpavanam, “Mathematical Methods in Chemical Engineering”, PHI
4) E. Balagurusamy, “Programming in ANSI C”, 6/e, TMH 2012.

18UCHL406	**Fluid Mechanics Laboratory**	**(0-0-3) 1.5**

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the principle, construction, working and analysis of different equipments in the fluid flow phenomena.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Calculate the discharge rate for flow measuring devices and pumps	4,15	10	9
CO-2	Distinguish the types of pipe fitting and identify their applications	4,15	10	9
CO-3	Identify the flow pattern of the fluid and evaluate the friction factor of the spiral coil	4,15	10	9
CO-4	Calculate the minimum fluidization velocity	4,15	10	9
CO-5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.2	2.2	-	-	-	-	3.0

List of Experiments:

1. Characteristics of fluidized bed.
2. Develop the characteristic curve for centrifugal pump
3. Local velocity measurement using Pitot tube.
4. Develop the characteristic curve for positivedisplacement pump
5. Characteristic of packed Bed
6. Significance of Reynolds number
7. Flow through spiral coil
8. Characteristics of Orifice meter and venturi meter
9. Friction in circular pipes
10. Different pipe fittings and its constant value
11. Weir characteristics
12. Pressure, velocity and elevation heads in Bernoulli's theorem

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGraw Hill.
2) Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1, 5/e. Butterworth publications.
3) Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4) R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

18UCHL407	Introductory Project	(0-0-2) 1

Contact Hours: 24

Course Learning Objective (CLO):

1. To identify and understand the community expectation in terms of possible engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses.

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Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) / PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify the problem.	2,10	12	7, 14
CO-2	Compare the literature review and select suitable existing solutions.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Prepare work plan with economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report with proper guidelines and references.	10	8,15	9

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	-	3.0	3.0	3.0	3.0	-	1.0	2.0	1.0	2.25	2.5	2.0	-	1.0	2.7

Introductory project is introduced with an objective of understanding and identifying the community expectation in terms of possible Engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses. The project shall be engineering oriented in terms of problem definition, related literature survey and existing solutions. The team consisting of 10-12 students shall be asked to identify problems related to community and try to propose a solution. The faculty members handling the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for introductory project.

Reference Books/Material:

1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field

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Academic Program: UG

Academic Year 2020-21

Syllabus

V & VI Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465 Fax: 0836-2464638** **Web:** www.sdmcet.ac.in

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for V & VI semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2020-21 till further revision.

Principal   Chairman BoS & HoD

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College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific outcomes (PSOs)

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for V Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UHUC500	HU	Management, Entrepreneurship and IPR	4-0-0	4	50	100	3	-	-
18UCHC500	PC	Chemical Reaction Engineering-II	4-0-0	4	50	100	3	-	-
18UCHC501	PC	Mass Transfer – I	3-2-0	4	50	100	3	-	-
18UCHC502	PC	Chemical Equipment Design-I	3-0-0	3	50	100	3	-	-
18UCHC503	PC	Chemical Process Integration	3-0-0	3	50	100	3	-	-
18UCHE50X	PE	Program Elective – 1	3-0-0	3	50	100	3	-	-
18UCHL504	PC	Heat Transfer Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL505	PC	Environmental Engineering Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL506	PC	Minor Project-1	0-0-2	1	50	-	-	-	-
18UHUL507	HU	Soft Skills/Aptitude	0-0-2	1	50	-	-	-	-
Total			**20-2-10**	**26**	**500**	**600**		**100**	
Electives									
18UCHE508	PE	Petroleum and Petrochemicals	3-0-0	3	50	100	3	-	-
18UCHE509	PE	Polymer Science and Technology	3-0-0	3	50	100	3	-	-
18UCHE510	PE	Air Pollution and Control Engineering	3-0-0	3	50	100	3	-	-

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Scheme for VI Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UCHC600	PC	Mass Transfer – II	4-0-0	4	50	100	3	-	-
18UCHC601	PC	Chemical Equipment Design-II	4-0-0	4	50	100	3	-	-
18UCHE60X	PE	Program Elective – 2	3-0-0	3	50	100	3	-	-
18UCHE60X	PE	Program Elective – 3	3-0-0	3	50	100	3	-	-
18UCHE60X	OE	Open Elective	3-0-0	3	50	100	3	-	-
18UCHL602	PC	Mass Transfer Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL603	PC	Chemical Reaction Engineering Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL604	PC	Minor Project– 2	0-0-4	2	50	-	-	50	3
18UHUL605	HU	Soft Skills/Aptitude	0-0-2	1	50	-	-	-	-
Total			**17-0-12**	**23**	**450**	**500**		**150**	
Electives									
18UCHE606	PE	Transport Phenomena	3-0-0	3	50	100	3	-	-
18UCHE607	PE	Catalyst Technology	3-0-0	3	50	100	3	-	-
18UCHE608	PE	Plant utilities and Industrial Safety	3-0-0	3	50	100	3	-	-
18UCHE609	PE	Drug and Pharmaceutical Technology	3-0-0	3	50	100	3	-	-
18UCHE610	PE	Food Engineering	3-0-0	3	50	100	3	-	-
18UCHE611	PE	Applied Mathematics in Chemical Engineering	3-0-0	3	50	100	3	-	-
18UCHO612	OE	Advanced Waste Water Treatment	3-0-0	3	50	100	3	-	-
18UCHO613	OE	Biology for Engineers	3-0-0	3	50	100	3	-	-
18UCHO614	OE	Composite Materials	3-0-0	3	50	100	3	-	-

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the third year: 49

V Semester

18UHUC500 Management, Entrepreneurship and IPR (4–0–0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the development and function of management, the concept of entrepreneurship, intellectual property rights and legal issues.

Course Outcomes (COs):

Description of the course: At the end of course, the student will able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain historical development and levels of management along with importance of planning and organizing	7,8	9,10	6
CO-2	Explain staffing, directing and controlling in modern organization structures.	7,8	9, 10	6
CO-3	Summarize the role of entrepreneurs in economic development and asses impact of liberalization and globalization on SSI.	7,8	9, 10	-
CO-4	Identify Institutional support to small scale industries and prepare project report and its feasibility studies.	8,11	9, 10, 14	-
CO-5	Describe forms of intellectual property rights and procedure for registration, infringements and penalties.	10,12	6,7,8	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	1.3	2.75	2.8	2.0	2.2	3.0	3.0	-	2.0	-

Course Content:

Unit-I

Management: Meaning, nature and characteristics of management. Levels of management, development of management thoughts, modern management approaches.

Planning and Organizing: Nature, importance, purpose and objectives of planning. Types of plans, decision making and hierarchy of plans. Types of organization, departmentation, committees, organization levels and span of control. **12 Hrs.**

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Unit-II

Staffing and Directing: Nature, importance, selection and recruitment. Leader ship styles, motivation, communication and coordination.

Controlling: definition, steps in controlling, essentials of a sound control system and methods of establishing controlling. **11 Hrs.**

Unit-III

Entrepreneurship: Evolution, meaning and characteristics of entrepreneur. Functions and types of entrepreneurs, role of entrepreneurship in economic development and barriers of entrepreneurship.

Small Scale Industry: Role of SSI in economic development, advantages SSI, steps to start a SSI. Impact of liberalization, privatization and globalization. Ancillary and tiny industries. **10 Hrs.**

Unit-IV

Institutional Support: Introduction, Institutions to assist SSI. Objectives and functions of SSIDC, SSIB, DICs, TCOs, ICICI, NSIC, SIDO, IDBI and SIDBI etc.

Preparation of Project Report: Project identification, selection, contents, feasibility studies and network analysis. **10 Hrs.**

Unit-V

Intellectual Property Rights: meaning and forms of IPR, international conventions, world court. Copy right, patents, Industrial designs and trademarks. Procedure for registration, infringements and remedies. Offenses and penalties. **9 Hrs.**

Reference Books:

1) Thomas W. Zimmerer, “Essentials of Entrepreneurship”, PHI, 2005.
2) Veerabhadrappa Havinal, “Management and Entrepreneurship”, 1/e, ISBN (13): 978-81-224-2659-5, New Age International, 2009.
3) Peter Drucker, “The Practice of Management”, ISBN-10: 0060878975 Harper Business Reissue edition, 2006
4) N.K. Acharya, “Text book on Intellectual Property Rights”, 4/e, Asia Law House.

18UCHC500	Chemical Reaction Engineering-II	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand Non-Ideal flow behavior in Chemical reactors.
2. To provide the forum to understand the Principles and concepts involved in Catalytic reactions.
3. To understand kinetics of heterogeneous reactions (Non-Catalytic) and apply the same for reactor design.

Course Outcomes (COs):

Description of the course outcome: At the end of the course, student will be able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Define residence time distribution and determine conversion using single parameter models for real reactors.	2	-	1
CO-2	Explain various models for fluid-particle reactions and design reactors for ideal flow patterns.	3, 13	2	4
CO-3	Develop rate equations for fluid-fluid reactions and design reactors for ideal flow patterns.	3, 13	2	4
CO-4	Explain various methods to estimate properties of solid catalyst, controlling mechanisms and reactor design.	3, 4, 13	1	-
CO-5	Develop deactivation kinetics and design catalytic reactor with regeneration.	3	4	-

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	1.5	2.3	3.0	1.75	-	-	-	-	-	-	-	-	3.0	-	-

Prerequisite: Chemical Reaction Engineering-I

Course content:

Unit-I

Non-ideal Flow: Causes for non-ideal flow, the residence time distribution (RTD), E, C and F. Curves, Experimental methods for finding extent of non-ideal behavior, Micro and macro mixing, conversion in non-ideal flow reactors from tracer information, dispersion model and tanks-in-series model. **12 Hrs.**

Unit-II

Fluid-Particle Reactions: Introduction to heterogeneous non-catalytic reactions, industrial examples, overall rate expression, Ideal contacting patterns, progressive conversion and shrinking core model, overall rate expression for various controlling mechanisms from shrinking core model, conversion – time expressions, Design of reactors for particles of single size and different sizes under ideal flow patterns. **10 Hrs.**

Unit-III

Fluid – Fluid Reactions: Industrial examples, Rate equations for straight mass transfer and mass transfer with chemical reaction, various kinetic regimes, liquid film enhancement factor, Role of Hatta number, Design of reactors for fluid-fluid reactions under co current and counter current operations based on ideal flow patterns. **10 Hrs.**

Unit-IV

Solid Catalyzed Reactions: The nature and mechanism of catalytic reactions, Adsorption isotherms, physical, chemical dynamic and mechanical properties of solid catalyst and their determination, catalyst preparation, overall rate expressions for various controlling mechanisms. Experimental methods to determine rate equation. **10 Hrs.**

Unit-V

Catalyst Deactivation: Causes for deactivation, mechanisms of deactivation, Experimental methods to find deactivation kinetics using Batch- solids and Batch-fluids, Batch solids and Mixed constant and variable flow of fluid, Batch solids and plug constant and variable flow of fluid. Deactivation with regeneration. **10 Hrs.**

Reference Books:

1) Octave Levenspiel, "Chemical Reaction Engineering", 3/e, John Wiley and Sons, 2004, ISBN:978-81-265-1000-9
2) J. M. Smith, "Chemical Engg Kinetics", 3/e, McGraw Hill, 1981. ISBN:0-07-066574-5
3) H. Scott Fogler, "Elements of Chemical Reaction Engineering", 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

18UCHC501	Mass Transfer- I	(3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the fundamentals and principles of diffusion mechanism in all the phases of matter along with equilibrium diffusion between the phases with an insight of interphase mass transfer.
2. To understand and apply analogy between transport processes along with an insight of interphase mass transfer applied to industrial diffusion separations, obtain transfer coefficients to propose and evaluate experimental investigations on mass transfer.

Course Outcomes (COs):

Description of the course outcome: At the end of the course, student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Appraise of the mechanisms of molecular and turbulent diffusion both in fluids and solids and develop mathematical expressions for one dimensional steady state diffusion.	3	1,7,13	-
CO-2	Apply interphase concept using transfer coefficients to evaluate	3	1,12,13	-

	stage efficiencies.			
CO-3	Analyze using interphase concept in crystallization along with stoichiometric calculations to evaluate performance of crystallizers.	3	1,7,12,13	-
CO-4	Apply interphase concept to humidification process, configurations and design of cooling tower for air-water system.	3	1,13	-
CO-5	Apply interphase concept to drying and adsorption along with stoichiometric computations and analyze stage wise operations.	3	1,7,14	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.0	-	3.0	-	-	-	2.0	-	-	-	-	2.0	2.0	2.0	-

Course content:

Unit-I

Diffusion: Types, importance, molecular versus turbulent diffusion, molecular diffusion in fluids, rates of diffusion, Fick's I-law. Diffusion in a binary system, steady state unidirectional diffusion in the fluids at rest and laminar flow. Cases with examples: 1. Unicomponent diffusion and 2. Equimolal counter diffusion. Pseudo steady state diffusion. Diffusivity of gases, empirical treatment. Convective mass transfer, Local and Overall mass transfer coefficients and correlations. Analogies; Reynold's, Prandtl's, Von Karman's, and Chilton and Colburn J-factor. Theories of convective mass transfer; Diffusion in solids, importance, types with different geometrical shapes **8+2 Hrs.**

Unit-II

Interphase Mass Transfer: Introduction, concentration profile. Use of Film Transfer Coefficients in unicomponent diffusion and equimolal counter diffusion. Use of Overall Transfer Coefficients. Graphical approach, equilibrium diffusion between the phases, types of operations. Material balance in each process. Stages, efficiencies

8+2 Hrs.

Unit-III

Crystallization: Introduction, importance with examples, solubility concept, equilibrium solubility etc. Saturation/equilibrium, super saturation, mechanism of crystallization etc. Myer's theory of super saturation, Methods of generating super saturation. Nucleation types, crystal breeding, growth regimes. Ostwald's ripening, crystal growth and coefficients, crystal size and shape factors. Material and balance calculations, ΔL law of crystal growth, caking of crystals. **8+2 Hrs.**

Unit-IV

Humidification: Importance and terminology, Psychrometric chart for air-water system. Measurement of Wet Bulb Temperature, Adiabatic Saturation Temperature, Lewis relation. Cooling towers, Theory of cooling towers. Types, construction and working. Design of cooling towers, NTU and HTU. **8+2 Hrs.**

Unit-V

Drying: Importance with examples. Terminology in drying. Graphical representations of various terms. Typical rate of drying curve. Drying time calculations. Mechanism of drying, use of heat transfer and mass transfer coefficients. Theories of moisture movement. Industrial Dryers.
Adsorption: Introduction, importance with examples, applications. Types of adsorption; nature of adsorbents, Adsorption equilibria; isotherms, isobars and isosteres. Adsorption calculations, Stage wise calculations and graphical representation. Adsorption equipments. **10+2 Hrs.**

Reference Books:

1) Robert E. Treybal, “Mass Transfer Operations”, 3/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 1981 ISBN: 0-07-066615-6.
2) Warren L. McCabe, Julian C. Smith and Peter Harriott, “Unit Operations of Chemical Engineering”, 6/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 2001; ISBN: 0-07-118173-3.
3) Christie J. Geankoplis, “Transport Processes and Unit Operations”, 3/e., Prentice Hall of India, New Delhi; 1993; ISBN: 13: 978-0139304392.
4) Binay K. Dutta, “Principles of Mass Transfer and Separation Processes”, PHI Learning, New Delhi; 2009; ISBN-13-9788120329904.

18UCHC502	Chemical Equipment Design-I	(3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To develop key concepts and techniques with relevant codes and standard procedures of different equipment’s.
2. To study the detailed design considerations of different types of equipment’s used in chemical industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		Mapping to POs (1-12) /PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Congregate the data from relevant code books and identify the standard procedures for the design of chemical equipment.	13	1	3
CO-2	Congregate the data from relevant code books to design and evaluate the pressure vessels and its components	3, 13	2	1
CO-3	Design and evaluate the reaction vessels and its components.	3, 13	2	1
CO-4	Design and evaluate tall vertical vessels and its components.	3, 13	2	1
CO-5	Estimate the pipe size; pump rating with accessories and Congregate the data to design the storage vessels.	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.2	2.0	2.6	-	-	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Introduction: Design procedure, equipment classification and components, design parameters, pressure vessel codes. Design considerations: Material selection, factors affecting design, stresses due to static and dynamic loads (Internal and External), temperature effects, and economic considerations. **07 Hrs.**

Unit-II

Design of Pressure Vessels: Design parameters, conditions and stresses. Design of shell and other vessel components. Vessel at low and high operating temperatures. Design of components, supports and selection of vessels accessories and mountings. Numerical problems. **09 Hrs.**

Unit-III

Design of Reaction Vessels: Design of reaction tanks-agitators, baffles, jackets, tank dimensions. Power calculations. Drive calculations and accessories. Support calculations for the system. Numerical problems. **07 Hrs.**

Unit-IV

Design of Tall Vertical Vessels: Vessels subjected to wind loads. Multi shell constructions. Determination of shell thickness. Supports for columns. Numerical problems. **07 Hrs.**

Unit-V

Pipe Line Design: Pipe thickness, pipe diameter. Optimum size of delivery line in pumping operations. Pump rating. Numerical problems.

Design of Storage Vessels: Process conditions and design parameters for storage of volatile, nonvolatile fluids and gases. Design of components, supports and selection of vessels accessories and mountings. Roofs for vessel. Numerical problems. **09 Hrs.**

Note: IS code book 2825 for pressure vessel design is permitted in the examinations for reference.

Reference Books:

1) V. V. Mahajani and S. B. Umarji, "Joshi's Process Equipment Design" – Trinity Press, Delhi, India 4/e.
2) S. D. Dawande, "Process Design of Equipment", Vol 1, Central Techno Publications. 3/e, 2003.
3) Brownell and Young, "Process equipment design" Willy student, 1/e, 2009
4) Don W. Green and Robert H. Perry, "Chemical Engineers Handbook", 6/e, McGraw Hill, 2014.
5) Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, New Delhi, 1969.

18UCHC503	Chemical Process Integration	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To teach students basic principles and methodologies for energy, mass and material integration for sustainable process synthesis and design.
2. It helps in understanding the usage of material, Heat and Mass effectively for the profit of Industry using pinch analysis.
3. It helps in formulating the design and optimizing the process in plant for the integrated approach.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and explain the importance of process integration and its types.	6,7	3	14
CO-2	Evaluate and analyze the direct			

	recycle strategy through material balance, graphical and algebraic approach.	13	2,3	1
CO-3	Illustrate and develop heat exchange network by pinch diagram and through algebraic approach	13	2,3	1
CO-4	Predict and evaluate the visualization strategies of mass integrated system through graphical and algebraic approach	13	2,3	1
CO-5	Formulate and optimize the different process integration networks along with combined heat and power integration	5,13	-	1,2

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	1.0	1.75	2.0	-	3.0	3.0	3.0	-	-	-	-	-	3.0	1.0	-

Course content

Unit-I

Introduction to Process Integration: Importance of process integration, Process synthesis and analysis, Categories of process integration. Mass targeting for minimum discharge of waste and minimum purchase of fresh utilities. **07 Hrs.**

Unit-II

Direct Recycle Strategies: Source-Sink mapping diagram, Multicomponent source sink mapping. Graphical and algebraic approach for direct recycle strategies. Property based pinch diagram. **09 Hrs.**

Unit-III

Heat Integration: Design and synthesis of heat exchange network (HENs). Heat exchange pinch diagram and algebraic approach for pinch point. Grand composite curves (GCC). **08 Hrs.**

Unit-IV

Mass Integration: Synthesis of mass exchange network (MEN). Design and cost optimization of mass exchangers. Algebraic and graphical approach to targeting mass exchange (Mass Integration) **08 Hrs.**

Unit-V

Optimization: Overview of optimization, classification and formulation of optimization programs. Different methods of optimization programming. Approach for direct recycle and synthesis of mass and heat exchange network using a programming language. **Combined heat and power integration** (Heat Pumps and Engines). Cogeneration process targeting. **07 Hrs.**

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Reference Books:
1) Mahmoud Halwagi, "Process Integration", 1/e, Elsevier, 2006.
2) I. C. Kemp, "Pinch analysis and process Integration" 2/e, Butterworth, 2006.
3) Robin smith, "Chemical Process Design and Integration", 1/e, Wiley, 2005

18UCHL504	Heat Transfer Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):
1. To study the phenomena of conduction, convection and radiation effects in different equipments and know the rate of heat transfer.
2. To study the working, construction and analyze the efficiency and performance of heat exchangers.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) / PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Demonstrate and outline the heat transfer coefficient and the performance of DPHE and Cross flow heat exchanger.	4,15	8, 10	9
CO-2	Determine the thermal conductivity of solids and liquids.	4,15	8, 10	9
CO-3	Explain and examine the effects of radiation using Stefan Boltzmann apparatus.	4,15	8, 10	9
CO-4	Evaluate the performance and efficiency of extended surfaces and packed bed heat exchanger and recognize the boiler characteristics.	4,15	8, 10	9
CO-5	Evaluate the performance and efficiency of the helical coil and jacketed vessel heat exchangers using the steam and recognize the boiler characteristics.	4,15	8, 10	9

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping level	-	-	-	3.0	-	-	-	2.0	1.0	2.0	-	-	-	-	3.0

List of Experiments:
1. Heat transfer coefficient of Double pipe heat exchanger.
2. Heat Transfer coefficient of Cross flow heat exchanger.
3. Thermal conductivity of liquids

4. Thermal conductivity of solids through lagged pipe.
5. Emissivity determination
6. Stefan – Boltzmann constant using Stefan-Boltzmann apparatus
7. Heat Transfer coefficient and efficiency of Extended surfaces
8. Heat transfer coefficient and Reynolds number effect in Packed bed vertical condenser
9. Heat Transfer coefficient through helical coil
10. Biot number in Unsteady state heat transfer
11. Natural and forced convection in a jacketed vessel
12. Thermal performance of Evaporator

Note: Minimum 10 experiments to be conducted

Reference Books:

1) J.P. Holman, "Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2) Rao Y.V.C., "Heat Transfer", Edition illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3) McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4) Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1. 6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

18UCHL505	Environmental Engineering Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the employability of instruments in determining various parameters of solid, liquid and gas samples to analyze completely and present a good technical report.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) / PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Reproduce theory and apply into practice for using high precision instruments for analysis.	4,15	10	9
CO-2	Characterize the samples through the use of pollution indicators and report the results.	4,15	10	9
CO-3	Comprehend the use of instruments in projects.	4,15	10	9
CO-4	Compile the data from the			-

	experiments conducted and discuss the results obtained with justification and conclusion in a report.	9	8, 10	

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.5	2.0	-	-	-	-	3

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List of Experiments:

1. Analysis of effluents for pH, alkalinity and turbidity.
2. Determination of COD and BOD of waste water
3. Volatile, Fixed, Filterable and Dissolved solid analysis of waste water
4. Measurements of particulate matter in ambient Air
5. Analysis of exhaust gas by Orsat Apparatus.
6. Dissolved Oxygen Measurement of water sample
7. Moisture content in liquid sample using KF Auto Titrator
8. Concentration of elements using Flame Photometer
9. Turbidity measurement of water sample using Turbidometer
10. Viscosity measurement of given oil using red wood viscometer
11. End point of titration using mV Titrator

Note: Minimum 10 experiments to be conducted

Reference Books:

1) C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2) Metcalf and Eddy - "Waste Water Engineering Treatment Disposal Reuse" 4/e, Tata McGraw Hill, 2003.
3) Jaffery, G.H., Basset, J., et. al., "Vogel's Text book of Quantitative Inorganic Analysis" 5/e, ELBX, 1998.
4) Skoog, D.A., "Principles of Instrumental Analysis" 3/e, Saunders College publishing 1985.

18UCHL506	Minor Project -1	(0-0-2) 1

Contact Hours: 40

Course Learning Objectives (CLOs):

1. To carry out the experimental/design tasks of relatively minor intensity and scope as compared to the major project and in line with the guidelines formulated by the DUGC.
2. To see that this project could be a prologue for the upcoming major projects in the final year.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic related to problems in community under chemical engineering work.	2,10	8, 12	7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	**PO -1**	**PO -2**	**PO -3**	**PO -4**	**PO -5**	**PO -6**	**PO -7**	**PO -8**	**PO -9**	**PO -10**	**PO -11**	**PO -12**	**PSO -13**	**PSO -14**	**PSO -15**
Mapping Level	-	2.0	3.0	2.0	3.0	-	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

The project is undertaken to focus on the domain related problem definitions, building prototypes which can lead to take up the project in the higher semester(s). The work based on the core courses studied shall be used to formulate the problem. The team consisting of 10-12 students shall be asked to identify the problems related to community and try to propose the solution. The faculty members handling the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for Minor project-1.

The Project shall be evaluated with due weightage on:

Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

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Reference Books/Material:

1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field.

18UHUL507	Soft skill and Aptitude	(0-0-2) 1

Contact Hours: 24

Course Learning Objectives (CLOs):

1. This is included with the objectives of improving the communication skills, proficiency in English language and aptitude ability of the student to enhance the employability.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the significance of communication in the profession		10	
CO-2	Use the English language with proficiency		10	12
CO-3	Solve Aptitude related problems		9	12
CO-4	Demonstrate the competency in the placement activities		9	

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.0	-	1.0	-	-	-

Contents: Training on communication skills, proficiency in English language and aptitude ability involving the internal and external resource.

Evaluation: Both the internal and external resource persons shall be engaged in imparting the related knowledge and shall have only CIE as the evaluation component. There shall be one test conducted at the end for 25 marks in Aptitude testing and there shall be one presentation by the student for 25 marks or any other suitable testing components. The arrangement for CIE evaluation is to be done by the department and maintain the relevant documents

18UCHE508	Petroleum and Petrochemicals	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. Studying this subject, the students will learn about the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Course Outcomes:

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the Indian petroleum industry and world scenario, and characterize the crude.	6	2	1
CO-2	Identify and characterize the different products of hydrocarbon.	2	14	3
CO-3	Apply the basic procedure and role of all fundamental system used in petroleum industry.	1,2	3	13
CO-4	Analyze the measuring parameters to be measured according to the operational conditions	13	1	4
CO-5	Describe basic principle, operation and analyze the key issues and optimization of petrochemical production system.	1	2, 13	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.25	2.5	1.3	1.0	-	3.0	-	-	-	-	-	-	2.0	2.0	-

Course Content:

Unit-I

Indian Petroleum Industry: prospects & future, major companies, world production, markets, offshore and onshore, oil well technology.

Petroleum Crude Characterization: Composition and classification, UOP K factor, TBP analysis, EFV Analysis, Average Boiling points, ASTM Curves, Thermal properties, Pour Point. **07 Hrs.**

Unit-II

Product Properties and Test Methods: Characterization -Flash point, Fire point, Reid vapor pressure Analysis, Octane Numbers, Cetane Index, smoke point, Burning quality, Carbon Residue, Viscosity Index, Softening point, Penetration Index, Oxidation Stability, Volatility, Aniline point, Pour point . Various Petroleum products & Additives for Naphtha, Gasoline, Gas, ATF, LPG, Kerosene, Diesel, Lubricating oils, Bitumen. **09 Hrs.**

Unit-III

Crude Pretreatment: Crude receiving, Storing, Pumping, dehydration, comparison, petroleum furnaces and comparison, Refining of petroleum – Atmospheric and vacuum distillation. **07 Hrs.**

Unit-IV

Treatment Techniques: Removal of sulphur compounds, storage and stability, product treatment using solvent, dewaxing, clay treatment and hydro refining.

Thermal Cracking: Visbreaking, Coking, Catalytic cracking (FCC), Hydro cracking, Air blowing of bitumen. Catalytic reforming, Extraction of Aromatics.

08 Hrs.

Unit-V

Petrochemicals: Definition, importance and growth potential of the field, raw materials for petrochemical industries, sources, economics and advantages. Production of petrochemicals like dimethyl terephathalate (DMT), ethylene glycol, synthetic glycerin, LAB, acrylonitrile, methyl methacrylate (MMA), phthalic anhydride, maleic anhydride, phenol acetone, formaldehyde, production of carbon black. **08 Hrs**.

Reference Books:

1) B.K. Bhaskar Rao, “Modern Petroleum Processes”, 3/e, Oxford IBH publisher.
2) Ram Prasad, “Petroleum Refining Technology”, Khanna Publishers, 2000.
3) W.L. Nelson, “Petroleum Refinery Engineering” 4/e, McGraw Hill, 1985.
4) B. K. Bhaskar Rao, “A text book on petrochemicals” 1/e, Khanna Publishers, New Delhi, 1987.

18UCHE509	Polymer Science and Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLO):

1. To provide a broad and fundamental knowledge of the polymers and their chemical, physical and mechanical behavior.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the Classification of polymers, kinetics, characteristics of polymers. Types and kinetics of polymerization	1	-	13
CO-2	Comprehend the different methods of polymerization and analyze the different properties of polymers.	13	-	2
CO-3	Explain the different Processing Technology of polymers	13	-	1, 2
CO-4	Comprehend different polymer	13	7	2

	manufacturing processes			
CO-5	Explain polymer recycling, frontiers and challenges and engineering applications.	14	6, 7	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.66	1.0	-	-	-	2.0	2.0	-	-	-	-	-	2.5	3.0	-

Course content:

Unit-I

Polymer Science: Introduction, IUPAC names, Classification of polymers (source, occurrence, elemental composition, geometry and tacticity, stereo regularity), Definition of polymerization, characterization, Chain polymerization (free radical, ionic and co-ordination polymerizations), Step (condensation) polymerization, copolymerization.

Polymerization Kinetics: Definition of reaction rate, order, molecularity, kinetics of step reaction polymerization, kinetics of addition polymerization. **07 Hrs.**

Unit-II

Methods of Polymerization*:* Bulk, solution, Suspension, Emulsion, solid phase, gas phase polymerizations (formulation, mechanism, properties of the polymer produced, advantages and disadvantages).

Polymer Properties: Tensile strength, Impact strength, glass transition temperature, melting temperature, testing: sample preparation, testing standards and methods, analysis of polymer. **08 Hrs.**

Unit-III

Processing Technology: Extrusion, Injection moulding, blow moulding Compression moulding, rotational moulding, thermoforming, Calendering, Compounding. **09 Hrs.**

Unit-IV

Polymer Manufacturing: Industrial production methods of PE, PP, PS, PVC, UF, PF, PU, Poly butadiene, Nylon 6 and Nylon 66. **08 Hrs.**

Unit-V

Frontiers of Polymer Materials: Biodegradable polymers, Biomedical polymers, Conducting polymers, Polymers for space, Thermoxidative degradation, fire hazards, toxicity, effluent disposal, Recycle and reuse of polymers. **07 Hrs.**

Reference Books:

1) R.J.Young and P.A. Lovell, “Introduction to polymers”, Chapman and Hall, London. 2/e. 1992.
2) Fried W.Billmeyer, “Text book of Polymer Science”, J.R.John Wiley and Sons, New York. 3/e. 1984.

3) F. Rodrignek, et al., "Principles of Polymer Systems", CRC Press. Taylor and Francis, Washington Dc. 5/e. 2003
4) Gowarikar, "Polymer Science", New Age International Pvt. Ltd. 1/e. 1986. Reprint in 2005.

18UCHE510 Air Pollution and Control Engineering (3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand the knowledge on the concepts of air pollution and its emerging trends.
2. To understand and deal with sampling and analysis, design of control of air pollution and modeling approaches.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Understand the basics of air pollution, legislation and its impact	6	7	3
CO-2	Comprehend the monitoring, meteorology and modelling of air pollution.	3, 5	-	14
CO-3	Design the control systems for particulate emissions.	3	-	14
CO-4	Design the control systems for gaseous emissions.	3	-	14
CO-5	Explain the vehicular emission and its control system, indoor air pollution and typical control system of any industry.	3	7	6

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.6	-	3.0	2.0	2.0	-	-	-	-	-	-	1.0	-

Course content:

Unit-I

Introduction: Structure and composition of Atmosphere. History of Air pollution and episodes. Causes of air pollution and types. Sources and classification of air pollutants. Effects of air pollutants on human health, vegetation and animals, Materials and Structures. Effects of air Pollutants on the atmosphere, Soil and Water bodies. Long- term effects on the planet, Global Climate Change, Ozone Holes. Ambient Air Quality and Emission Standards and air quality legislations. Air Pollution Indices – Emission Inventories. **07 Hrs.**

Unit-II

Air Pollution Monitoring, Meteorology and Modeling: Air Sampling and monitoring methods. Physico chemical processes governing the spread of pollutants from point, non-point, line, and area sources. Generation, transport and decay of air pollutants. Introduction to meteorology toxicology and transport of air pollution. Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants. Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport and Dispersion of Air Pollutants - Modeling Techniques – Mathematical Modeling of dynamics of pollutants. Different dispersion models. **08 Hrs.**

Unit-III

Control of Particulate Contaminants: Factors affecting Selection of Control Equipment - Gas Particle Interaction, Working principle, Design and performance equations of Gravity Separators, cyclones, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators - Operational Considerations - Process Control and Monitoring - Costing of APC equipment - Case studies for stationary and mobile sources. **08 Hrs.**

Unit-IV

Control of Gaseous Contaminants: Control Equipment, Factors affecting Selection of Control Equipment - Working principle, Design operation and performance of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Bio filters - Process control and Monitoring - Operational Considerations - Costing of APC Equipment - Case studies for stationary and mobile sources. **08 Hrs.**

Unit-V

Automobile, Noise and Indoor Pollution: Vehicular Pollution: Types of emissions-Exhaust emissions, evaporative emissions, crank-case emissions. Prevention and control of vehicular pollution. Noise Pollution due to automobiles and in general. Sources types and control of indoor air pollutants and health effects. Air pollution legislation and regulations. **Case studies:** Few industrial pollution control systems like coal, cement, petroleum etc. **08 Hrs.**

Reference Books:

1) Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Air Pollution Control Engineering, Handbook of Environmental Engineering Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Edition, Tokyo, 2004.
2) Noel de Nevers, Air Pollution Control Engg, Mc. Graw Hill, New York, 3/e. 1995.
3) David H.F. Liu, Bela G. Liptak, Air Pollution, CRC Press. 1/e. 2000. ISBN-10: 1566705134.
4) Anjaneyulu. Y, Air Pollution & Control Technologies, BS Publication, 2/e. 2000. ISBN: 9789387593053.
5) M.N. Rao and H. V. Rao, Air Pollution, McGrew Hill Publications, 2007. ISBN-13- 9780074518717.

VI Semester

18UCHC600	Mass Transfer - II	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the principles and mechanism of diffusion mass transfer in applying to various separation processes viz. distillation, absorption, extraction and leaching.
2. To propose and evaluate the performance of the related equipment for separations involving diffusion.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Outline the principles of different mass transfer equipment and Interpret the concept and mechanism of the absorption tower and its sizing	1, 3	2	13
CO-2	Explain the phenomena of vapor-liquid equilibria, principle and types of distillation process	3, 13	2	1
CO-3	Calculate the no of stages for distillation process by different methods	3, 13	2	1
CO-4	Explain the extraction concepts and processes to determine the no of stages required	3, 13	2	1
CO-5	Explain the leaching concepts and processes to determine the no of stages required.	3, 13	2	1

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	1.4	2.0	3.0	-	-	-	-	-	-	-	-	-	2.6	-	-

Prerequisite: Mass Transfer-I

Course content:

Unit-I

Gas Liquid Contacting Systems: Types, construction and working of equipment – Distillation, Absorption.

Gas Absorption: introduction, Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption

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columns. Design of Plate columns. Absorption and desorption factors. Construction details. HETP and HTU concepts. Liquid phase hold up and pressure drop in absorption towers. Operating line and minimum solvent flow rates. Design of packed towers (height and diameter).Multi-component absorption. Absorption with chemical reaction. **12 Hrs.**

Unit-II

Distillation: Introduction. Vapour liquid equilibrium (T-x,y, P-x,y. H-x,y and x-y diagrams for binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component systems. Non-ideal systems. Azeotropes. Immiscible systems. Steam distillation. Flash and simple distillation. **10 Hrs.**

Unit-III

Multistage Distillation: Multi-stage rectification column. Design using McCabe Thiele method for binary mixtures. Ponchon-Savarit method. Efficiencies–overall, local, and Murphree plate efficiencies. Multicomponent distillation. Vacuum, molecular, extractive and azeotropic distillations. **10 Hrs.**

Unit-IV

Liquid-Liquid Extraction: Liquid-Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Equipment for liquid-liquid extraction. **10 Hrs.**

Unit-V

Leaching Operation: Solid-liquid extraction (Leaching), various types with application, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Leaching equipment: Selection, construction, and operation. **10 Hrs.**

Reference Books:

1) Robert. E. Treybal, "Mass Transfer Operation", 3/e, McGraw Hill, 1981.
2) McCabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/e, Mc Graw Hill, 2001.
3) Coulson and Richardson, "Chemical Engg Vol. 2 and Vol 4, 4/e. Pergamon press, 1998.
4) Geankoplis, C.J., "Transport Processes and Unit Operations", 3/e, Prentice Hall (I).

18UCHC601	Chemical Equipment Design-II	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To develop key concepts and techniques to design process equipment in a process plant.
2. To expose students to the practices followed in the design of chemical equipment and their drawing.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Congregate and analyze the data from the hand book, code book to design and evaluate the heat transfer equipment	3, 13	2	1
CO-2	Congregate and analyze the data from the hand book, code book to design and evaluate the mass transfer equipment	3, 13	2	1
CO-3	Congregate and analyze the data from the hand book, code book to design and evaluate the simultaneous heat and mass transfer equipment	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	2.0	3.0	-	-	-	-	-	-	-	-	-	3.0	-	-

Prerequisites: Process Heat Transfer, Chemical Engineering Drawing, Mass Transfer I and II

Course content:

- Detailed Chemical Engineering Process Design of the following equipment.
- Necessary aspects studied in "Chemical Equipment Design" is to be applied for mechanical design.
- Use of standard code books to be taught.

1. Double Pipe Heat Exchanger
2. Shell and Tube Heat Exchanger.
3. Condenser
4. Distillation Column.
5. Evaporator
6. Absorption Column.
7. Rotary Dryer.

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NOTE:

1. The question paper to contain two full design problems (100 Marks each) for the equipment from the above list and **student to answer any One full question.**

2. Perry's Chemical Engineer's Handbook shall be allowed in the examination as reference. IS Code 4503 for Heat Exchangers (if required) shall be permitted.
3. The answer shall include detailed process design steps using the data given in the problem, mechanical design for component dimensions.

Reference Books:

1) R. H. Perry and D. W. Green "Chemical Engg Hand Book", 6/e, McGraw Hill, 1998.
2) Donald Q. Kern, "Process Heat Transfer", McGraw Hill, 1997.
3) Robert E. Treybal, "Mass Transfer Operations", 3/e, McGraw Hill, 1981.
4) J. M. Coulson & J. F. Richardson, "Chemical Engineering", Vol. 6 Pergamon Press, 1993.
5) Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, New Delhi, 1969; IS Code 4503 for Heat Exchangers.

18UCHL602	**Mass Transfer Laboratory**	**(0-0-3)1.5**

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To provide an understanding of extending the theory into practice through various experiments related to diffusion, both molecular and convective; transfer coefficients and other diffusion based separation processes.
2. To analyze experimental data from the experiment conducted and present a good technical report, thereby demonstrating skills in communication through mandatory oral presentations.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) / PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Evaluate Rayleigh's equation, vaporization and thermal efficiencies using distillation principles.	4, 15	10	9
CO-2	Estimate the percentage recovery for types of Extraction equipments.	4, 15	10	9
CO-3	Calculate the Diffusion coefficient for Diffusion of organic vapour experiment, and height of cooling tower	4, 15	10	9
CO-4	Explain the temperature dependency on ternary phase diagram.	4, 15	10	9
CO-5	Evaluate Freundlich equation	4, 15	10	9

	using adsorption principles			

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	-	1.0	2.0	-	-	-	-	3.0

List of Experiments:

1. Diffusion coefficients of organic vapors in air.
2. Efficiency determination in Steam distillation unit.
3. Rayleigh's expression using Distillation - Simple (Differential) distillation
4. Extraction studies using single and multiple stages in Solid - liquid leaching
5. Himus expression using Surface evaporation
6. Freundlich expression verification using adsorption studies
7. Generation the VLE data on Liquid - Liquid / Vapor - Liquid systems
8. Extraction studies in Liquid extraction - (Cross current: single and 2 or 3 Stage)
9. Liquid phase transfer coefficient calculation using Wetted wall column
10. Height of packing calculation by NTU and HTU concepts using Cooling tower
11. Rate of dissolution by conducting Solid dissolution

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Robert E. Treybal, "Mass Transfer Operation" 3/e, Mc Graw Hill.
2) Coulson and Richardson, "Chemical Eng Vol. 1 and Vol. 2", 4/e.
3) Geankoplis C.J, "Transport Processes and Unit Operations", 3/e, Prentice Hall (I).
4) Mc Cabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/e Mc Graw Hill

18UCHL603	Chemical Reaction Engineering Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To study the reaction kinetics for lab scale reactors by applying the knowledge of chemistry and engineering into practice.
2. To analyze and interpret the experimental data to find the rate law and project in the form of a report and oral presentation.

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Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the kinetics of the reaction for batch, semi batch and flow reactors	4, 15	10	9
CO-2	Evaluate the activation energy of the reaction	4, 15	10	9
CO-3	Characterize the non ideal behavior in the reactors	4, 15	10	9
CO-4	Analyze and interpret the data for reactor design	4, 15	10	9
CO-5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.2	2.2	-	-	-	-	3.0

List of Experiments

1. Saponification reaction in a Batch Reactor (Equimolar and Non-Equimolar Mixture)
2. Study the performance of Plug Flow Reactor.
3. Study the performance of Semi Batch Reactor
4. Study the performance of Mixed Flow Reactor
5. Study the performance of Adiabatic Batch Reactor
6. Study the performance of Packed Bed Reactor
7. RTD Studies in Tubular Reactor
8. Determination of activation energy using Arrhenius law.
9. RTD Studies in Mixed Flow Reactor
10. Study the performance of CSTRs in series
11. RTD studies on Spouted Bed Reactor

Note: Minimum10 experiments to be conducted.

Reference Books

1) Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley and Sons, 1999.
2) J. M. Smith, “Chemical Engg Kinetics”, 3/e, Mc Graw Hill, 1984.

18UCHL604	Minor Project-2	(0-0-4) 2

Contact Hours: 40

Course Learning Objectives (CLOs):

1. To carry out the experimental/design tasks of relatively minor intensity and scope as compared to the major project and in line with the guidelines formulated by the DUGC.
2. To see that this project could be a prologue for the upcoming major projects in the final year.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical engineering or integrated problems (allied fields).	2,10	8, 12	7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.0	3.0	2.0	3.0	-	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

The project work is to be taken up having had an exposure to the project work in the previous semesters. The students are expected to locate the state-of-the-art technology in his/her domain of interest by an extensive literature survey and select a topic from an emerging area relevant to their branch/interdisciplinary and define the problem for the project work. The problem could be defined to develop prototypes for industrial needs. A team consisting of not more than 4 students shall be guided by a faculty member. This project work is to supplement and prepare the students to take up major project work at higher semesters. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE with suitable rubrics. The weightage of marks shall be 50% for the committee and 50% for the guide. There is a SEE (viva voce) examination which shall be examined by two internal examiners appointed by COE based on the suggestions by the respective HoD.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:

3. Offline/online chemical engineering and its related field Journals.
4. Books in the area of chemical engineering and its related field.

18UHUL605	**Soft skill and Aptitude**	**(0-0-2) 1**

Contact Hours: 24

Course Learning Objectives (CLOs):

2. This is included with the objectives of improving the communication skills, proficiency in English language and aptitude ability of the student to enhance the employability.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the significance of communication in the profession		10	
CO-2	Use the English language with proficiency		10	12
CO-3	Solve Aptitude related problems		9	12
CO-4	Demonstrate the competency in the placement activities		9	

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.0	-	1.0	-	-	-

Contents: Training on communication skills, proficiency in English language and aptitude ability involving the internal and external resource.

Evaluation: Both the internal and external resource persons shall be engaged in imparting the related knowledge and shall have only CIE as the evaluation component. There shall be one test conducted at the end for 25 marks in Aptitude testing and there shall be one presentation by the student for 25 marks or any other suitable testing components. The arrangement for CIE evaluation is to be done by the department and maintain the relevant documents

18UCHE606	Transport Phenomena	(3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide basic understanding of laws governing transport processes and effect of various parameters.
2. To provide an understanding of steady state shell balances for velocity, temperature and concentration distribution under laminar flow.
3. To deal with equations of change and analogies amongst transport processes along with their applications

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	State laws of momentum, energy and mass transport. Discuss effect of temperature and pressure on transport properties of fluid.	1	-	-
CO-2	Formulate velocity distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-3	Formulate temperature distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-4	Formulate concentration distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-5	Apply equations of change for isothermal systems and write analogies between momentum, heat and mass transport problems.	-	2, 3, 13	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	2.0	-	-	-	-	-	-	-	-	-	2.0	-	-

Prerequisites: Fluid Mechanics, Heat and Mass Transfer

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Course content:

Unit-I

Introduction: Importance of transport phenomena in chemical engineering, Momentum, Energy and Mass transport, Newton's law of viscosity, Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction, Ficks law of diffusion, effect of temperature and pressure on transport properties of fluids. Numerical problems using all law. **07 Hrs.**

Unit-II

Velocity Distribution in Laminar Flow: Steady state shell momentum balance, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through circular tube, flow through annulus, flow between parallel plates and slit. Numerical problems using the equation derived above. **09 Hrs.**

Unit-III

Temperature Distribution in Laminar Flow: Steady state shell balance, boundary conditions applicable to energy transport problems, heat conduction through compound walls, heat conduction with internal generation by electrical source, nuclear and viscous energy sources. Heat conduction in a cooling fin, Forced and free convection heat transfer. Numerical problems using equation derived above. **08 Hrs.**

Unit-IV

Concentration Distribution in Laminar Flow: Steady state shell balance, Boundary conditions applicable to mass transport problems, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion, Diffusion into falling film, Forced convection mass transfer, Diffusion with homogeneous and heterogeneous reaction. Numerical problems using the equation derived above.
08 Hrs.

Unit-V

Equation of Change of Isothermal Systems: Non isothermal systems and Multicomponent systems. Application of these equations in solving steady state problem. **Analogies and Navier Stokes equation:** Simple numerical problems on it. Analogies between Momentum, Heat and mass transport and their numerical problems. **07 Hrs.**

Reference Books:

1) Bird, Stewart and Lightfoot, "Transport Phenomena", John Wiley, 2/e. 1994.
2) Robert Brodkey and Henry C. Hershey, "Transport Phenomena Unified Approach", International Edition- 1988. ISBN-10: 0070079633
3) Bennet and J. E., "Momentum Heat and Mass Transfer", Myer- McGraw Hill. 3/e. 1982.
4) Suryavanshi and Dongre, "Transport Phenomena", Nirali Prakashan. 7/e. 2012. ISBN: 978-81962-56-5.

18UCHE607	Catalyst Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand controlling mechanisms in solid catalyzed reactions, characterization of catalyst properties and is preparation.
2. To provide catalytic reactor design concepts involving solid catalyzed reaction and catalyst deactivation.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain catalyst technology development, economic importance and develop overall rate expressions.	1,2	-	-
CO-2	Explain makeup of solid catalyst and its various properties.	1,2	-	-
CO-3	Explain catalyst preparation and its characterization.	1,2	-	-
CO-4	Formulate performance equation for ideal flow patterns and apply the same for reactor design.	1,2,3	13, 14	-
CO-5	Explain causes and mechanisms of catalyst deactivation and determine deactivation kinetics.	1,2,3	13	-

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	3.0	3.0	3.0	-	-	-	-	-	-	-	-	-	2.0	2.0	-

Course content:

Unit-I

Fundamentals of Catalytic Phenomena: Brief history of catalyst technology development and its economic importance. Various controlling mechanisms involved in solid catalyzed reactions, overall rate expressions. **07 Hrs.**

Unit-II

Catalyst Materials and Properties: Makeup of a typical heterogeneous catalyst and their functions. Molecular sieves and zeolites. Physical, Chemical, Dynamic and Mechanical properties of solid catalyst and adsorption isotherms. **07 Hrs.**

Unit-III

Catalyst Preparation and Characterization: Various catalyst preparation methods and equipments used, catalyst activation and forming**.** Catalyst characterization. **08 Hrs.**

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Unit-IV

Reactor Design: Basic approaches to reactor design, performance equations, collection of data form laboratory reactors, experimental methods to find rate equations and reactor design. **08 Hrs.**

Unit-V

Catalyst Deactivation: Causes and mechanisms of catalyst deactivation, prevention and regeneration. Experimental methods to find rate of deactivation, design and operation strategies with deactivating catalysts. **09 Hrs.**

Reference Books:

1) Prof. I.P. Mukhlyonov, " Catalyst Technology", MIR Publishers.
2) R.P. Farrauto and C.H. Bartholomew, "Fundamentals of Industrial Catalytic Processes".
3) Hamid Al-Mergen and Tian Cum Xiao, " Petrochemical Catalyst Materials, Processes and Emerging Technologies", IGI Global Series Book, 2016, ISBN:97814666699755.

18UCHE608	**Plant Utilities and Industrial Safety**	**(3-0-0)3**

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand the utilities in a chemical process plant, types, role and their selection.
2. To understand the principles of safety with insight of safety analysis techniques and application of safety devices.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the selection and role of utilities and appraise the generation, handling and role of water and steam.	-	3	14
CO-2	Appraise the generation, handling and role of air with the use of devices.	3	14	-
CO-3	Assess refrigerants, evaluate the performance and apply refrigeration.	3	7,14	-
CO-4	Prioritize safety aspects, plan	3	6,8	14

	and use safety devices in defiant situations in a chemical plant.			
CO-5	Interpret safety analysis tools and techniques and translate to hazardous conditions.	3	7	14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.8	-	-	2.0	2.0	2.0	-	-	-	-	-	1.4	-

Course content:

Unit-I

Introduction: Utilities and their role, selection criteria etc. **Water and Steam:** Resources, Cooling water-requirements and treatments, Process water-Ion Exchange, Water softening methods-Ion exchange, Reverse osmosis, Electro dialysis, Water pretreatment, recycle and reuse, various pumps. Generators, Efficiency, Feed water Treatment and Steam quality, Steam consumption, Steam distribution, Condensate removal, condensate recovery. **08 Hrs.**

Unit-II

Air: Compressed air for process and instruments, Blowers and Fans-Characteristics, Compressed- Positive displacement and Centrifugal features, Multistage Compression-features, Vacuum pumps, Air Drying-Pressure swing Adsorption with applications, Skarstrom cycle. **08 Hrs.**

Unit-III

Refrigeration: Carnot Cycle and Reverse Carnot Cycles, Tonnage, Primary and Secondary refrigerants, Vapor Compression Refrigeration; various refrigerants, Tonnage. Vapor Absorption Refrigeration- Characteristics, Comparison. **08 Hrs.**

Unit-IV

Process Safety and Devices: Safety aspect, safe design, Intrinsic and Extrinsic safety, Hazards, Risk, Toxicity, Flammability, Fire, Explosion, TLV, Sources of ignition, Hazardous materials and conditions, Reactive chemicals, Combustion and Flammability, Gas explosion, Dust Explosion, UCVCE, Static Electricity, Vacuum Hazards, Inert Gas Hazards, Gas Dispersion, Safety Devices; Pressure Relief Systems, Emergency relief devices, Flame arrestors, storage and handling.

08 Hrs.

Unit-V

Safety Analysis and Case Studies: Hazard Analysis (HAZAN), Hazard and Operability studies (HAZOP), Comparison, Risk Analysis and Estimation, Safety check list. Case Studies: Vishakapatnam, Bhopal, Jaipur, Flixborough, Seveso, Piper Alpha, Mexico [LPG Fire] **07 Hrs.**

Reference Books:

1) Perry's "Handbook of Chemical Engineers" 7/e, Mc-Graw Hill Publications.
2) Frank P. Lees, "Loss Prevention", Vol 1 and Vol 2.
3) Jack Broughton, "Process Utilities", I Chem publications.

18UCHE609 Drug and Pharmaceutical Technology (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide students with the basics of drug and pharma technology and develop the skills for understanding the constituents of drug and its production.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)** Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Develop nomenclature for upcoming drugs and gain knowledge of therapeutic agents to be used for treatment.	1	-	14
CO-2	Estimate the pharmacokinetic parameters and analyze the transformation of drugs in the body.	14	2, 7	-
CO-3	Employ standards of hygiene in the manufacturing processes of drugs and pharmaceuticals.	14	2, 7	-
CO-4	Examine the constituents present in pharmaceutical and microbiological products.	14	2, 7	-
CO-5	Formulate drug delivery systems to transport pharmaceutical agents in the body to achieve therapeutic effect.	14	2, 7	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.0	-	-	-	-	2.0	-	-	-	-	-	-	2.6	-

Course content:

Unit-I

Introduction: Development, sources, and characteristics of drugs; Important terms used in chemistry of drugs- Medicinal Chemistry, Pharmacology, Pharmacophore, Gram positive and negative bacteria, virus, fungi; Classification and nomenclature of drugs. **07 Hrs**

Unit-II

Pharmacokinetics and Pharmacodynamics: Physico - chemical principles; Pharmacokinetics - Absorption Distribution, Metabolism and Excretion of Drugs; Bioavailability measurement - Plasma level-time and Urinary excretion studies; Basic Pharmacodynamics. **08 Hrs**

Unit-III

Manufacturing Principles: Compressed tablets and coating, Wet granulation, Dry granulation or Slugging, Capsules, Parenteral solutions, Oral liquids, Ointments, Good Manufacturing Practice as per Drugs and Cosmetics Act. **08 Hrs**

Unit-IV

Pharmaceuticals, Microbiological Products: Laxatives, Radiopharmaceuticals, Cardiovascular agents, Central Nervous System stimulants, External Antiseptics, Analgesics, Antacids, Antibiotics, Antineoplastic drugs, Antidiabetic drugs, Hormones, Vitamins. **08 Hrs**

Unit-V

Drug Delivery: Transdermal drug delivery, Polymers in drug delivery, Liposomal drug delivery, Nano drug delivery, Opthalmic drug delivery, Design of Controlled Drug Delivery Systems. **08 Hrs**

Reference Books:

1) G. R. Chatwal. “Synthetic Drugs”. 2/e. Himalaya Publishing House, Delhi, 2009. ISBN: 978-93-5097-253-3.
2) D. M. Brahmankar and S. B. Jaiswal. “Biopharmaceutics and Pharmacokinetics - A Treatise”, Vallabh Prakashan, New Delhi. 2015.
3) Felton, Linda A., Remington: “Essentials of Pharmaceutics”, College of Pharmacy, Philadelphia, 1/e. Pharmaceutical Press. 2013.
4) Juergen Siepmann, Ronald A. Siegel, Michael J. Rathbone, “Fundamentals and Applications of Controlled Release Drug Delivery”, Springer New York, 2011.
5) L. Lachman, Lieberman H.A. and Kanig J.L., “”he Theory and Practice of Industrial Pharmacy”, 3/e. Indian Edition, Varghese Publishing House, Mumbai, 2013.

18UCHE610	Food Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand the basic principles of Food Science and Technology and applying it to the growing and dynamic engineering needs of the Food Industries.
2. To study the application of unit operations and modern trends in food processing industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (1,2,3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the general food properties and its unit operations in industries.	1	-	13
CO-2	Comprehend on food preserving techniques, food contamination and food safety aspects.	14	6, 7	1
CO-3	Explain and distinguish the different techniques of food preservation in industries	14	6, 7	1
CO-4	Understand and discuss the different food additives and its safety	14	6, 7	1
CO-5	Identify and apply the different food processing techniques and food packing	14	6, 7	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	-	-	-	-	2.0	2.0	-	-	-	-	-	1.0	3.0	-

Course content:

Unit-I

Introduction to Food Engineering: Introduction: general aspects of food industry, world food demand and Indian scenario, Physical properties of food materials: Rheological models, Water activity, Fluid Flow in Food Processing: Liquid Transport Systems; Pipes for Processing Plants, Pumps for food plants; Numerical on fluid flow in food processing. **07 Hrs**

Unit-II

Food Preservation: Food deterioration – Causes, Aims and objectives of preservation and processing. **Food Contamination and Adulteration:** Types of adulterants and contaminants, Intentional adulterants, Metallic contamination, Incidental adulterants, Nature and effects, food laws and standards, Hazard analysis and critical control points or HACCP**,** Food Safety and Standards Authority of India (FSSAI) **08 Hrs**

Unit-III

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High-Temperature Preservation: Introduction to Thermal Processing; Pasteurisation; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Numericals; Batch & continuous Retorts for Thermal processing; Cold sterilization: Gamma irradiation; Microwave & Ohmic heating. **08 Hrs**

Low-Temperature Preservation: principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidized bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank‟s equation and Nagaoka‟s equation. **08 Hrs**

Unit-IV

Food Additives: Introduction and need for food additives, Types of additives – antioxidants, chelating agents, colouring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives: types and applications, Stabilizers and thickeners, other additives, Additives and food safety. **08 Hrs**

Unit-V

Food Processing process: Introduction to Extrusion, Basic Principles, Extrusion Systems, Cold Extrusion, Extrusion Cooking, Single Screw Extruders, Twin-Screw Extruders. **Packaging Concepts:** Introduction to packaging, food protection, product containment, commutation, convenience, mass transfer in packaging materials, and permeability of packaging material to fixed gases, innovations in food packaging, passive packaging, active packaging, intelligent packaging, food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labelling. **08 Hrs**

Reference Books:

1) R. Paul Singh and Dennis R. “Introduction to Food Engineering, Elsevier Science and Technology”, 5/e, 2013. ISBN: 9780123985309.
2) P.G. Smith, “Introduction to Food Process Engineering” 2/e, Springer Press New York, 2009. ISBN 978- 1-4419-7661-1.
3) Subbulakshmi G. and Shobha A. Udupi, “Food Processing and Preservation”, New Age International Pvt. Ltd., 2001. ISBN: 8122412831.

18UCHE611	Applied Mathematics in Chemical Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. To understand the Computational techniques and use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand calculations for application in Chemical Engineering.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (1,2,3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and apply mathematical methods to solve chemical engineering problems	1	2	3
CO-2	Evaluate and analyse different chemical engineering problems using interpolation techniques	3, 5, 13	2	1
CO-3	Interpret and develop the relationship in chemical engineering using different numerical differentiation techniques	3, 5, 13	2	1
CO-4	Formulate and optimize with different methods of ODE to solve chemical engineering problems unit operation and process.	3, 5, 13	2	1
CO-5	Formulate and optimize with different methods of PDE to solve chemical engineering problems unit operation and process.	3, 5, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	2.6	-	3.0	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Computation and Error Analysis: Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation. Linear Systems and Equations Matrix representation, Calculation of Eigen Values and Eigen vectors, Solution by Cramer's rule; Iterative Method-- Jacobi iteration; Gauss-Seidel Method, Chemical Engineering Examples: Material and energy balance problems involving at least 3 simultaneous equations Non-linear Algebraic Equations (single and multivariable) Secant, Multivariate Newtons method Chemical Engineering Examples: Equation of state (van der Waals, Beattie-Bridgeman, etc.), Friction factor equation etc. **07 Hrs.**

Unit-II

Regression and Interpolation: Polynomial regression, Newtons Difference Formulae, Cubic Splines Chemical Engineering Examples: Free settling velocity of particles, Arrhenius Equation, Specific heat w.r.to temperature etc. **08 Hrs**

Unit-III

Numerical Differentiation: Numerical differentiation; higher order formulae. Integration and Integral Equations Two and Three point Gaussian quadrature formula Chemical Engineering Examples: Rayleigh's equation, Rate equation.

08 Hrs

Unit-IV

Ordinary Differential Equations: Initial Value Problems Runge – Kutta method for second order differential equations, Explicit Adams-Bashforth technique, Implicit Adams-Moulton technique, Predictor-Corrector technique. Stiffness of ODE"s ODEs: Boundary Value Problems: Orthogonal Collocation, shooting techniques. Chemical Engineering Examples: Rate equation, Steady-state material or energy balance equations etc. **08 Hrs**

Unit-V

Solution of Partial Differential Equations: Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, implicit and explicit methods, Cranks Nicolson Method, Chemical Engineering Examples: unsteady-state one dimensional heat conduction. Use of MATLAB with chemical engineering examples. **08 Hrs**

Reference Books:

1) Gupta S.K , "Numerical Methods for Engineers", 3/e, ISBN : 978-81-224-3359-3, New Age International, 1995
2) Alkis Constantinides and Navid Mostoufi, "Numerical Methods for Chemical Engineers with MATLAB Applications", ISBN-10: 0130138517, Prentice Hall, 1999.
3) Steven Chapra and Raymond Canale, "Numerical Methods for Engineers.", 6/e, McGrew Hill Publication, 2010.
4) M. K. Jain, S. R. K. Iyengar, and R. K. Jain, "Numerical Methods", 6/e New Age International Publishers, New Delhi, 2012

18UCHO612	Advanced Waste Water Treatment	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To create awareness on the water pollution aspects and understand the kinetics and the designing system of the plant.
2. To understand the different parameters, treatment methods and control techniques of water pollution.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Cognize the different characteristics of waste water and regulatory standards with basic design criteria	-	14	3, 6, 7

	for waste water treatment			
CO-2	Comprehend the reaction kinetics, reactor selection and its process analysis.	13, 14	3, 6, 7	5
CO-3	Design and operational concepts of secondary treatment systems	13, 14	3, 6, 7	-
CO-4	Design and operational concepts of tertiary treatment systems	13, 14	3, 6, 7	-
CO-5	Learn the wastewater treatment criteria based on the regional requirement to understand the sewage management of the city.	3, 6, 7	14, 15	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	3.0	2.6	2.0

Course content:

Unit-I

Introduction of Wastewater Treatment: Flow measurements and Composition. Characterization -properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central. Theoretical principles and design considerations - screens, equalization basin, grit chamber, primary and secondary settling tanks. **07 Hrs.**

Unit-II

Microbiology of Waste Treatment: Growth and inhibition of bacteria. Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization. Effects of endogenous metabolism and kinetics Monod's and Michaclis menton kinetics and their applications. Determination of biokinetic constants in batch and continuous system. **08 Hrs.**

Unit-III

Secondary Waste Water Treatment: Aerobic, anaerobic, suspended and attached growth systems. Activated sludge process standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds, bio-towers, RBC. Treatment disposal of sludge- Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation. Reactor configurations. Case studies. **08 Hrs.**

Unit-IV

Tertiary Waste Water Treatment: Introduction, Need of Tertiary Waste Water Treatment, Purpose of Advanced Waste Water Treatment. Nitrogen and Phosphorus Nitrogen Removal: Nitrification, Denitrification Simultaneous nitrification and denitrification Phosphorus Removal. Membrane Bioreactor with Membrane

Module Submerged in the Bioreactor. Electro-coagulation, Electro dialysis, Reverse osmosis, Ion exchange, Adsorption, absorption, Evaporators. Case studies. **08 Hrs.**

Unit-V

Sewage Treatment and Disposal: Introduction, importance of sewage, Characteristics of sewage, Sampling and analysis of sewage, Sewage treatment and disposal: Skimming, Grit chamber, Sedimentation tanks, Septic tank, Secondary treatment-types of filters, rate of filter loading, Activated sludge process, sludge digestition, Sludge disposal. **08 Hrs.**

Reference Books:

1) Metcalf and Eddy. "Waste water Engineering: Treatment and Reuse". McGrew Hill Publication. ISBN-10: 9780070495395. 4/e. 2017
2) A. F. Gaudy and E. T. Gaudy. "Microbiological for environmental Scientist and engineers" McGraw Hill 1/e. 1980.
3) T. McGhee. "Water Supply and Sewerage", McGraw Hill. 6/e. 1991. ISBN-10: 0070609381
4) G. S. Bridie and J.S. Brides. "Water Supply and Sanitary Engineering". Dhanpat Rai & Sons 2010. ISBN-10: 8187433795.

18UCHO613	Biology for Engineers	(3-0-0)3

Contact Hours: 39

Course Learning Objective (CLO):

1. Gain vivid knowledge in the fundamentals and uses of biology, human system and plant system

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)** Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Describe the fundamentals of living things.	1	-	12
CO-2	Apply the concept of plant, animal and microbial systems and growth in real life systems.	13	2,3	1
CO-3	Comprehend genetic and the immune system	-	4	5

CO-4	Analyze the cause of symptoms, diagnosis and treatment of common diseases.	2	12	6
CO-5	Illustrate the application of biology system in relative industries.	1,2	3	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.33	2.66	2.0	2.0	1.0	1.0	-	-	-	-	-	1.5	2.0	-	-

Course Content:

Unit-I

Introduction to Life: Characteristics of living organisms-Basic classification-cell theory-structure of prokaryotic and eukaryotic cell-Introduction to biomolecules: definition-general classification and important functions of carbohydrates-lipids-proteins-nucleic acids vitamins and enzymes-genes and chromosome. **07 Hrs.**

Unit-II

Biodiversity: Plant System: basic concepts of plant growth-nutrition-photosynthesis and nitrogen fixation-Animal System: elementary study of digestive-respiratory-circulatory-excretory systems and their functions-Microbial System: history-types of microbes-economic importance and control of microbes. **07 Hrs.**

Unit-III

Genetics and Immune System: Evolution: theories of evolution-Mendel's cell division–mitosis and meiosis-evidence of laws of inheritance-variation and speciation- nucleic acids as a genetic material-central dogma immunity-antigens-antibody-immune response. **08 Hrs.**

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Unit-IV

Human Diseases: Definition- causes, symptoms, diagnosis, treatment and prevention of diabetes, cancer, hypertension, influenza, AIDS, Hepatitis and COVID-19 **08 Hrs.**

Unit-V

Biology and Its Industrial Applications: Transgenic plants and animals-stem cell and tissue engineering-bioreactors-biopharming-recombinant vaccines-cloning-drug discovery-biological neural networks-bioremediation-biofertilizer-biocontrol-biofilters-biosensors-biopolymers- bioenergy- biomaterials-biochips-basic biomedical instrumentation **09 Hrs.**

Reference Books:

1) Biology for Engineers: As per Latest AICTE Curriculum Wiley Editorial, ISBN: 9788126576340.
2) A Text book of Biotechnology, R.C.Dubey, S. Chand Higher Academic Publications, 2013

3) Diseases of the Human Body, Carol D. Tamparo and Marcia A. Lewis, F.A. Davis Company, 2011.
4) Biomedical instrumentation, Technology and applications, R. Khandpur, McGraw Hill Professional, 2004

18UCHO614 Composite Materials (3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. To understand the nature, properties, structure and processing of composite materials and their engineering applications.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (1,2,3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain composites and the properties of composites	2,14	6	-
CO-2	Analyse and compile the different manufacturing method for preparing the materials	14	2	7
CO-3	Compare and assess the different processing techniques for advanced materials	14	2	7
CO-4	Compare and assess the different processing techniques for advanced materials based on reaction method	14	2	7
CO-5	Distinguish between different specific composite materials, their manufacturing and applications	14	2	7

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.2	-	-	-	2.0	1.0	-	-	-	-	-	-	3.0	-

Course content:

Unit-I

Introduction: Definitions, Composites, Reinforcements and matrices, Types of reinforcements, Types of matrices, Types of composites, Carbon Fibre composites, Properties of composites in comparison with standard materials, Applications of metal, ceramic and polymer matrix composites. **Advanced material and properties:** Semi-conducting and Super-conducting materials with superior structural, mechanical, optical and electrical properties. **07 Hrs.**

Unit-II

Manufacturing Methods: Hand and spray lay - up, injection molding, resin injection, filament winding, pultrusion, centrifugal casting and prepregs. Fibre/Matrix Interface, mechanical. Measurement of interface strength. Characterization of systems; carbon fiber/epoxy, glass fiber/polyester, etc. **08 Hrs.**

Unit-III

Processing Techniques: Sintering, hot pressing, hot isostatic pressing, tape-casting sol-gel processing for the formation of monolithic ceramics, composites (ceramic, ceramic metal, as well as metal matrix), SiO_2, Glasses from above powders. **08 Hrs.**

Unit-IV

Processing Techniques Based on Reaction Methods: Chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI), self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibers and semi conducting materials such as Si and gallium arsenide. **08 Hrs.**

Unit-V

Reinforced Metal Matrix: Methods for preparation of powdered metal matrix, fiber reinforced metal matrix. Types and Properties of matrix materials and its industrial application **Ceramic Reinforced Matrix:** Cold pressing & sintering method, liquid silicon infiltration technique for synthesis of ceramic reinforced matrix, Types and properties of ceramic Matrix and its industrial applications. **Polymer Composites:** Stress-Strain modulus relationship for fiber reinforced polymer composites, **Manufacturing Methods:** Hand layouts, filament winding, pultrusion, SMC and DMC. Applications of polymer reinforced composites in marine, aerospace, automobile, building & computer industry. **08 Hrs.**

Reference Books:

1) W.D. Kingery. “Introduction to Ceramics”. 2/e. Willey- Blackwell Publication. 1976. ISBN-10: 0471478601
2) K. K. Chawla. “Advanced Composites”. 2/e. Springer New York. Publication. 1987.
3) James.T.Schockel Ford. “Introduction to Material Science for Engg.” 2/e. McMillan publications.
4) L.H. Vanvlack. “Elements of Material Science and Engineering” 6/e. Pearson Education. 2002. ISBN-10: 8131706001.
5) M.N. Rahaman. “Ceramic processing and sintering” 2/e, Marcel Dekker, Inc, New York. 1995.

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Academic Program: UG

Academic Year 2020-21

Syllabus

VII & VIII Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution recognized by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465** **Fax: 0836-2464638** **Web:** www.sdmcet.ac.in

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SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for VII & VIII semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2020-21 till further revision.

Principal   Chairman BoS & HoD

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SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

✣ In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs):

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs):

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific outcomes (PSOs):

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for VII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC700	Process Dynamics and Control	4-0-0	4	50	100	3		
15UCHC701	Chemical Technology	4-0-0	4	50	100	3		
15UCHC702	Biochemical Engineering	3-0-0	3	50	100	3		
15UCHL703	Major Project-1	0-0-6	4	50			50	3
15UCHL704	Process Control Laboratory	0-0-3	1.5	50			50	3
15UCHL705	Computer Applications in Chemical Engineering and Simulation Laboratory	0-0-3	1.5	50			50	3
15UCHE70X	Elective – 5	4-0-0	4	50	100	3		
15UCHE70X	Elective – 6	4-0-0	4	50	100	3		
	Total	**19-0-12**	**26**	**400**	**500**		**150**	
	Electives							
15UCHE706	Pilot Plant and Scale up Methods	4-0-0	4	50	100	3		
15UCHE707	Transport Phenomena	4-0-0	4	50	100	3		
15UCHE708	Process Modeling and Simulation in Chemical Engineering	4-0-0	4	50	100	3		
15UCHE709	Novel Separation Techniques	4-0-0	4	50	100	3		
15UCHE710	Wastewater Treatment and Engineering	4-0-0	4	50	100	3		

Scheme for VIII Semester

Course Code	Course Title	Teaching		Examination				
		L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
				Max. Marks	*Max. Marks	Duration in hours	Max. Marks	Duration In hours
15UCHC800	Process Engineering Economics and Management	4-0-0	4	50	100	3		
15UCHL801	Seminar	0-0-3	2	50				
15UCHL802	Major Project-2	0-0-12	10	50			50	3
15UCHE80X	Elective – 7	4-0-0	4	50	100	3		
15UCHE80X	Elective – 8	4-0-0	4	50	100	3		
Total		**12-0-15**	**24**	**250**	**300**		**50**	
Electives								
15UCHE803	Solid Waste Management	4-0-0	4	50	100	3		
15UCHE804	Instrumental Methods of Analysis**	4-0-0	4	50	100	3		
15UCHE805	Sugar Technology	4-0-0	4	50	100	3		
15UCHE806	Bioprocess Engineering	4-0-0	4	50	100	3		
15UCHE807	Unit Processes in Organic Synthesis**	4-0-0	4	50	100	3		

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
* SEE for theory courses is conducted for 100 marks and reduced to 50 marks.
** To be handled by the Chemistry department faculty

Total credits offered for the Fourth year: 50

Interdisciplinary Elective open for all Engineering Branches:
15UMAE875 Applied Numerical Methods (VIII Sem)
15UPHE876 Nanotechnology (VIII Sem)

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VII Semester B.E.

15UCHC700	Process Dynamics and Control	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the basic principles and importance of process control in industrial process plants.	13	1	-
CO-2	Formulation of dynamic models based on fundamental laws and analytically solve linear dynamic models of first and second order system.	-	2,3	13
CO-3	Predict the closed-loop behavior using block diagram and control valves.	-	2,10	13
CO-4	Predict closed loop behavior using block diagram and analyze control valves.	-	2	13
CO-5	Analyze controllers and determine the stability of a closed-loop feed-back control system.	-	2,3	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.0	2.0	2.0	-	-	-	-	-	-	2.0	-	-	1.4	-	-

Course Content:

Unit-I

Introduction: Classification of variables, control configuration, classification of control systems. Laplace Transform, types of inputs- step, impulse, linear and sinusoidal. **09 Hrs.**

Unit-II

Process Dynamics: First order systems, transfer functions - mercury in glass thermometer, level, mixing tanks, stirred tank reactors, Response of first order system in series: Interacting and non-interacting systems, Linearization of non-linear first order systems. **12 Hrs.**

Unit-III

Second Order Systems: U-tube manometer, damped oscillator, response equations, terms of second order under damped system, Transportation lag **09 Hrs.**

Unit-IV

Block Diagram: Importance, reduction rules, steps, servo and regulator problem, overall transfer function for set-point change and load change.

Final Control Element: control valves, types, actuators, positioners, valve characteristics. **10 Hrs.**

Unit-V

Controllers: Transfer functions for two position, proportional, Proportional +Reset (P+I), Proportional + Rate (P+D), Proportional + Reset +Rate controller (P+I+D), servo and regulator control system.

Stability: Concept of Stability, Stability criterion, Routh Herwitz test for stability, Root Locus method. Stability of linear control system, Routh –Hurwitz, Root Locus methods. **12 Hrs.**

Reference Books:

1) Coughanour and Koppel, “Process System Analysis and Control”, 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2) Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, 2/e, McGraw Hill, 1990.
3) Coulson and Richardson, “Chemical Engineering” Vol, III, 3/e, Pengeman Press.
4) George Stephanopoules, “Chemical Process Control” An Introduction to Theory and Practical, Prentice Hall, New Delhi, 1998.

15UCHC701	Chemical Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the industry protocols used in the manufacture of chemicals both inorganic and organic with the use of reference flow sheets.
2. Identify major engineering problems associated with manufacturing processes.
3. Overcoming bottlenecks and trouble shooting.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the impetus of Chemical Industry globally and summarize production process of industrial gases.	6,7	12	1
CO-2	Apply the concepts of unit operations and processes, reaction kinetics to Chlor-Alkali and acids production.	12,13,1	9,10, 14	3
CO-3	Illustrate the technology of manufacturing fertilizers and phosphorous compounds.	14	9, 12	--
CO-4	Interpret the concept of operation, process reactions and unit operation to pulp and paper and fermentation industries.	14	3, 6, 7	--
CO-5	Prioritize trouble shooting to overcome the bottlenecks in a process and develop the technology within realistic constraints of oils and fats and soap industries.	13,14	12	---

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.0	-	1.5	-	-	2.5	2.5	-	2.0	2.0	-	2.25	3.0	2.75	-

Course contents:

Unit-I

Introduction to Chemical Process Industries: Chemical Industry in this millennium, Scenario of Indian and World chemical industry.

Industrial and Fuel Gases: H_2, O_2, N_2, CO_2, Water gas, Producer gas. **10 Hrs.**

Unit-II

Chlor-Alkali Industry: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder

Acids: Sulfuric, Nitric, Hydrochloric and Phosphoric acids. **12 Hrs.**

Unit-III

Fertilizer Industry: Ammonia, Urea, Ammonium Nitrate, Ammonium Sulfate, DAP, Potash fertilizers, Bio-fertilizers.

Phosphorous Industry: Red and White phosphorous, Phosphorous pentoxide, Phosphate fertilizers, Super phosphate and Triple super phosphate.

10 Hrs.

Unit-IV

Pulp and Paper Industry: Raw materials, manufacture of pulp and paper, recovery of chemicals.

Fermentation and Distillery: Manufacture of alcohol, beer, wine, vinegar.

10 Hrs.

Unit-V

Oils and Fats Industry: Manufacture of oils (vegetable and industrial) processing and refining, essential oils and uses,

Soaps Industry: Types of soaps and fatty acid, manufacturing process and uses

10 Hrs.

Reference Books:

1) George T Austin: Shreves, "Chemical Process Industries", Mc Graw Hill International ltd.
2) Gopal Rao and Marshall, "Dryden's Outlines of Chemical Technology", East-West Press.
3) S.D. Shukla and G.N. Pandey, "Text book of Chemical Technology" Vol.1 and 2, Vikas Publishing House Pvt. Ltd. New Delhi.
4) S.C. Bhatia, "Chemical Process Industries", Vol.1 and 2, CBS Publishers, New Delhi

15UCHC702	**Biochemical Engineering**	**(3-0-0) 3**

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide the forum to understand the principles and concepts of microbiology, cell biology and biochemistry and thereby apply chemical engineering principles to asses and evaluate the cell as a reactor.
2. To incorporate the principles of chemical engineering in understanding the upstream and downstream processing techniques in a biochemical industry.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the microorganisms in the context of industrial and environmental microbiology and explain the chemicals of life with the properties and their derivates.		7	2
CO-2	Interpret and evaluate the enzyme kinetic parameters with different effects of the reactors.	13	3	2
CO-3	Analyze cell growth kinetics and solve problems of upstream bio processing.	13	3	2
CO-4	Explain the various configurations of bioreactors along with fermentation technology	12,13	3	2
CO-5	Identify and explain the methods involved in product recovery and purification	12,14	3	2

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	1.0	2.0	-	-	-	2.0	-	-	-	-	3.0	3.0	3.0	-

Course content:

Unit-I

Microbiology: Scope, structure of cells: Prokaryotic and Eukaryotic, characterization and classification of microorganisms - Taxonomy and Whitaker's 5-Kingdom concept, environmental and industrial microbiology, control of microorganisms.

Biochemistry: Chemicals of life - Lipids, sugars and polysaccharides; amino acids, proteins and enzymes; vitamins, biopolymers, nucleic acids and their derivatives. **08 Hrs.**

Unit-II

Enzyme Catalyzed Reactions: Enzyme Nomenclature and classification, enzyme kinetics, Mechanism and kinetics of enzymatic reactions, evaluation of kinetic parameters, factors affecting enzyme activity, Inhibitors and inhibition kinetics, Industrial enzymes and applications, methods of immobilization of enzymes. **08 Hrs.**

Unit-III

Biomass Production in Cell Cultures: Ideal reactors for kinetic measurements - batch and continuous reactors, Monod's growth kinetics,

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Transient growth kinetics, Cell growth and kinetic patterns, Reactors and their configurations. **09 Hrs.**

Unit-IV

Fermentation Technology: Ideal bioreactors, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations. **07 Hrs.**

Unit-V

Downstream Processing: Steps involved in product recovery, operations involved - centrifugation, chromatography and emerging technologies including membrane separation techniques. **07 Hrs.**

Reference Books:

1) Jay Bailey, James Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill, 1986.
2) Michael L. Shuler and Fikret Kargi, "Bioprocess Engineering - Basic Concepts", 2/e, Prentice Hall of India (2003).
3) Michael J. Pelczar, E. C.S. Chan and Noel R. Krieg, "Microbiology Concepts and Applications", 5/e, McGraw Hill reprint 2001.
4) Syed Tanveer Ahmed Inamdar, “Biochemical Engg: Principles and Concepts” 3/e, Prentice Hall of India Learning Pvt. Ltd. (2012), New Delhi.

15UCHL703	Major Project – 1	(0-0-6) 4

Contact Hours: 72

Course Learning Objectives (CLOs):

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical			

	engineering or integrated problems (allied fields).	2,10	8, 12	6, 7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.0	3.0	2.0	3.0	1.0	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

Course Content:

The students in a group (minimum 2 and maximum 4) will be assigned an experimental, a design, a case study or an analytical problem to be carried out under the supervision of a guide. The project has to be assigned at the beginning of the VII semester or project of VI semester can also be extended here. The project group should complete the preliminary literature survey, plan of project and submit the synopsis at beginning of VII semester. After getting the approval from DUGC, the project work should be carried out in VII and VIII semester. The project report should be submitted in VII semester which includes literature survey, plan of work and any progress of the work. The final project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:

Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related fie

15UCHL704	Process Control Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. The purpose of this laboratory is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply fundamentals of industrial processes, process measurement and process control theory.	4, 15	9,10	-
CO-2	Analyse transient behavior of simple systems.	4, 15	9,10	-
CO-3	Analyse data from experiments and prepare well organized laboratory report.	4, 15	9,10	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	-	2.0	2.0	-	-	-	-	3.0

List of Experiments:

1. Step response of first order systems (Thermometer).
2. Step response for Single Tank System - first order System.
3. Step & Impulse response for two first order systems arranged in Non - Interacting mode.
4. Step & Impulse response for first order systems arranged in Interacting mode.
5. Level Control Trainer– P, PI, PD, PID action.
6. Temperature Control Trainer– ON/OFF, P, PI, PD, PID action.
7. Control Valve Characteristics.
8. Temperature sensors characteristics – RTD , Thermocouple, Thermistor.
9. Characteristics of Temperature Transmitter.
10. Characteristics of I/P and P/I converters.
11. Analysis of Flapper-Nozzle system.

Note: Minimum 10 experiments to be conducted.

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Reference Books:

1) Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2) Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.

15UCHL705 Computer Applications in Chemical Engineering and Simulation Laboratory (0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To make the students understand physical systems in chemical engineering and using C program to develop models and solutions for these models.
2. The students will also learn to use the commercial process simulations using simulation software.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) /PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Solve Chemical Engineering problems using the analytical methods and programming.	4, 5,15	10	9
CO-2	Compute the chemical engineering problems with nonlinear-algebraic equations.	4, 5,15	10	9
CO-3	Compute the chemical engineering problems with Numerical Integration	4, 5,15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	3.0	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – Simpson's1/3 rule.
6. Curve fitting – Least square method
7. Double pipe heat exchanger (Area, Length)
8. Bubble and dew point calculation.
9. Introduction to Unisim design Software
10. Simulation studies of flash drum
11. Simulation studies of CSTR
12. Simulation studies of Heat Exchanger.
13. Simulation studies of Mixer

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jenson, V.J. and Jeffereys, G.V., "Mathematical Methods in Chemical Engineering", Academic Press, London and New York, 1977.
2) Mickley, H.S., Thomas. K. Sherwood and Road, C.E., "Applied Mathematics in Chemical Engineering", Tata McGraw-Hill Publications, 1957.
3) S. Pushpavanam, "Mathematical Methods in Chemical Engineering", PHI
4) E. Balagurusamy, "Programming in ANSI C", 6/e, TMH 2012.
5) Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.
6) William L. Luyben, "Process modeling, simulation and control for Chem. Engg.", Mc. Graw Hill, 1990.

15UCHE706	Pilot Plant and Scale up Methods	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results, and apply process scale-up methods.
2. To study proper designs, modeling and processing and the importance of the process geometry.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and explain the need for pilot plant and its demonstration with economic evaluation.	3	-	14
CO-2	Identify and develop different models and similarity studies for scale up methods.	5	2	13
CO-3	Explain and compare the different concepts of regime in scale up studies.	3	2	13
CO-4	Interpret and analyse different approaches for scale up studies in chemical engineering mixing system.	2, 3	5	13, 14
CO-5	Interpret and analyse different approaches for scale up studies in heat and mass transfer system.	2, 3	5	13, 14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.5	3.0	-	2.3	-	-	-	-	-	-	-	1.0	1.0	-

Course contents:

Unit-I

Introduction: Process development, Need for pilot plants, Scale-up procedures, basic terminologies- prototypes, models, scale ratios and elements. Major issues, fundamental principles, Demonstration, Economic evaluation of scaling up. **10 Hrs.**

Unit-II

Dimensional Analysis and Principles of Similarity: Significance of Dimensionless Numbers**,** Generalized dimensionless equations from Differential equation for static systems, flow systems, thermal systems, mass transfer processes, Homogeneous and heterogeneous chemical processes. **Principles of Similarity:** Geometric similarity, Distorted similarity, Static, dynamic, kinematics, thermal and chemical similarity with examples. **12 Hrs.**

Unit-III

Regime: Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects. **10 Hrs.**

Unit-IV

Scale up of Mixing Process and Chemical Reactors: Mixing Processes: Scale-up relationships, Scale-up of polymerization units, Continuous stages gas liquid slurry processes. Fluid-fluid Reactors: Scale-up considerations in packed bed absorbers and bubble columns, Applicability of models to scale-up. **10 Hrs.**

Unit-V

Scale up of Mass and Heat Transfer Processes: Continuous Mass Transfer Process: Fundamental considerations scale-up procedure for distillation, Absorption, Stripping and extraction units. Scale up of momentum and heat transfer systems.

10 Hrs.

Reference Books:

1) Attilio Bisio, Robert L. Kabel, “Scale up of Chemical Processes”, John Wiley Interscience publication, 1985.
2) Ibrahim and Kuloor, “Pilot plant and Scale up Studies”.
3) Johnstone and Thring, “Pilot Plants Models and scale up method in Chemical Engineering”, McGraw Hill, 1962.
4) Marko Zlokarnik, “Dimensional Analysis and Scale-up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986.

15UCHE707	Transport Phenomena	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide basic understanding of laws governing transport processes and effect of various parameters.
2. To provide an understanding of steady state shell balances for velocity, temperature and concentration distribution under laminar flow.
3. To deal with equations of change and analogies amongst transport processes along with their applications

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	State laws of momentum, energy and mass transport. Discuss effect of temperature and pressure on transport properties of fluid.	1	-	-
CO-2	Formulate velocity distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-3	Formulate temperature distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-4	Formulate concentration distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-5	Apply equations of change for isothermal systems and write analogies between momentum, heat and mass transport problems.	-	2, 3, 13	1

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	1.4	2.0	2.0	-	-	-	-	-	-	-	-	-	2.0	-	-

Course content:

Unit-I

Introduction: Importance of transport phenomena in chemical engineering, Momentum, Energy and Mass transport, Newton's law of viscosity, Newtonian and Non-Newtonian fluids. Fourier's law of heat conduction, Ficks law of diffusion, effect of temperature and pressure on transport properties of fluids. Numerical problems using all law. **10 Hrs.**

Unit-II

Velocity Distribution in Laminar Flow: Steady state shell momentum balance, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through circular tube, flow through annulus, flow between parallel plates and slit. Numerical problems using the equation derived above. **11 Hrs.**

Unit-III

Temperature Distribution in Laminar Flow: Steady state shell balance, boundary conditions applicable to energy transport problems, heat conduction through compound walls, heat conduction with internal generation by electrical source, nuclear and viscous energy sources. Heat conduction in a cooling fin, Forced and free convection heat transfer. Numerical problems using equation derived above. **11 Hrs.**

Unit-IV

Concentration Distribution in Laminar Flow: Steady state shell balance, Boundary conditions applicable to mass transport problems, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion, Diffusion into falling film, Forced convection mass transfer, Diffusion with homogeneous and heterogeneous reaction. Numerical problems using the equation derived above. **10 Hrs.**

Unit-V

Equation of Change of Isothermal Systems: Non isothermal systems and Multicomponent systems. Application of these equations in solving steady state problem. **Analogies and Navier Stokes Equation:** Simple numerical problems on it. Analogies between Momentum, Heat and mass transport and their numerical problems. **10 Hrs.**

Reference Books:

1) Bird, Stewart and Lightfoot, “Transport Phenomena”, John Wiley, 2/e. 1994.
2) Robert Brodkey and Henry C. Hershey, “Transport Phenomena Unified Approach”, International Edition- 1988. ISBN-10: 0070079633
3) Bennet and J. E., “Momentum Heat and Mass Transfer”, Myer- McGraw Hill. 3/e. 1982.
4) Suryavanshi and Dongre, “Transport Phenomena”, Nirali Prakashan. 7/e. 2012. ISBN: 978-81962-56-5.
5)

15UCHE708 Process Modeling and Simulation in Chemical Engineering (4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To study basic concepts of modeling and formulation of mass and energy balance relationships and thereby it helps for the development of complex models.
2. To understand the advanced technologies in simulation field and the

applicability in industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain and apply the different fundamentals to develop the models for chemical engineering system.	1,3	2	5
CO-2	Interpret and develop different mathematical methods for chemical engineering system.	3,13	1, 2	5
CO-3	Apply and assess different relevant software and models for solving chemical engineering problems.	5, 13	2,3	-
CO-4	Identify the different simulation tools and Ability to solve chemical engineering problems using numerical techniques	5, 13	2,3	-
CO-5	Demonstrate and analyse the different model solving ability for various chemical engineering process.	5, 13	2, 3	-

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	2.5	2.0	2.4	-	2.2	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Modeling in Chemical Engineering: Introduction, Principles of Formulation, Fundamental laws; Continuity Equation, Energy Equation, Equation of motion, Transport Equations, Equation of States, Equilibrium, Chemical Kinetics, Classification of Mathematical models. **10 Hrs.**

Unit-II

Numerical Techniques: Iterative convergence methods like bisection and secant method, Newton raphson method, Numerical integration of ordinary differential equations like Euler and Runge Kutta method. Numerical solution of partial differential equations of first order approximation with examples. **12 Hrs.**

Unit-III

Models in Chemical Engineering: Introduction, Series of Isothermal, Constant-Holdup CSTRs, CSTRs with Variable Holdups, Two Heated Tanks, Gas-Phase, Pressurized CSTR, Non-isothermal CSTR, Single-Component Vaporizer, Multicomponent Flash Drum, Batch Reactor, Reactor With Mass Transfer, Ideal Binary Distillation Column, Multicomponent Non-ideal Distillation Column Batch Distillation With Holdup. **14 Hrs.**

Unit-IV

Computer Simulation: Introduction to Simulation, Role of Computers and Numerical Methods in simulation, Iterative convergence methods, Explicit Convergence methods, Explicit Numerical Integration algorithm, Implicit Methods, Numerical examples. **08 Hrs.**

Unit-V

Specific Simulation/ Model Development: Batch reactor, CSTR, Bioreactor, activity coefficient models, Distillation and equilibrium Flash vaporization. **08 Hrs.**

Reference Books:

1) William L. Luyben, "Process modeling, simulation and control for Chem. Engg.", Mc. Graw Hill, 1990.
2) Edger TF and Himmelblau D M, "Optimization of chem. Process" Mcgraw Hill, 1989.
3) Asghar Hussain, "Chemical process simulation", Wiley Eastern Ltd, 1986.
4) Roger G.E Franks, "Modeling and Simulation in Chemical Engineering" Wiley Inter science. New York, USA, 1972.

15UCHE709	Novel Separation Techniques	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide an understanding of novel/newer separations using mass transfer and thermodynamic considerations.
2. To provide an understanding of their applications at different levels in industry, viz. refineries, biochemical processing, pharmaceuticals, gaseous separations, metallurgical etc.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the use of separation factors and understand continuous adsorption processes with advanced chromatographic techniques.	4, 14	-	-
CO-2	Classify membrane based separations and explain their mass transfer and thermodynamic	-	4,12	-

	considerations with applications.			
CO-3	Explain the surfactants based micellar and foam separations with applications.	14	4, 12	-
CO-4	Describe Super Critical Fluid Extraction process with applications.	-	4, 12	14
CO-5	Explain the processes of gaseous diffusion, thermal diffusion, and electrophoresis.	4	-	14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO-14	PSO -15
Mapping Level	-	-	-	2.4	-	-	-	-	-	-	-	2.0	-	2.0	-

Course content:

Unit-I

Introduction to separations: Importance, principles and separation factors, economic significance etc.

Adsorptive Separations: Thermal swing adsorption, gradient chromatography, Ligand chromatography and unsteady state fixed bed adsorption etc. **11 Hrs.**

Unit-II

Membrane Separation Processes: Classification, structure and characteristics of membranes, membrane modules, concentration polarization and fouling of membranes, R.O., U.F, Pervaporation, and gaseous separations. **11 Hrs.**

Unit-III

Surfactant Based Separations: Fundamentals of surfactants at surfaces and in solutions. Liquid membrane permeation, foam separations, micellar separations. **10 Hrs.**

Unit-IV

Super Critical Fluid Extraction: Physicochemical principles, thermodynamics, process description. Applications and case study. **10 Hrs.**

Unit-V

Miscellaneous Separations: Gaseous diffusion, Thermal diffusion, electrophoresis and types. **10 Hrs.**

Reference Books:

1) P.C. Wankat, “Large scale adsorption chromatography” CRC Press,1986.

2) R.W. Rousseu, "Handbook of separation process technology", John Wiley and sons 1987.
3) S.Sourirajan and T. Matsura, "Reverse osmosis and Ultra filtration process principle", NRC publication Ottawa, 1985.
4) Richard Baker, "Membrane Technology and Applications", 2/e, ,John Wiley and Sons Ltd.

15UCHE710	Wastewater Treatment and Engineering	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To create awareness on the water pollution aspects and understand the kinetics and the designing system of the plant.
2. To understand the different parameters, treatment methods and control techniques of water pollution.

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will be able to		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Cognize the different regulatory standards with design criteria for environmental parameters	-	14	3, 6, 7
CO-2	Understand the microbiology of waste water and determine the growth and kinetic constant	3, 6, 7	14	-
CO-3	Identify the physical treatment system and design the sewer system for the local region.	14	3, 6, 7	-
CO-4	Identify and Design the secondary treatment plant system for any Industry.	14	3, 6, 7	-
CO-5	Design the treatment plant for tertiary treatment system based on the fundamentals studies of waste water.	14	3, 6, 7	-

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO -9	PO -10	PO -11	PO -12	PSO -14	PSO -15	PSO -16
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	2.6	-	-

Course Content:

Unit-I

Objectives of Wastewater Treatment: Flow measurements and Composition. Characterization: properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. State and central standards for Effluent discharge to water bodies and land applications. **10 Hrs.**

Unit-II

Microbiology of Waste Treatment: Growth and inhibition of bacteria. Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization. Effects of endogenous metabolism and kinetics Manod's and Michaclis menton kinetics and their applications. Determination of kinetic coefficients. **11 Hrs.**

Unit-III

Sewerage System- Design of Sanitary Sewer: Sewerage System- Design of storm water sewers, Physical and Chemical treatment of wastewater, Screens, Commuters, Grit chambers, Sedimentation Chemical treatment. **10 Hrs**.

Unit-IV

Biological Treatment Process: Activated sludge process standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds Treatment disposal of sludge- Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation. **11 Hrs.**

1

Unit-V

Advanced Waste Water Treatment: Introduction, Need of Advanced Waste Water Treatment, Purpose of Advanced Waste Water Treatment. Nitrogen & Phosphorus Nitrogen Removal: Nitrification, Denitrification Simultaneous nitrification and denitrification Phosphorus Removal. Membrane Bioreactor with Membrane Module Submerged in the Bioreactor. Electro-coagulation: Factors affecting Electro coagulation, Electrode materials, Reactor configurations. **10 Hrs**.

Reference Books:

1) Metcalf and Eddy. “Waste water Engineering: Treatment and Reuse”. McGrew Hill Publication. ISBN-10: 9780070495395. 4/e. 2017
2) A. F. Gaudy and E. T. Gaudy. “Microbiological for environmental Scientist and engineers”. McGraw Hill 1/e. 1980.
3) T. McGhee. “Water Supply and Sewerage”, McGraw Hill. 6/e. 1991. ISBN-10: 0070609381
4) G. S. Bridie and J.S. Brides. “Water Supply and Sanitary Engineering”. Dhanpat Rai & Sons 2010. ISBN-10: 8187433795.

VIII Semester

15UCHC800 Process Engineering Economics and Management (4–0–0)4

Contact Hours: 52

Course Learning Objective (CLO):

1. Prepare the students to analyse cost/revenue data and carry out economic analysis in the decision-making process to justify alternatives/projects on an economic basis and prepare to function in the business and management side of professional engineering practice.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1,12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the concepts of plant location, layout, and feasibility survey and perform cost estimation.	-	9,10	12
CO-2	Apply economic concepts viz. depreciation, cash flow, profitability, replacement, breakeven analysis etc. in solving chemical engineering problems.	10,11	9,14	12
CO-3	Interpret production management with its virtues inclusive of automation, work study and method study applied to a chemical industry.	10,11	9,14	12
CO-4	Interpret material management with its virtues inclusive of value engineering applied to a chemical industry.	10,11	9	12
CO-5	Interpret marketing management with its virtues inclusive of product life cycle applied to a chemical industry.	10, 11	9	12

POs/PSOs	PO-1	PO-2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.8	3.0	1.0	-	2.0	-

Course content:

Unit-I

Introduction Importance of economics and management, plant location and plant layout, feasibility survey.

Cost Estimation Factors involved in project cost estimation, methods employed for the total cost estimation, Cost Index. **12 Hrs.**

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Unit-II

Depreciation: Different methods of Depreciation. Time value of money and its equivalence. Cash flow diagrams. Taxes and Insurance.

Profitability and Methods of Evaluation: Replacement and alternative investments. Break even analysis. Financial statements. **12 Hrs.**

Unit-III

Production Management: Types of production and planning, manufacturing planning, factory planning, production planning, schedule, work study, method study, incentives and bonus, Automation. Organization of production, planning and control department. **10 Hrs.**

Unit-IV

Material Management: Functions of purchasing. Quality standards and Inspection. Sources of supply, Inventory management. ABC analysis, EOQ model. Value analysis and engineering. **09 Hrs.**

Unit-V

Marketing Management: Functions of marketing, marketing and sales, marketing engineer, and Market research. Product life cycle, Promotion of sales. Pricing methods, advertisements etc. **09 Hrs.**

Reference Books:

1) Peters and Timmerhaus, “Plant design and Economics for Chemical Engineers”, McGraw Hill, 1991.
2) Banga and Sharma, “Industrial Organization and Engineering Economics”, Khanna Publications, 1999.
3) Tripathi and Reddy, “Principles of Management”, 5/e, Tata McGraw-Hill Education, 2004.

15UCHL801	Seminar	(0-0-3)2

Contact Hours: 40

Course Learning Objectives (CLOs):

1. To provide platform to focus on knowledge of technical data collection, communication skills and report writing.
2. To develop intellectual and professional competence and work on the chosen topic to improve skills in writing and oral presentation.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) /PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review and acquire knowledge on the chemical engineering topic outside the scope of curriculum	14	6,7,8,9,12	4, 5
CO-2	Outline and consolidate the required information on chosen topic	9	6,7,8	-
CO-3	Organize the technical matter in the required format and compile the same	12	9	-
CO-4	Interpret and communicate the topic with proper justification and conclusion	9, 10	-	-

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	-	-	-	1.0	1.0	2.0	2.0	2.0	2.5	3.0	-	2.5	-	3.0	-

Course content:

Seminar should be based on a detailed study of any topic related to Chemical Engineering (preferably the advanced areas / application) and the topic should preferably be relevant to the curriculum. Students may undertake studies in research survey, literature review and analysis, synthesis, design and development, generation of new ideas and concept, modification in the existing process/system, development of computer programs, solutions, modeling and simulation related to the subject. Topics of interdisciplinary nature may also be taken up. A detailed literature survey is expected to be carried out as a part of the work.

A technical report is required to be submitted at the end of the term and a presentation made based on the same. It is expected that the student collect information from reference books, standard journals. The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow. The discussion and conclusions shall form the last part of the text.

The seminar shall be evaluated with due weightage on:

Topic-10%

Literature survey-25%

Report-20%

Presentation-25%

Conclusion and querries-20%

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Reference Books/Material:

Offline/online chemical engineering and its related field Journals.

Books in the area of chemical engineering and its related field.

15UCHL802	Major Project – 2	(0-0-12)10

Contact Hours: 100

Course Learning Objectives (CLOs):

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) /PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical engineering or integrated problems (allied fields).	2,10	8, 12	6, 7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.0	3.0	2.0	3.0	1.0	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

Course Content:

The project has been assigned at the beginning of the VII semester. The project group would have carried out the preliminary literature survey, plan of project and submitted the synopsis in the VII semester. After the approval from DUGC, the left project work should be carried out and completed in the VIII semester. The detailed project report should be submitted along with the presentation on the work carried out at the end of VIII semester.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
Offline/online chemical engineering and its related field Journals.
Books in the area of chemical engineering and its related field.

15UCHE803	Solid Waste Management	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide students with a comprehensive understanding of integrated solid waste management from an environmental and public health perspective.
2. To study the detailed engineered system of solid waste management system.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the components and characteristics of a solid waste management system.	6	7	3
CO-2	Identify the various collection, transfer and transport mechanisms of municipal solid waste management.	6	3,7	-
CO-3	Explain various processing, material and energy recovery facilities.	14	3	
CO-4	Describe different methods and safety precautions used in disposal of MSW.	6,7	14	
CO-5	Explain types of hazardous solid waste and Discuss safe methods of disposal of hazardous waste & their management principles.	6,7	14	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	1.5	-	-	3.0	2.5	-	-	-	-	-	-	2.3	-

Course content:

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Unit I

Introduction to Solid Wastes: Definition, Characteristics, Types of solid waste, Physical, Chemical and Biological properties of Municipal Solid Waste, Overview of materials flow in society and 4R concept of solid waste management. Evolution of SWM, Effect on health and environment. Legislation and government agencies. **10 Hrs.**

Unit II

Engineered Systems for Solid Waste Management: Generation of solid waste, Quantities of solid Waste, Methods to measure solid waste quantities, Solid waste generation and collection, Factors affecting solid waste generation rate, Onsite handling, Storage and Processing, Transfer and transport, Collection system and devices. **12 Hrs.**

Unit III

Processing Techniques and Recovery of Energy: Objectives of waste processing, component separation and volume reduction, various processing technologies — biological and chemical conversion methods, Composting, Factors affecting composting, Aerobic composting and anaerobic Digestion, Details of energy recovery system, heat recovery, gasification, pyrolysis and refuse derived fuels (RDFs). Municipal incinerators, Grates, Furnances of solid waste. Recovery, Material and Energy recovery operations. **12 Hrs.**

Unit IV

Disposal of Solid Wastes: Various disposal methods, landfills — site selection, site infrastructure, essential components of landfill; types of landfilling methods, landfill planning –leachate management and gas control; Environmental monitoring systems for landfill sites, closure and post-closure plans for landfills, landfill site rehabilitation, reclamation and remediation. **10 Hrs.**

Unit V

Hazardous Wastes: Definition, identification and classification of hazardous solid waste, Origin and reduction at source, Collection and handling, Management issues and planning methods, Environmental Act, E-waste handling and disposal.

Industrial Solid Waste Management: Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units. **10 Hrs.**

Reference Books:

1) George Tchobanoglous, “Integrated Solid waste Management-Engineering Principles and Management issues”, McGraw Hill, 1993.
2) Howard Peavy, “Environmental Engineering”, McGraw Hill,1986.

3) Dutta, "Industrial Solid waste Management and landfilling practice", Narose Publication, 1999.

15UCHE804	Instrumental Methods of Analysis	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the principles and concepts behind the qualitative and quantitative analysis of molecules and compounds using instrumental methods with their applications.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain and analyse Flame photometry and AAS techniques and its application.	-	2	1
CO-2	Explain and analyse the electrochemical techniques and its application	-	2	1
CO-3	Identify the concepts for analysis of molecules and compounds using instrumental methods.	1	-	-
CO-4	Interpret and analyse the different spectroscopic techniques.	1	-	-
CO-5	Explain and analyse the chromatography technique and its applications	1	-	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.2	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisite: Chemistry and Fundamentals

Course content:

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Unit-I

Introduction to Flame Photometry and Atomic Absorption Spectroscopy: Introduction, Principle, Flame and flame spectra, variation of emission intensity with flame, Metallic spectra in flame, flame ground, Role of temperature on absorption emission and fluorescence. Comparative study of Flame Emission ectroscopy (FES) and Atomic Absorption Spectroscopy (AAS) Instrumentation and Applications. Qualitative and titative determination of alkali and alkaline earth metals. **11 Hrs.**

Unit-II

Electrochemical Techniques: Introduction to Electrochemistry, Electrode Potential, Measurement, sign convention, Standard electrode potential, Cell Potential: Liquid junction potential, Effect of current. Polarization: Sources, over voltage, concentration polarization, Mechanism of mass transport. Potentiometric Methods: reference Electrodes- calomel electrode Ag- Agcl (s) electrode, Hydrogen electrode, Potentiometric titrations and applications. Membrane Electrodes: Classification of properties, Principle design, theory of ion selective electrodes Membrane potential, Selectivity, Crystalline liquid membrane and electrodes. **11 Hrs.**

Unit-III

Nuclear Magnetic Spectroscopy: Introduction, Chemical shifts, Mechanism of shielding and deshielding. Types of nuclei, Theory of population of nuclear magnetic energy levels, Spin –spin coupling, Rules of governing the interpretation of first order spectra, Low and high resolution NMR, Instrumentation and application to structure elucidation of simple organic molecules. **10 Hrs.**

Unit-IV

Mass Spectroscopy: Introduction, theory, Instrumentation of mass spectrometer, Methods of generation of positively charged ions, Mass analyzers, Resolving power, Molecular ion peak, Base peak, Metastable peak, Modes of fragmentations, Application of mass spectrometry in Qualitative and Quantitative analysis. Structural elucidation of simple organic molecules **10 Hrs.**

Unit-V

Chromatography: Introduction to chromatographic techniques, General descriptions, definitions, terms and parameters used in chromatography. Classification of chromatographic methods, working principles, Instrumentation and applications of Thin layer chromatography (TLC), Gas chromatography(GC), High pressure liquid chromatography (HPLC). **10 Hrs.**

Reference Books:

1) Jaffery, G.H., Basset, J., et. al., “Vogel’s Text book of Quantitative Inorganic Analysis”, 5/e, ELBX, 1998.
2) Skoog, D.A., “Principles of Instrumental Analysis”, 3/e, Saunders College publishing, 1985.
3) W.H. Willard, “Instrumental Methods of analysis”, 7/e, L.L., Merritt and J.A. Dean, 1988.

4) B.K. Sharma ,“Instrumental Methods of Chemical Analysis”, Goel Publishing House Meerut, 2000.

15UCHE805	Sugar Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the different processing methods practiced for production of sugar. Learn about the extraction and production of sugar, learn different unit operation and unit process application with practical difficulties encountering during process along with its remedies.

Course Outcomes (COs):

Description of the course outcomes: At the end of the course student will be able to		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Relate the Indian Sugar industry and World scenario	-	6	7, 14
CO-2	Analyze Working, operation and performance of sugar production process.	-	2	1
CO-3	Identify various equipments for sugar production.	-	14	-
CO-4	Formulate a system to meet the needs considering the constraints of economics, safety and environmental problems associated with sugar industry.	3, 14, 6	7	-
CO-5	Identify the various means of cogeneration and its importance on economy of sugar industry.		2	13, 14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	2.0	3.0	-	-	2.5	1.5	-	-	-	-	-	1.0	1.75	-

Course content:

Unit- I

Sugar Industry in India: Chemical and physical properties of sucrose and reducing sugars. Sources of sucrose, formation of sucrose plants, non sugar compounds of sugarcane, inorganic constituents of sugar cane juices and sugars analytical used in sugar industry. **10 Hrs.**

Unit- II

Purification: Technology of the purification process, fundamental reactions and physical chemistry aspects of clarification, liming, Sulphitation and carbonation process, filtration of sugar juices. **10 Hrs.**

Unit- III

Unit Operations: Evaporation of sugar juice, heat transfer in evaporators, evaporation equipment and auxiliaries. Crystallography: solubility of sucrose, theoretical aspects of crystal growth, factors influencing rate of crystallization, control methods and equipment in sugar crystallization, technology of sugar crystallization, boiling scheme of crystallization Centrifugation: theory of the centrifugal process, centrifugal operation, engineering principles of sugar centrifugals, and the centrifugal equipment and auxiliaries, grading of sugar.

12 Hrs.

Unit- IV

Distillery: Production of final molasses and molasses's utilization and storage. Molasses characteristics for alcohol. Fermentation methodology for alcohol production, factors influencing the production. Distillation methods used in separation process, Design consideration for distillation column. **10 Hrs.**

Unit- V

Co-generation: Types of co-generation methods, quality of bagasse used, different types of boilers used and efficiency, factors influencing the operation, methods of obtaining steam, and quality of steam

Environmental Management Plan: Pollution control measures for water, air, solid waste, noise in sugar industries. **10 Hrs.**

Reference Books:

1) Honing P (Ed), "Principles of Sugar Technology", Vol I to III, Elsevier publishing company, 1953.
2) Jenkinos. G.H., "Introduction to cane sugar Technology", Elsevier, 1966.
3) Mathur.R.B.L, "Handbook of cane Sugar Technology", 2/e, Oxford and I.B.H. Publishing Co., 1997.
4) R.K. Rajputh, "A text book on Power Plant Engineering", 2/e, Laxmi publications (p) Ltd., New Delhi, 2001.

15UCHE806	Bioprocess Engineering	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide the students with the basics of bioreactor engineering.
2. To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts and cell lines and other process criteria.	-	3, 7	2
CO-2	Design and analyse the scale up criteria for the different bioreactors.	5	2, 3, 7	-
CO-3	Understand the enzyme kinetics and design the immobilized enzyme bioreactors.	13	3, 7	-
CO-4	Apply modeling and simulation of bioprocesses so as to reduce costs and to enhance the quality of products and systems.	5	3, 7	-
CO-5	Identify the different cell cultivation system to apply in the different bioreactors.	13	3, 7	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	1.5	2.0	-	3.0	-	2.0	-	-	-	-	-	3.0	-	

Prerequisite: Biochemical Engineering

Course content:

Unit-I

Operational Modes of Bioreactors: Fed batch cultivation, Cell recycle cultivation, Cell recycle cultivation in waste water treatment, two stage cultivation. Packed bed reactor, airlift reactor, fluidized bed reactor and bubble column reactor. **10 Hrs.**

Unit-II

Bioreactor Scale-Up: Regime analysis of bioreactor processes, oxygen mass transfer in bioreactors microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. **12 Hrs.**

Unit-III

Bioreactor Consideration in Enzyme Systems: Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors. **10 Hrs.**

Unit-IV

Modeling and Simulation of Bioprocesses: Study of structured models for analysis of various bioprocess – compartmental models, models of cellular energetic and metabolism, single cell models, plasmid replication and plasmid stability model. Dynamic simulation of batch, fed batch, steady and transient culture metabolism. **10 Hrs**

Unit-V

Recombinant Cell Cultivation: Different host vector system for recombinant cell cultivation strategies and advantages. E.coli, yeast Pichia pastoris/ Saccharomyces cereviseae, Animal cell cultivation, plant cell cultivation, Insect cell cultivation. High cell density cultivation, process strategies, reactor considerations in the above system. **10 Hrs.**

Reference Books:

1) Jens Nielson, John Villadsen and Gunnar Liden, “Bioreaction engineering principles”, 2/e, Kulwer Academic, 2002
2) Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, 2/e, CRC press, London. 1995.
3) James E. Bailey and David F. Ollis, “Biochemical Engineering Fundamentals”, 2/e, McGraw Hill. Singapore. 1986
4) Atkinson, B, Mavituna, F, “Biochemical Engineering and Biotechnology Handbook” 2/e, Macmillan Publishers Ltd, New York, 1992.

15UCHE807	Unit Processing in Organic Synthesis	4-0-0(4)

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To study the fundamental concepts of Industrial Chemistry and theirapplications.
2. To have knowledge on various reaction mechanisms, preparation of organiccompounds, classification of the compounds etc

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	To apply basic knowledge of chemical processes and equations to	1	2	-

	solve numerical problems.			
CO-2	To converge the concepts of chemical processes of sulphonation for industrial products	1	-	-
CO-3	To elaborate halogenations its process, kinetics and interpret it for modern industrial processes.	1	-	-
CO-4	To correlate oxidation and analyze various unit processes of many organic compounds for improvement of existing techniques for the preparation of better yield and quality	1	-	-
CO-5	To evaluate hydrogenation reaction and processes with mechanisms for innovative industrial products	-	2	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisite: Basic Chemistry

Course content:

Unit-I

Introduction: Unit processes and principles of thermodynamics and kinetics related to unit processes. Nitration: Introduction, nitrating agents, aromatic nitration, thermodynamics, kinetics and mechanism, nitration of paraffin hydrocarbon, Mixed acid for nitration, process equipment for technical nitration typical industrial nitration processes (nitrobenzene). **11 Hrs.**

Unit-II

Sulfonation: Introduction, sulfonating agents and their application, chemical and physical factors, kinetics mechanism and thermodynamics of sulfonation, industrial equipments for batch and continuous processes industrial processes (Monosulphonation of benzene, detergent alkylate). **11 Hrs.**

Unit-III

Halogenation: Introduction survey of halogenation processes thermodynamics and kinetics, chlorination in presence of catalyst, photo halogenation, industrial equipment for halogenation, typical processes (Chlorobenzene). **10 Hrs.**

Unit-IV

Oxidation: Types of oxidative reactions, oxidizing agents. Typical liquid phase oxidation processes, vapor phase oxidation of aromatic compounds. Industrial processes (styrene from ethyl benzene, acetaldehyde to acetic acid.) **10 Hrs.**

Unit-V

Hydrogenation: Introduction, methods of hydrogen production, general principles relating to hydrogenation catalysts, kinetics and thermodynamics, industrial apparatus for hydrogenation and typical examples of hydrogenation processes (Hydrogenation of oils and fats). **10 Hrs.**

Reference Books:

1) P. H. Groggins. "Unit Processes in Organic Synthesis ", 5/e, Tata Mc Graw Hill, 1995.
2) Kirk R. E. Othmer D. F. "Encyclopedia of Chemical Technology", Inter Science Publishers.
3) Bahl and Bahl, "Organic Chemistry", Chand Publications, New Delhi.

Academic Program: UG

(under NEP 2020)

Academic Year 2021-22

Syllabus

I & II Semester B.E.

(Common to all branches)

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution approved by AICTE & Affiliated to VTU, Belagavi)

Ph: 0836-2447465, 2255619 **Fax: 0836-2464638** **Web:** www.sdmcet.ac.in

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SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabi for I & II semester of UG program common to all branches of Engineering is recommended by Board of Studies of Basic Sciences & Joint Board of Studies involving members from various Engineering Departments and approved in 24th Academic Council meeting by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabi will be in force from the academic year 2021-22 till further revision.

Chairman BoS **Principal**

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College Vision and Mission

Vision:

To develop competent professionals with human values.

Mission:

1. To have contextually relevant Curricula.
2. To promote effective Teaching Learning Practices supported by Modern Educational Tools and Techniques.
3. To enhance Research Culture.
4. To involve Industrial Expertise for connecting classroom content to real life situations.
5. To inculcate Ethics and impart soft-skills leading to overall Personality Development.

SDMCET- Quality Policy

- In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Programme Outcomes (POs):

PO 1. **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

PO 2. **Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3. **Design/Development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5. **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6. **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7. **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. **Individual and Team work:** Function effectively as an individual and as a member or leader in diverse teams and individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11. **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12. **Life-long Learning:** long learning: Recognize the need for and have the Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

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I semester B. E. (Common to all Branches)

Physics cycle

Course Code	*Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	**Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
21UMAC100	BS	Engineering Mathematics-I	2 - 2 - 0	3	50	100	3	-	-
21UPHC100	BS	Engineering Physics	3 - 0 - 0	3	50	100	3	-	-
21UEEC100	ES	Basic Electrical Engineering	3 - 0 - 0	3	50	100	3	-	-
21UCVC100	ES	Elements of Civil Engineering and Mechanics	3 - 0 - 0	3	50	100	3	-	-
21UMEC100	ES	Elements of Mechanical Engineering	2 - 0 - 0	2	50	50	2	-	-
21UHUC100	HU	Functional English	1 - 2 - 0	2	50	50	2	-	-
21UPHL100	BS	Engineering Physics Lab	0 - 0 - 2	1	50	-	-	50	2
21UESL100	ES	Basic Engineering Skills Lab	0 - 0 - 2	1	50	-	-	50	2
21UAEE1XX	AE	Ability Enhancement Course	2- 0- 0	2	50	50	2	-	-
Total			16 – 4 - 4	20	450	550		100	

- * BS- Basic science ES- Engineering Science HU- Humanities, languages and Management AE- Ability enhancement course
- ** Semester End Examination conducted for 100 marks will be reduced to 50 marks

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Chemistry cycle

Course Code	*Course Category#	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	**Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
21UMAC100	BS	Engineering Mathematics – I	2-2-0	3	50	100	3	-	-
21UCYC100	BS	Engineering Chemistry	3-0-0	3	50	100	3	-	-
21UECC100	ES	Basic Electronics	3-0-0	3	50	100	3	-	-
21UCSC100	ES	Problem Solving & Programming in C	3-0-0	3	50	100	3	-	-
21UMGC100	ES	Engineering Graphics	2-0-0	2	50	50	2	-	-
21UCYL100	BS	Engineering Chemistry Lab	0-0-2	1	50	-	-	50	2
21UCSL100	ES	Computer Programming Lab	0-0-2	1	50	-	-	50	2
21UAEE1XX	AE	Ability Enhancement Course	2-0-0	2	50	50	2	-	-
21UHUC101	HU	Society, Environment and Engineering	2 -0-0	2	50	50	2	-	-
Total			17 - 2 -4	20	450	550		100	

- * BS- Basic science ES- Engineering Science HU- Humanities, languages and Management AE- Ability enhancement course
- ** Semester End Examination conducted for 100 marks will be reduced to 50 marks

Elective Course:

Course Code	Course Title	Credits
21UAEE100	Biology for Engineers	2

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II semester B. E. (Common to all Branches)

Physics cycle

Course Code	*Course Category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	**Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
21UMAC200	BS	Engineering Mathematics-II	2 - 2 - 0	3	50	100	3	-	-
21UPHC200	BS	Engineering Physics	3 - 0 - 0	3	50	100	3	-	-
21UEEC200	ES	Basic Electrical Engineering	3 - 0 - 0	3	50	100	3	-	-
21UCVC200	ES	Elements of Civil Engineering and Mechanics	3 - 0 - 0	3	50	100	3	-	-
21UMEC200	ES	Elements of Mechanical Engineering	2 - 0 - 0	2	50	50	2	-	-
21UPHL200	BS	Engineering Physics Lab	0 - 0 - 2	1	50	-	-	50	2
21UESL200	ES	Basic Engineering Skills Lab	0 - 0 - 2	1	50	-	-	50	2
21UAEE2XX	AE	Ability Enhancement Course	2- 0- 0	2	50	50	2	-	-
21UHUC201	HU	Society, Environment and Engineering	2 -0-0	2	50	50	2	-	-
Total			17 – 2 - 4	20	450	550		100	

* BS- Basic science ES- Engineering Science HU- Humanities, languages and Management AE- Ability enhancement course
** Semester End Examination conducted for 100 marks will be reduced to 50 marks

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Chemistry cycle

Course Code	*Course Category#	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Credits	CIE	Theory (SEE)		Practical (SEE)	
					Max. Marks	**Max. Marks	Duration in Hrs.	Max. Marks	Duration In Hrs.
21UMAC200	BS	Engineering Mathematics – II	2-2-0	3	50	100	3	-	-
21UCYC200	BS	Engineering Chemistry	3-0-0	3	50	100	3	-	-
21UECC200	ES	Basic Electronics	3-0-0	3	50	100	3	-	-
21UCSC200	ES	Problem Solving & Programming in C	3-0-0	3	50	100	3	-	-
21UMGC200	ES	Engineering Graphics	2-0-0	2	50	50	2	-	-
21UHUC200	HU	Functional English	1-2-0	2	50	50	2	-	-
21UCYL200	BS	Engineering Chemistry Lab	0-0-2	1	50	-	-	50	2
21UCSL200	ES	Computer Programming Lab	0-0-2	1	50	-	-	50	2
21UAEE2XX	AE	Ability Enhancement Course	2-0-0	2	50	50	2	-	-
Total			16 - 4 -4	20	450	550		100	

* BS- Basic science ES- Engineering Science HU- Humanities, languages and Management AE- Ability enhancement course
** Semester End Examination conducted for 100 marks will be reduced to 50 marks

Elective Courses:

Course Code	Course Title	Credits
21UAEE201	Numerical Techniques for Engineers	2
21UAEE200	Cyber Law	2

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I Semester B.E.
Detailed Syllabus

21UMAC100	Engineering Mathematics-I	(2-2-0) 3

Contact Hours: 39 CIE:50 Marks SEE:100 Marks Exam Duration:3 Hrs.

Course Learning Objectives (CLOs):
This course will enable students to master the basic tools of differential & integral calculus, differential equations and elementary Linear algebra and become skilled to formulate, solve and analyze science and engineering problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Apply** the knowledge of calculus to solve problems related to polar curves, curvature and its applications in determining the bentness of a curve.	-	-	1,2
CO-2	**Learn** partial differentiation to calculate rates of change of multivariate functions, solve problems related to composite functions, Jacobians and application such as maxima and minima.	-	-	1,2
CO-3	**Apply** the concept of multiple integration and their usage in computing the area and volumes.	-	1,2	-
CO-4	**Solve** first order linear differential equations analytically using standard methods and analyze engineering applications.	-	1,2	-
CO-5	**Compute** the solution of system of equations, Eigen values and Eigen vectors and their applications.	-	1,2	-

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POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.6	1.6										

Prerequisites: 1.Differentiation and integration of function.
2. Properties of Determinant & Matrices.
3. Elementary row/column transformations.

Contents:

Unit I

Differential Calculus-1

Polar curves-angle between the radius vector and tangent, angle between two curves, Pedal equation. Curvature and radius of curvature-Cartesian and polar forms(without proof).

Self Study: Centre and circle of curvature (formulae only).Applications to Evolute. Demonstrate curves and properties using Geogebra. **07L + 01T**

Unit II

Differential Calculus-2

Taylor's and Maclaurin's series expansions for one variable(statements only).Indeterminate forms($0\times\infty, \infty-\infty, 0^0, \infty^0, 1^\infty$).

Partial differentiation: Euler's theorem, Total derivatives, Differentiation of composite functions. Maxima and Minima for a function of two variables, Jacobians and properties (without proof).

Self Study: Method of Lagrange's multipliers with one subsidiary condition. Demonstrate Taylor's and Maclaurin's series expansions for one variable and indeterminate forms using Geogebra. **07L + 01T**

Unit III

Integral Calculus

Multiple Integrals: Evaluation of double integrals (direct examples and with region given). Evaluation of double integrals by change of order of integration and changing into polar co-ordinates. Evaluation of Triple integrals.

Self Study: Applications to find Area and Volume. **07L + 01T**

Unit IV

Beta, Gamma functions & Ordinary Differential Equations of first order

Beta and Gamma functions: Definitions, Relation between Beta and Gamma functions.

Ordinary Differential Equations of first order

Bernoulli's equation, Exact differential equations. Orthogonal trajectories (Cartesian curves) Applications of ODE's: R-C circuit
Self Study: Orthogonal trajectories (Polar curves).Applications of ODE's: R-L circuit. **07L + 01T**

Unit V

Elementary Linear Algebra
Rank of a matrix- Row Echelon form. Solution of system of linear equations – Gauss-elimination method (consistency), Gauss-Seidel iterative method. Eigen values and Eigen vectors- Rayleigh's power method.
Self Study: Test for consistency for system of linear equations. **06L + 01T**

Question Paper Pattern:

1. Each question will carry 20 marks with maximum of four sub divisions
2. Each unit will consists of two full questions.
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1. **B.S. Grewal**: Higher Engineering Mathematics, Khanna Publishers, 44^{th} Ed., 2017.
2. **E. Kreyszig**: "Advanced Engineering Mathematics", John Wiley & Sons, 10th Ed. (Reprint), 2016.
3. **B.V. Ramana:** "Higher Engineering Mathematics" 11th Edition, Tata McGraw-Hill, 2010.
4. **H.K. Dass, Er. Rajnish Verma:** "Higher Engineering Mathematics", 2^{nd} revised edition, S. Chand & company Ltd., 2012.

21UPHC100/200	**Engineering Physics**	**(3-0-0) 3**

Contact Hours: 39 CIE:50 Marks SEE:100 Marks Exam Duration:3 Hrs.

Course Learning Objectives (CLOs):
Engineering Physics course is designed to deliver optimum knowledge of materials and energy concepts. Content explores the fundamental theories, experimental demonstrations and their applications in various engineering fields. Scope of the curriculum includes the study of special theory of relativity, quantum mechanics, electrical properties of materials and photonics.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explore the basics of theory of relativity and their significance in understanding material properties.	2	1	
CO-2	Demonstrate the concept of dual natures of energy and matter, one-dimensional wave equation and its relevance in understanding quantum structures.	1	2	
CO-3	Understand the electrical properties of metals and superconductors for engineering applications.	1	2	
CO-4	Elaborate the behavior of material at nano-size and concept of semiconductors, which supports for their applications.	1	2	
CO-5	Discuss the optical phenomena *vis a vis* interaction of radiation with matter, lasing action, and the basics of optical fibers and their applications.	1		

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	2.8	2.25										

Prerequisites: Nil

Contents:

Unit I

Theory of Relativity

Classical theory of relativity-Frames of reference (Inertial and Non-inertial) and Galilean transformations. Michelson-Morley experiment, Postulates of Special theory of relativity, Lorentz transformations. Consequences of Lorentz transformations-length contraction, time dilation(twin paradox) and addition of velocities. Relativistic mass and mass- energy equivalence (qualitative).Numerical examples. **07 Hrs.**

Unit II

Quantum Mechanics

Introduction to quantum mechanics, de-Broglie hypothesis, Davisson-Germer's experiment (demonstration).Concept of phase velocity, group velocity and particle velocity (qualitative).Relation between group velocity and particle velocity.Application of de-Broglie hypothesis. Heisenberg's uncertainty principle and applications. Wave function, properties and physical significance of a wave function. Probability density and normalization of wave function, setting up of 1-dimensional time independent Schrödinger wave equation. Applications of Schrödinger wave equation – (a) Energy Eigen values and (b) Eigen functions of a particle in a one-dimensional potential well of infinite height and free particle. Numerical examples. **08 Hrs.**

Unit III

Quantum theory of Conductivity

Conductors: Review of classical free electron theory- Assumptions and failures. Quantum free electron theory (QFET) – assumptions, Distribution of electrons, Fermi level, Fermi energy, Fermi velocity, Fermi temperature, concept of density of states (in bulk), Fermi-Dirac statistics- Dependence offermi factor and Occupation of density of states on temperature. Expression for electrical conductivity, success of QFET. Numerical examples.

Superconductors: Appearance of residual resistivity in typical metal – Concept of zero resistivity and superconductivity – critical temperature, persistent current, BCS theory. Meissner effect, Critical field, Soft and Hard superconductors, Applications. **08 Hrs.**

Unit IV

Materials Science

Semiconductors: Direct and indirect band gap semiconductors, Fermi level in semiconductor, carrier concentration and electrical conductivity in semiconductors (qualitative). Hall effect– determination of Hall voltage and Hall coefficient .Numerical examples.

Nanomaterials: Introduction, size dependent properties of nanomaterials, classification – based on electron confinement, variation of DOS. Syntheses of nanomaterials by top down and bottom up approaches (one example for each). Characterization techniques (qualitative).Carbon nanostructures-Graphene, fullerene and CNTs. Applications of nanomaterials- Super-capacitors, LED and Solarcells. **08 Hrs.**

Unit V

Photonics

Laser: Basics of light amplification, Einstein's coefficients (expression for energy density), principle and operation of CO_2 and semiconductor diode laser. Applications - LIDAR, laser cooling, laser fusion.

Optical Fiber: Principles of optical fiber (total internal reflection), Angle of acceptance, Numerical aperture, Fractional Index change, V-number and Modes of propagation. Types of Optical fibers, Attenuation co-efficient and fiber losses (qualitative). Numerical examples. **08 Hrs.**

Question Paper Pattern:

1. Each question will carry 20 marks with maximum of four sub divisions.
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1) Avadhanalu and Kshirasagar, Text book of Engineering Physics, S. Chand Publishers.
2) Kenneth S. Krane,, Modern Physics, 3rd Edition, John Wiley & Sons Publishers
3) M. Ali Omar, Elementary Solid State Physics, Addison-Wesley Publishers
4) C. P. Poole, Introduction to Nanotechnology, John Wiley & Sons Publishers
5) J. C. Upadyaya, Classical Mechanics, 2nd Edition, Himalaya Publishing House

21UEEC100/200	Basic Electrical Engineering	(3-0-0) 3

Contact Hours:39 CIE: 50 Marks SEE: 100 Marks Exam Duration: 3 Hrs.

Course Learning Objectives (CLOs):

The student is expected to learn the concepts of dc circuits, magnetic circuits, fundamentals of single phase and poly phase ac systems including power factor improvement measures. They are required to understand the meaning of balanced and unbalanced supply system and different electrical loads. Further, they need to know the power apparatus viz. transformer, generator, motor etc. and be able to determine the performance and use for different applications. They are required to know the sources of energy, power flow, to develop wiring scheme, protection of the equipment and personnel safety.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Recite the electric and magnetic circuit basic laws and solve the numericals.	1		
CO-2	Describe AC fundamentals and analyze the single-phase series and parallel circuits with numericals and also know significance of PF.	1		
CO-3	Analyze the three phase circuits with numericals.	1	2	
CO-4	Exhibit the knowledge of single-phase transformers and three phase Synchronous generator with numericals.	1	2	
CO-5	Exhibit the knowledge of three phase Induction Motors with numericals and recite types of energy sources, supply systems, domestic wiring with protective features.	1	2	6, 7

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	3.0	2.0				1.0	1.0					

Prerequisites: Knowledge of Matrices, Complex numbers, Differentiation & Integration

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Contents:

Unit I

D. C. Circuits& Network Theorems: Review of basics, series-parallel network reduction and mesh analysis (maximum three mesh), Superposition & Thevenin's theorems, Relevant Numericals. **04 Hrs.**

Magnetic Circuits: Electromagnetic induction-laws and applications**,** dynamically and statically induced emf. Electromagnets-series magnetic circuit with and without air gap (leakage and fringing can be mentioned & while solving problems it can be neglected), Relevant Numericals. **03 Hrs.**

Unit II

Single phase AC Circuits: Review of AC fundamentals– definitions of RMS and Average Values, form factor, phasor algebra, j-operator. Analysis of circuits with different loads such as R-L, R-L-C connected in Séries and Parallel. Power triangle. signifiance of Power factor & its improvement using parallel capacitor, Relevant Numericals. **08 Hrs.**

Self Study: Problems on series parallel circuits and effect of power factor on electricity bill.

Unit III

Three phase Circuits: Three phase supply system-3 wire and 4 wire**,** Necessity and advantages of three phase systems, Meaning of Phase sequence. Balanced supply and load. Relationship between line and phase values for balanced star and delta connections. Power in balanced three-phase circuits, Relevant Numericals. **07 Hrs.**

Unit IV

Synchronous Generator: Principle of operation, types & constructional features, EMF equation (excluding derivation of K_d and K_p), illustrative examples. **03 Hrs.**

Self Study: Synchronization- necessity and conditions.

DC Motors: Construction of Permanent Magnet DC Motor, Principle of operation & torque equation. **02 Hrs.**

Single phase transformer: Principle, types & construction, expression for induced Emf, transformation ratio, losses and efficiency, condition for maximum efficiency (excluding derivation), voltage regulation (no derivation). Applications, Relevant Numericals. **04 Hrs.**

Unit V

Three Phase Induction Motors: Concept of rotating magnetic field, principle of operation, types, construction and working, applications of squirrel cage and slip ring motors, Motor starters- necessity & types and star delta starter, Relevant Numericals. **04 Hrs.**

Miscellaneous Topics: Sources of energy- conventional and renewable energy sources, Single line diagram of power flow from generation to consumer premises, , Fuses-need, types & selection, MCB, Earthing-need and types-pipe and plate earthing, Batteries: types, rating and applications, Study of UPS with schematic diagram. **04 Hrs.**

Self Study: load calculation of domestic installation and wiring diagram.

Question Paper Pattern:
1) Each question will carry 20 marks with maximum of four sub divisions
2) Each unit will consists of two full questions
3) Students have to answer one full question from each unit and total five questions to be answered.
4) The question paper will have built in choice in the unit.

Reference Books:
1) E. Hughes - Electrical Technology, 8th Edition, Pearson, 2006.
2) B. L. Theraja- Fundamentals of Electrical & Electronics Engineering, SChand, 2006.
3) R.L. Chakrasali- Basic Electrical Engineering, Prism Books Pvt. Ltd,Bangalore.
4) B.H. Khan- Non Conventional Energy Sources, TMH publishing, 2006.

21UCVC100/200 Elements of Civil Engineering and Mechanics (3-0-0) 3

Contact Hours:39 CIE: 50 Marks SEE:100 Marks Exam Duration: 3 Hrs.

Course Learning Objectives (CLOs):

The objectives of this course is to make students to learn basics of civil engineering concepts and infrastructure development, solve problems involving Forces, loads & moments and know their applications in allied subjects. It is a pre-requisite for several courses involving Forces, Moments, Frictional forces, Centroids and Moment of inertia.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Know basics of Civil Engineering, its scope of study, knowledge about Roads, Bridges and Dams			1
CO-2	Summarize, sketch different force systems Analyze problems related to coplanar concurrent and non-concurrent force system	1,2		12
CO-3	Comprehend the action of Forces, Moments and other loads on systems of rigid bodies and compute the reactive forces that develop as a result of the external loads	1,2		12
CO-4	Understand laws of friction and solve problems related to blocks, inter connected blocks, wedges, ladder and belt	1,2		12
CO-5	Calculate geometric properties – CG and MI of planar elements	1,2		12

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	2.6	3										1

Prerequisites:
1. Basics of trigonometry.
2. Basics of calculus.
3. Newton's laws of motion.

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Contents:

Unit I

Introduction to Civil Engineering, Scope of different fields of Civil Engineering - Surveying, Building Materials, Construction Technology, Geotechnical Engineering, Structural Engineering, Hydraulics, Water Resources and Irrigation Engineering, Transportation Engineering, Environmental

Engineering. Infrastructure: Types of infrastructure, Role of Civil Engineer in the Infrastructural Development, Effect of the infrastructural facilities on socioeconomic development of a country.
Roads: Classification of Roads and their functions
Bridges: Types of Bridges and Culverts.
Dams: Different types of Dams. **07 Hrs.**

Unit II

Analysis of Force Systems- Concurrent &Non-Concurrent System:
Concurrent Force System : Composition of forces - Definition of Resultant; Composition of coplanar - concurrent force system, Parallelogram Law of forces, Principle of resolved parts; Numerical problems on composition of coplanar concurrent force systems.
Non-Concurrent Force System: Composition of coplanar - non-concurrent force system, Varignon's principle of moments Numerical problems on composition of co planar non-concurrent Force system. **08 Hrs.**

Unit III

Equilibrium of Concurrent and Non-concurrent Forces:
Equilibrium of forces - Definition of Equilibrant; Conditions of static equilibrium for different force systems, Lami's theorem; Numerical problems on equilibrium of coplanar – concurrent and non-concurrent force systems.
Support Reaction:
Types of Loads and Supports, statically determinate beams, Numerical problems on support reactions for statically determinate beams subjected to point load, uniformly distributed loads, uniformly Varying loads and moments. **08 Hrs.**

Self-study: Types of supports- smooth, hinge, roller and fixed.

Unit IV

Friction:
Definitions: Types of friction, Laws of static friction, Limiting friction, Angle of friction, angle of repose; Impending motion on horizontal and inclined planes; Numerical Problems on single and two blocks on inclined planes. Numerical problems on Ladder and Wedge friction. **07 Hrs.**

Self-study: Lifting machines like screw jack and pulley**.**

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Unit V

Centroid and Moment of Inertia of Engineering Sections

Centroids:

Introduction to the concept, centroid of area, centroid of basic geometrical figures, computing centroid for planar areas, composite planar sections with Numerical problems.

Moment of Inertia:

Introduction to the concept, Radius of gyration, Parallel axis theorem, Perpendicular axis theorem, Moment of Inertia of basic planar figures, computing moment of Inertia for planar and composite sections. **09 Hrs.**

Self-study:Centroid and moment of inertia for built up sections

Question Paper Pattern:

1. Each question will carry 20 marks with maximum of four sub divisions
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1) Bhavikatti S. S. & Rajashekarappa K. G., "Engineering Mechanics", New Age International (P) Ltd.
2) Singer F.L., "Engineering Mechanics", Harper & Row Publication, London.
3) Ferdinand P. Beer and E. Russell Johnston "Mechanics for Engineers: Statics", McGraw-Hill Book Company, New York.
4) M.N.Shesha Prakash and Ganesh. B. Mogaveer, "Elements of Civil Engineering and Engineering Mechanics", PHI Learning, 3rd Revised edition

21UMEC100/200	**Elements of Mechanical Engineering**	**(2-0-0) 2**

Contact Hours:26 CIE:50 Marks SEE:50 Marks Exam Duration: 2Hrs.

Course Learning Objectives(CLOs):

The objectives of this course are to make the student to learn basic concepts and principles in mechanical engineering like IC engines, refrigeration and Air conditioning, Transmission of power by belt and gears, Metal cutting operations, and systems in automobiles.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the working principles of different prime movers.	-	1	2
CO-2	Describe the working principle of refrigeration and air-conditioning systems.	-	-	1
CO-3	Calculate proper size of pulleys / gears to obtain the required velocity ratio and vice versa.	-	1	2
CO-4	Describe different manufacturing processes.	-		1
CO-5	Explain different types of simple bearings and methods of lubrication.	-	-	1
CO-6	Explain the working of various systems in automobiles.	-		1

POs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisites:

Contents:

Unit I

Prime Movers: Classification of IC engines, working of 2 & 4 stroke IC engines and performance parameters.

Boiler & Turbines: Classification of turbines, Francis turbine and Pelton wheel, working of modern boiler & De' Laval Impulse steam turbine. **06 Hrs.**

Unit II

Power Transmission: Classification

Belt drives: Ratio of tensions, velocity ratio and power transmitted. (Simple Numericals).

Gear drives: Types of gears, and their application, Gear trains. (Simple Numericals). **06 Hrs.**

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Unit III

Basic Manufacturing processes:

a) Casting, Forming (forging, rolling and sheet metal work)

b) Machining – Lathe Specifications, plain & taper turning operations.
Sensitive drilling machine, reaming and boring operations. **06 Hrs.**

Unit IV

Bearings and Lubrication: Function of a bearing, bushed bearing and ball bearing.

Lubrication: Classification of lubricants, properties of lubricants, siphon wick lubricator.

Refrigeration and Air Conditioning: Principle and working of vapour compression refrigerator and window air conditioner. **04 Hrs.**

Unit V

Joining Process: Welding – Arc welding and TIG welding

Systems in automobiles-

a) Transmission system
b) Braking system
c) Steering system
d) Cooling system **04 Hrs.**

Question Paper Pattern:

1. Each question will carry 10 marks with maximum of three sub divisions
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Text Book:

1) K. R. Gopalakrishna, Sudheer Gopala Krishna and S C Sharma, "Elements of Mechanical Engineering", 30th edition, Subhas stores, 2019.

Reference Books:

1) Manglik V. K, "Elements of Mechanical Engineering", PHI Learning Pvt. Ltd., 2014.
2) K. P. Roy, S. K. HazraChoudhary and A. K. HazraChoudhary, "Elements of Mechanical Engineering", 6th edition, Media Promoters and Publishers, 2003.

21UHUC100/200	Functional English	(1-2-0) 2

Contact Hours: 26 CIE: 50 Marks SEE: 50 Marks Exam Duration: 2Hrs.

Course Learning Objectives (CLOs):
This course provides a platform to the students to enhance their English Language skills, spoken and written Communication skills and language proficiency through Language Laboratory.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Exhibit essentials of language skills and identify the nuances of pronunciation and phonetics	10		
CO-2	Implement English vocabulary and basic English grammar		10	
CO-3	Identify common errors in spoken and written communication and show familiarity with language proficiency		10	
CO-4	Use sensible writing skills through Précis/Essay/Report/Letter Writing (Personal, Official and Applications) acquire employment and workplace communication skills	10		
CO-5	Demonstrate their technical communication skills and perform well in campus selection	10		

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	-	-	-	-	-	-	-	-	-	2.6	-	-

Prerequisites: A course on English of Pre-University level

Contents:

UNIT-I

Fundamentals of Communicative English: Barriers to Effective Communicative English, Different styles in Communicative English, Interpersonal Communication

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Skills, How to improve Interpersonal Communication Skills, Developing Interpersonal Skills.
Grammar: Basic English Grammar and Parts of Speech - Nouns, Pronouns, Adjectives, Verbs, Adverbs, Preposition, Articles, Conjunctions. **06 Hrs.**

UNIT-II

Introduction to Phonetics: Speech Sounds, Vowels and Consonants - Exercises on it. Sounds Mispronounced, Silent and Non silent Letters, Homophones and Homonyms, One-word equivalents, Idioms & Phrases: Meaning & Usage in sentences (Language Lab). **05 Hrs.**

UNIT - III

Conversation and Dialogues: Question Tags, Question Tags for Assertive Sentences(Statements) – Some Exceptions in Question Tags and Exercises. Vocabulary – Synonyms and Antonyms, Exercises on it. Words formation - Prefixes and Suffixes. The Sequence of Tenses (Rules in use of Tenses) and Exercises on it. **05 Hrs.**

UNIT-IV

Writing skills: Organizing Principles of Paragraphs in Documents, Writing Introduction and Conclusion, Importance of Proper Punctuation, The Art of Condensation (Precise writing) and Techniques in Essay writing, Common Errors due to Indianism in English Communication. **05 Hrs.**

UNIT-V

Speaking Skills: Non-Verbal Communication Skills (Body Language), Presentation skills and Formal presentations by Students, Situational Dialogues (Practical Sessions by Students), Voices (Active and Passive) and Reported Speech, Listening Comprehension, Exercises on Spotting Errors, Exercises on Sentence Improvement. **05 Hrs.**

Question Paper Pattern:

1. Each question will carry 10 marks with maximum of two sub divisions .
2. Each unit consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper should have built in choice in the unit.

Text Books:

1) M.L.Tichoo, A.L.Subramanian, P.R. Subramanian. Intermediate Grammar, Usage and Composition, Orient Black Swan – 2016

2) Sanjay Kumar and PushpLata. Communication Skills, Oxford University Press - 2018.
3) Sanjay Kumar and PushpLata. Communication Skills – A Workbook, OUP – 2018

Reference Books:

1) Wren & Martin. High School English Grammar & Composition, S Chandh & Co. Ltd – 2015.
2) Meenakshi Raman and Sangeetha Sharma. Technical Communication – Principles and Practice, Third Edition, Oxford University Press 2017
3) English Language Communication Skills – Lab Manual cum Workbook, Cengage learning India Pvt Limited [Latest Revised Edition] – 2019
4) M Ashraf Rizvi. Effective Technical Communication – Second Edition, McGraw Hill Education (India) Private Limited – 2018
5) N.P.Sudharshana and C.Savitha. English for Engineers. Cambridge University Press– 2018
6) Jones “New International Business English,published. Cambridge university Press. 2003
7) John Seely. The Oxford Guide to Writing and Speaking: OUP, 2004

21UPHL100/200	Engineering Physics Lab	(0-0-2) 1

Contact Hours: 26 CIE: 50 Marks SEE: 50 Marks Exam Duration: 2 Hrs.

Course Learning Objectives (CLOs):

Engineering Physics laboratory course provides real time experience in handling equipments and measurement techniques. Experiments are designed to learn the material characterization techniques and realization of material properties. Basic objective of the course is to learn the experimental procedure and execution skills.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Develop the stepwise flowchart for the conduction of experiment	1		
CO-2	Perform the experiment and tabulate the observations.		2	

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CO-3	Obtain an expected experimental result by computing the tabulated data.	1	2	
CO-4	Interpret the experimental results and conclusions.	2		
CO-5	Understand the relevant theory.	1	2	

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	**3**	**2.25**										

Prerequisites: Nil

Contents:

1) Determination of the value of Young's modulus of the given wooden bar by single cantilever method.
2) Study of Photocell and determination of the Plank's constant.
3) To study the frequency response of series and parallel LCR circuits.
4) Determination of the Fermi Energy of a given metal.
5) Verification of Stefan-Boltzmann's Law by electrical method.
6) Determination of the energy gap of a given semiconductor.
7) Determination of numerical aperture and acceptance angle of an optical fiber.
8) Determination of the dielectric constant of a dielectric material by charging & discharging method.
9) Study of the characteristics of a given laser source using diffraction method.
10) Determination of resistivity of semiconductor using Four Probe method.
11) Study of Basic and Universal Logic gates.
12) Study of transistor characteristics.

Note: Minimum ten experiments are to be performed to complete the course.

Reference Books:

1) Edward R. Shaw, Physics by Experiment, Create Space Independent Publishing Platform, 2014.
2) Kakani S. L., Engineering Practical Physics, CBS Publishers & Distributors

21UESL100/200	Basic Engineering Skills Lab	(0-0-2) 1

Contact Hours: 25 CIE: 50 Marks SEE: 50 Marks Exam Duration: 02 Hrs.

Course Learning Objectives (CLOs):

The student is expected to acquire basic minimum engineering skills with hands on in multiple disciplines of engineering like Civil, Mechanical, Electrical, electronics, computer Science etc. Further, the student will come to know about the role of different streams of engineering in practical systems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Recite the general Engineering principles, laws and applications.		1,2	
CO-2	Perform skill exercises to implement simple engineering systems in Civil, Mechanical, Electrical, Electronics, Computer Science and demonstrate the working.	4	3	9
CO-3	Use computer skills to generate/prepare technical write up/report.			10

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	2.0	2.0	2.0	3.0					1.0	1.0		

Contents:

Skill Exercises:

1) Acquire the skills of soldering, develop scheme to charge battery employing transformer & conversion circuits and make observations using suitable display equipment.
2) Acquire the skills of setting up of simple circuits with power control, measure electrical quantities, understand electrical behavior of different types of load along with safety and protection aspects.

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3) Acquire the skills to set up a circuit to run 3 phase electrical motor and demonstrate the operation with load, record the speed and establish the relation between speed and load.
4) Acquire engineering skills to select sensors (temperature, flow, level etc.), develop an application set up to demonstrate the use of sensors.
5) To Calculate area of a given map/ plan
6) To understand and carry out plumbing activity
7) To prepare a building plan for given requirements
8) To make a fit from given raw material as given in the model drawing.
9) To make sheet metal model using GI sheet as given in development drawing.
10) Disassembling and assembling of components of a given system

Demonstration:

11) Demonstration of working of Public Address (PA) system, different electrical appliances, report generation using word, Excel and interfacing of computer peripherals (Demonstration only).
12) To determine water quality of the given sample of water
13) Demonstration of welding process

Reference Books:

1) Write up prepared by the Departments
2) E. Hughes - Electrical Technology, 8th edition, Pearson, 2006.

Mode of carrying out the skill exercises:

1. There shall be three faculty members one each from Civil, Mechanical and Circuit stream (preferably from Electrical &Electronics Engineering department) to train the students.
2. The contents are developed taking inputs from Chemical, Civil, Mechanical, E&E, E&C, Computer Science & Engg., Information Science &Engineering.
3. There shall be 10 skill exercises and 2 demonstration sessions
4. Three exercises from Civil, three exercises from Mechanical and four exercises from circuit streams form the list of 10 exercises. One each from circuits and Mechanical / Civil will form demonstration list.
5. A common facility shall be created in the department of Mechanical Engineering to carry out this course.
6. Preparation to carry out all 10 exercises shall be done and kept ready for the students to work
7. A batch of about 35 students will come to this lab once in every week during the allotted time of 2 hrs as per the time table.

8. A batch will be divided in to 10 sub batches each batch consisting of 3 to 4 students
9. All the 10 exercises shall be implemented in cyclic fashion.
10. A total of three faculty members, one each from Civil, Mechanical and Electrical will train the students in their related skill exercise.
11. The students shall prepare the report on the skill exercises conducted using word / excel (computer skills) and submit at the end of the semester for evaluation.
12. There shall be Semester End Examination consisting of one examiner from Civil, one from Mechanical and one from Electrical Engineering. Preferably the examiners shall be the faculty involved in training the students.

The students are expected to wear boiler suit and should use insulated shoes.

21UAEE100 Biology for Engineers (2-0-0) 2

Contact Hours: 26 CIE: 50 Marks SEE: 50 Marks Exam Duration: 2 Hrs.

Course Learning Objective (CLO):

To enable learners to understand the basic organization and functioning of living organisms from an engineering perspective.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Describe the fundamentals of living things.	-	-	1
CO-2	Apply the concept of plant, animal and microbial systems and growth in real life systems.	-	2	1
CO-3	Analyze the cause of symptoms, and treatment of common diseases.	-	2	1
CO-4	Comprehend on genetic and the immune system	-	2	1
CO-5	Illustrate the application of biology system in relative industries.	1,2	3	

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POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.4	2.25	2	-	-	-	-	-	-	2.6	-	-

Prerequisites: A course on Biology Preferred

Contents:

Unit-I

Introduction to Cell Biology: Need to study biology, Cell, structure types, function of prokaryote and eukaryote, cell organization cell differentiation, cell theory etc. Microbiological fundamentals (yeast, bacteria and virus) **06 Hrs.**

Unit-II

Biomolecules: Structure, classification and functions of lipid and fats proteins, enzymes, nucleic acids, vitamins, carbohydrates etc. **05 Hrs.**

Unit-III

Physiology and Human Diseases: Excretory, circulatory, respiratory, digestive and nervous system, immunology. Jaundice, cancer, diabetes, COVID-19. **05 Hrs.**

Unit-IV

Cell and Tissue Engineering: Recombinant DNA technology, stem cells genetically modified organisms, biosensors, applications. **04 Hrs.**

Unit-V

Industrial Biology: Cycles of life: Nitrogen, oxygen, carbon etc. Culture media, sterilization etc. microbes in food products, Basics of Biochips, Biofertilizer, Biofuels. **06 Hrs.**

Question Paper Pattern:

1. Each question will carry 10 marks with maximum of three sub divisions
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1. S. Thyaga Rajan, N. Selvamurugan, M. P. Rajesh, R. A. Nazeer, Richard W. Thilagaraj, S. Barathi, and M. K. Jaganathan, "*Biology for Engineers*," Tata McGraw-Hill, New Delhi, 2012.
2. Wiley, "Biology for Engineers" Wiley India Ltd.

3. Jeremy M. Berg, John L. Tymoczko and LubertStryer, “*Biochemistry*,” W.H. Freeman and Co. Ltd., 6th Ed., 2006.
4. Robert Weaver, “*Molecular Biology*,” MCGraw-Hill, 5th Edition, 2012.
5. Jon Cooper, “*Biosensors A Practical Approach*” Bellwether Books, 2004.
6. Martin Alexander, “*Biodegradation and Bioremediation,”* Academic Press, 1994.
7. Kenneth Murphy, “*Janeway's Immunobiology*,” Garland Science; 8th edition, 2011.
8. Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, “Principles of Neural Science, McGraw-Hill, 5th Edition, 2012.

Chemistry Cycle

21UCYC100/200	Engineering Chemistry	(3-0-0) 3

Contact Hours: 39 CIE: 50 Marks SEE: 100 Marks Exam Duration: 3 Hrs.

Course Learning Objectives (CLOs):

In this course, the student is expected to learn principles of electrochemistry, construction and working of advance batteries, new techniques of corrosion control, metal finishing, and alternative energy sources and their significance, determination of various parameters of water, conversion of sea water into potable, sewage management, and synthesis of industrially important polymers. The course intends to provide strong foundation on these topics to engineering students of all disciplines. Delivery of the contents will be made through lectures, demonstration and experiments. The evaluation will be carried-out through quiz, internals and end sem. examination.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Apply basic knowledge of Chemistry, and fundamental equations in solving electrochemistry numericals and in	2	1	

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CO-2	Understand appropriate techniques & modern tools to modify surface properties & analyzing coated material, their properties in controlling the corrosion.	3	1	
CO-3	Analyze the water sample parameters & identify the impurities and its effects. Able to design process for purification of water towards the safety of health and environment.		2	1
CO-4	To identify & interpret the qualities of Chemical Energy resources using experimental techniques in professional engineering practices.		2	1
CO-5	To understand the properties and applications of polymers in various engineering fields.		1	2

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	1.6	2.0										

Prerequisites: Basic knowledge of chemistry

Contents:

Unit I

Electrochemistry: Introduction, Nernst equation, numerical problems on E, Ecell,, E0, E0cell, [Mn+]. Reference electrodes, Secondary reference electrodes: construction, working and applications of calomel. Construction and working of glass electrode; determination of pH using glass electrode. Electrolyte concentration cells, numerical problems. **04 Hrs.**

Energy storage devices: Introduction, classification-primary, secondary and reserved batteries. Construction, working and applications of, Li-MnO2 and Li-ion batteries. Fuel Cells: Difference between conventional cell and fuel cell, limitations, advantages. Construction & working of solid-oxide fuel cells. **04 Hrs.**

Self study components: Ag/AgCl electrodes, methanol-oxygen fuel cells.

Unit II

Water resource management: Introduction, hardness and alkalinity of water, determination of hardness of water. Determination of DO and COD; Numerical problems on hardness and COD. Determination of Chloride, Determination of Sulphate (gravimetric method) and Determination of Nitrate by phenol disulfonic acid method. **04 Hrs.**

Water Treatment: Conversion of sea water into potable by Desalination: Electro dialysis, Reverse osmosis and flash evaporation methods. Sewage management: Primary, secondary (activated sludge method) and tertiary methods. **03 Hrs.**

Unit III

Corrosion Technology: Introduction, Electrochemical theory of corrosion, Factors affecting the rate of corrosion: Nature of metal, anodic and cathodic areas, nature of corrosion product, nature of medium – pH, conductivity and temperature. Types of corrosion- Differential metal corrosion, Differential aeration corrosion (Pitting and water line corrosion), stress corrosion with examples. Corrosion control: Metal coatings; Galvanization and Tinning. Cathodic protection; Sacrificial anodic method and impressed current method. **05 Hrs.**

Metal finishing: Introduction, Technological importance, Theory of electroplating, Electroplating of Gold (Cyanide process) and Electro-less plating of Nickel and their applications. **03 Hrs.**

Unit IV

Energy resources and significance: Introduction, classification, calorific value-gross and net calorific values, determination of calorific value of fuel using Bomb calorimeter, numerical problems. Cracking: fixed bed and fluidized bed catalytic cracking. Octane and cetane numbers, knocking and their mechanism, anti-knocking agents, unleaded petrol and power alcohol. Synthesis of petrol by Bergius process and Fischer-Trops process. **08 Hrs.**

Self study component: Renewable energy sources; Solar energy, Technical significance of solar energy, Photovoltaic cell, principle, construction and working.

Unit V

Industrially important Polymers: Introduction, Glass transition temperature (Tg): Factors influencing Tg- Flexibility, inter molecular forces, molecular mass, branching & cross linking, and stereo regularity. Synthesis of polymers: Preparation, properties and applications of polycarbonate. Elastomers:

Introduction, synthesis, properties and applications of butyl rubber and silicone rubber. Adhesives: Introduction, synthesis, properties and applications of epoxy resin. **04 Hrs.**

Material Science: Composite polymers: Carbon fibers; Introduction, Preparation, properties and application. Conducting Polymers- Introduction, Polyaniline: Mechanism of conduction in polyaniline and applications. **04 Hrs.**

Question Paper Pattern:

1. Each question will carry 20 marks with maximum of four sub divisions
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1) R. V. Gadag & A. Nityananda Shetty, "Engineering chemistry", 2/e IK International Publishing House Private Ltd. New Delhi, 2010.

2) B.S. Jai Prakash, R.Venugopal, Sivakumaraiah & Pushpa Iyengar., "Chemistry for Engineering Students" Subhash Publications, Bangalore.

3) F. W. Billmeyer, "Text book of Polymer Science", 2/e, John Wiley & Sons, 2007.

4) K. Pushpalatha, "Engineering Chemistry", Revised Edition, Wiley Precise Textbook Series, Wiley, India Pvt. Ltd. 2014.

21UECC100/200	**Basic Electronics**	**(3-0-0) 3**

Contact Hours: 39 CIE:50 Marks SEE:100 Marks Exam Duration: 3 Hrs.

Course Learning Objectives(CLOs):

The course focuses on characteristics of widely employed electronic devices, their applications and design of simple analog and digital circuits.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Discuss semiconductor diodes and apply the knowledge to build regulated power supply units.	3	1,2	--

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CO-2	Describe the operation of BJT and its applications.	--	1	2,3
CO-3	**Explain** the working principle and configuration of operational amplifier and discuss its applications.	--	1,2	3
CO-4	**Apply** the concepts of analog and digital techniques to build simple electronics circuits.	--	2,12	1,3
CO-5	**Explain** various processors and hardware, software units embedded into a system.	--	--	1

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.6	1.75	1.5	--	--	--	--	--	--	--	--	2

Prerequisites: Semiconductor theory

Contents:

Unit-I

Semiconductor Diode and Characteristics: P-N junction diode, Diode characteristics, Photo diode, LED and Zener diode.
Applications of Diodes: Rectification-Half wave rectifier, Full wave rectifier, Bridge rectifier, Effect of capacitor filter on rectifiers, Zener diode as a voltage regulator, 78XX fixed IC voltage regulator, Regulated power supply. **07 Hrs.**

Unit-II

Bipolar Junction Transistor: Construction and working, CB,CE,CC configurations, Transistor voltage and currents, DC operating point, Selection of operating point, Fixed biasing, Voltage divider biasing.
Applications of BJT: BJT as a switch, BJT as an amplifier, Feedback Amplifiers – Principle, Properties, Advantages of negative feedback, Voltage series feedback, Oscillators – Barkhausen's criteria for oscillation, RC phase shift oscillator, Hartley oscillator. **09 Hrs.**

Unit-III

Introduction to Operational Amplifier: Introduction to op-amp, Pin Configuration of 741, Op-amp differential amplifier configurations, Ideal characteristics, CMRR, PSRR, Slew Rate, Input offset voltage, Bias current, Frequency response.
Applications of Operational Amplifiers: Inverting amplifier, Adder, Voltage follower, Integrator, Differentiator, Comparator. **07 Hrs.**

Unit-IV

Digital Electronics Fundamentals: Difference between analog and digital signals, Boolean algebra, Basic and Universal gates, Realization of expression using universal gates, Half adder, Full adder.

Basics of Communication Systems: Block diagram of communication system, Modulation and need for modulation, Amplitude modulation, Frequency modulation. **09 Hrs.**

Unit-V

Introduction to Embedded Systems: An embedded system, Hardware units, Software embedded into a system, Exemplary embedded systems.

Processors in the System: Introduction, Microprocessor, Microcontroller, Digital signal processor. **07 Hrs.**

Question Paper Pattern:

1. Each question will carry 20 marks with maximum of four sub divisions
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1) D.P. Kothari, I.J. Nagarath, “Basic Electronics”, 2/e, McGraw Hill, 2018.
2) Robert L. Boylestad and Louis Nashelsky, “Electronic Devices and Circuits”,10/e, PHI, 2008.
3) Thomas L. Floyd, “Electronic Devices”, 9/e, Pearson Education, 2012.
4) David A. Bell, “Electronic Devices and Circuits”, 5/e, Oxford University Press, 2008.
5) George Kennedy and Bernard Davis, “Electronic Communication Systems”, 5/e, TMH, 2011.
6) Raj Kamal, “Embedded Systems, Architecture, Programming and Design”, 1/e, TMH, 2008.

21UCSC100/200	Problem Solving and Programming in C	(3-0-0) 3

Contact Hours: 39 CIE: 50 Marks SEE:100 Marks Exam Duration:3 Hrs.

Course Learning Objectives (CLOs): The course focuses on the following learning results:

- Developing the problem solving skills that can be applied to problems in different areas which enables students to take-up subsequent course work and professional career.
- Provides a comprehensive study of the features of C programming language.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Design a solution by analyzing the given problem scenario and represent it using algorithm / flowchart.	-	1,2,3	-
CO-2	Explain the C language primitives, language principles and use them in writing simple programs.	-	1,2,3	-
CO-3	Write a C program using proper control structures to solve simple problems.	-	1,2,3	-
CO-4	Write a C program using arrays, and strings to solve simple problems.	-	2,6	-
CO-5	Explain the usage of pointers and the need for writing modular programs and demonstrate its use in writing programs.	-	-	1,2,3

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.7	1.8	1.7	-	-	2.0	-	-	-	-	-	-

Prerequisites: NIL

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Contents:

Unit I

Flow-Chart and Algorithm: Solving various scientific, engineering and business related problems of varying complexity.

Fundamentals of C Programming Language: Program structure and execution. Character set, data types, operators, type conversion, expression evaluation. Input and output statements. **08 Hrs**

Unit II

Decision making and Branching: if statement and its different forms, switch statement. **08 Hrs**

Unit III

Decision making and Looping:loops and their behavior – entry and exit controlled loops, conditional and unconditional jump statements, Nested loops. **08 Hrs**

Unit IV

Arrays: Single and multidimensional arrays, advantages and disadvantages of arrays, searching and sorting

Strings: Definition, Different ways of reading and printing strings, string handling functions, applications. **08 Hrs**

Unit V

Modular Programming: Declaration, definition and use of functions, passing parameters to function. **07 Hrs**

Question Paper Pattern:

1. Each question will carry 20 marks with maximum of four sub divisions
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1) E Balagurusamy, “Programming in ANSI C”, 6th Edition, Tata McGraw Hill, 2012.
2) Brian W Kernighan & Dennis M Ritchie, “The C programming language”, 2nd Edition, Prentice-Hall India, 2004.
3) R.G. Dromey., “How to solve it by Computer”, Prentice-Hall India, 2008

4) B A Forouzan and R F Gilberg, “Computer Program: A structured programming approach using C”, 3rd Edition, Thomson Learning, 2005
5) Brain W. Kernighan and Rob Pike, “The Practice of Programming”, Pearson Education Inc. 2008.

21UMGC100/200	Engineering Graphics	(2-0-0) 2

Contact Hours: 26 CIE: 50 Marks SEE:50 Marks Exam Duration:02 Hrs.

Course Learning Objectives (CLOs): The objectives of this course are to make the student to learn:

1. General projection theory, with emphasis on orthographic projection to represent in two-dimensional views.
2. Dimensioning and annotation of two-dimensional engineering drawings.
3. Application to industry standards and best practices applied in engineering graphics.
4. Freehand sketching to aid in the visualization process and to efficiently communicate ideas graphically.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Draw projections of points and lines.	1	6	2
CO-2	Draw the projections of regular planes.	1	6	2
CO-3	Draw the projections of regular solids.	1	6	2
CO-4	Develop the lateral surfaces of regular truncated / frustums of solids.	1	6	2
CO-5	Draw isometric projections of combination of regular solids.	1	6	2

POs	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mapping Level	3	1	-	-	-	2	-	-	-	-	-	-	-	-

Prerequisites:

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Contents:

Unit I

Introduction to Engineering Graphics: Geometrical constructions-point, line, regular planes (triangle, square, rectangle, pentagon, hexagon and circle), BIS conventions: Dimensioning, Lines, Scale- full scale, enlarged and reduced scale, Standard sheet sizes.

Orthographic projection: XY line, Reference Planes- Horizontal, Vertical and Profile planes, quadrants, object, projectors, projections, observer, representation of projected points in front, top and side view. Relative positions of object, observer, planes in various quadrants and corresponding principal views.

Projection of Points and Lines: Projection of points in all quadrants.

Projection oflines: First quadrant only- line parallel to both reference planes, line inclined to one reference plane and parallel to another, line inclined to both reference planes. **05 Hrs.**

Unit II

Projection of Planes: Projections of square, pentagonal, hexagonal and circular lamina with surface inclined to both HP and VP. **05 Hrs.**

Unit III

Projections of Solids: Projections of regular solids - prism, pyramid (Square, pentagon based), cone and cylinder with axis inclined to both HP and VP

05 Hrs.

Unit IV

Development of Lateral surfaces of truncated / frustums ofsolids: Development of prism, pyramid (Square, pentagon based), cone and cylinder. **05 Hrs.**

Unit V

Isometric Projection of Solids: Isometric projection of regular solids, combination of solids (cone on cube, prism on square block and sphere on cube)

Introduction to Solid Edge software: Use of commands for 2D environment. Exercises using software. **06 Hrs.**

Question Paper Pattern:

1) Each question will carry 10 marks with maximum of two sub divisions
2) Each unit will consists of two full questions
3) Students have to answer one full question from each unit and total five questions to be answered.
4) The question paper will have built in choice in the unit.

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Text Book:

1) K. R. Gopalakrishna "Engineering Graphics", 32nd Edition, Subash Publishers, Bangalore, 2018.

Reference Books:

1) N.D. Bhatt & V.M. Panchal, "Engineering Drawing", 50th edition, Charotar Publishing House, Gujarat, 2010.
2) A Primer on "Computer Aided Engineering Drawing", Published by VTU, Belgaum, 2006
3) S. Trymbaka Murthy, "Computer Aided Engineering Drawing", 3rd revised edition, I.K. International Publishing House Pvt. Ltd., New Delhi, 2006.

21UCYL100/200	Engineering Chemistry Laboratory	(0-0-2) 1

Contact Hours: 26 CIE: 50 Marks SEE: 50 Marks Exam Duration: 3 Hrs.

Course Learning Objectives (CLOs):

To study and acquire experimental skills for qualitative and quantitative analysis of given material such as ore, hard water, cement etc.

Course Outcomes (Cos)):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Demonstrate experimental skills, interpret the data for quantitative estimation of Iron, Copper and Acid mixture in the given solution.	3		
CO-2	Demonstrate experimental skills, interpret the data for quantitative estimation of hardness, calcium in cement and Iron in Haematite ore solution.		4	
CO-3	Estimate dissociation constant and viscosity, Interpret the data		3	
CO-4	Determination of COD and copper in Brass, interpret the data for quantitative estimation.	4		
CO-5	Prepare and write the experimental results.		3,4	

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POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.6	2.0										

Contents:

PART – A

1) Estimation of FAS potentiometrically using standard $K_2Cr_2O_7$ solution.
2) Estimation of copper by colorimetrically.
3) Estimation of given acid using standard sodium hydroxide by conductometric method.
4) Determination of pKa of weak acid using pH meter.
5) Determination of Viscosity co-efficient of a liquid using Ostwald's viscometer.
6) Construction of Daniel cell and measurement of potential.

PART – B

1) Estimation of Total hardness of water by EDTA complexometric method.
2) Estimation of Ca present in cement by EDTA method.
3) Determination of percentage of Copper in brass solution using standard sodium thiosulphate solution.
4) Estimation of Iron in hematite ore solution using $K_2Cr_2O_7$ solution by external indicator method.
5) Determination of Chemical Oxygen Demand of waste water.

Reference Books:

1. G.H. Jeffery, J. Bassett, J. Mendham and R.C Denney, "Vogel's Text Book of Quantitative Chemical Analysis" 3/e, 2005.
2. Sudha Rani & S. K. Bashin, "Laboratory manual on Engineering Chemistry", Dhanpat Rai Publishing Co.New Delhi, 2014.
3. O.P. Vermani & Narula, "Theory and Practice in Applied Chemisrty" New Age International Publisers.
4. Sunita Rathan, "Experiments in Applied Chemistry" S.K. Kataria & Sons Publisher.

21UCSL100/200	Computer Programming Lab	(0-0-2) 1

Contact Hours: 26 CIE: 50 Marks SEE:50 Marks Exam Duration:3 Hrs.

Course Learning Objectives (CLOs): The course focuses on the following learning results through practice:

- Conceptualization of the solutions for the given simple problems.
- Representation of the solutions using algorithm and flow chart.

- Writing modular C program to solve simple problems.
- Practicing coding and debugging standards to understand maintainability, testability and other quality parameters.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Design a solution by analyzing the given problem scenario and represent it using algorithm / flowchart.	-	1,2,3	-
CO-2	Explain the C language primitives, language principles and use them in writing simple programs.	-	1,2,3	-
CO-3	Write a C program using proper control structures to solve simple problems.	-	1,2,3	-
CO-4	Write a C program using arrays, and strings to solve simple problems.	-	1,2,3	-
CO-5	Explain the usage of pointers and the need for writing modular programs and demonstrate its use in writing programs.	-	-	1,2,3

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.7	1.7	1.7	-	-	-	-	-	-	-	-	-

Prerequisites: NIL
Working Platform: Linux Operating System

Expected Coding Practices:

1. Use of Good Programming practices: Declaration of variables, Indentation, Documentation, Simplicity of logic, Efficiency of logic, uniformity etc.
2. Generic and Reusable code.
3. Inclusions of exceptional cases.
4. Better usability

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Course Contents:
Programming exercises of varying complexity, to meet the learning results stated in course outcomes for this course.

Reference Books:

1) E Balagurusamy, “Programming in ANSI C”, 6th Edition, Tata McGraw Hill, 2012.
2) Brian W Kernighan & Dennis M Ritchie, “The C programming language”, 2nd Edition, Prentice-Hall India, 2004.
3) R.G. Dromey., “How to solve it by Computer”, Prentice-Hall India, 2008
4) B A Forouzan and R F Gilberg, “Computer Program: A structured programming approach using C”, 3rd Edition, Thomson Learning, 2005
5) Brain W. Kernighan and Rob Pike, “The Practice of Programming”, Pearson Education Inc. 2008.

21UAEE200	Cyber Law	(2-0-0) 2

Contact Hours: 26 CIE: 50 Marks SEE: 50 Marks Exam Duration: 2 Hrs.

Course Learning Objectives (CLOs): This course will cover the basics of cyber-crimes & spread awareness of this field to help the students understand the importance of security and related laws.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Explain the meaning of cyber-crime and its implications. [usage] [BL-3]	-	1, 2, 3, 5	-
CO-2	Identify and Elaborate the taxonomy and classifications of cyber-crimes. [Familiarity] [BL-2]	2	1	-
CO-3	Identify the scope and applicability of IT Act-2000; [Familiarity] [BL-2]	-	3	1, 2
CO-4	Explore the Legal Protection against Cyber Crimes. [Familiarity]	2	4, 5, 6	-
CO-5	Study recent trends in cyber law and development. [Familiarity] [BL-3]	2	4, 5, 6	

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.66	2	2	2	2	2	-	-	-	-	-	-

Prerequisites: NIL

Contents:

Unit I

Introduction:

Cyber Crime: Meaning and Definition, Meaning of Crime, Meaning of Cyber Crime. **04 Hrs.**

Unit II

Classification of Cyber Crimes:

Taxonomy of Cyber Crime, Classifications of Cyber Crimes, Cyber Crimes against Persons, Crimes against Persons' Property, Cybercrimes Against Government, Cybercrimes Against Society at large, Causes of Cyber Crime, Impact and Effects of Cyber Crimes, Cyber Crime: Some Landmark Occurrence. **06 Hrs.**

Unit III

Information Technology Law:

A Bird's Eye View, Cyber World vis-a-vis need of Legal Protection, Information Technology Act, 2000: A Beginning, Objectives of Information Technology Act, 2000, Scope of Information Technology Act, 2000, Applicability of Information Technology Act, 2000, Information Technology Act, 2000: A Snapshot, Information Technology (Amendment) Act, 2008, Recompense of Information Technology Law, Limitation of Information Technology Law. **06 Hrs.**

Unit IV

Legal Protection against Cyber Crimes:

Criminal Liabilities under Information Technology Act, 2000 Common Cyber Crimes and Applicable Legal Provisions: A Snapshot, Civil Liabilities under Information Technology Act, 2000, Civil Liability for Corporate: Cyber Crimes under IPC and Special Laws, The Indian Penal Code, 1860, Cyber Crimes under the Special Acts. **06 Hrs.**

Unit V

Cyber Laws – Recent Trends

Different types of cyber law trends and developments of India. **04 Hrs.**

Question Paper Pattern:

1. Each question will carry 10 marks with maximum of two sub divisions.
2. Each unit will consists of two full questions
3. Students have to answer one full question from each unit and total five questions to be answered.
4. The question paper will have built in choice in the unit.

Reference Books:

1) CYBER CRIME LAW AND PRACTICE, Published by: THE INSTITUTE OF COMPANY SECRETARIES OF INDIA, 2016
2) https://cybercrimelawyer.wordpress.com/category/66cpunishment-for-identity theft /
3) www.cyberlawsindia.net
4) http://www.enotes.com/research-starters/social-impactscyber-crime

21UAEE201	Numerical Techniques for Engineers	(2-0-0) 2

Contact Hours: 26 CIE: 50 Mark SEE: 50 Marks Exam Duration: 2Hrs.

Course Learning Objectives (CLOs): The student is expected to learn the concepts of Errors in Computations, able to learn to solve Linear System of Equations through Matrix Inversion methods, Approximate the functions by using various schemes and describe the Co-ordinate Systems in Finite Element Method.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1,12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	**Locate** various types of errors in computations			1,2
CO-2	**Apply** the knowledge of interpolation for solving Algebraic and Transcendental Equations using various methods.			1,2
CO-3	Solve Linear System of Equations through Matrix Inversion methods.			1,2
CO-4	Approximate the functions by using various schemes.			1,2

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CO-5	**Apply** the knowledge of calculus to describe the Co-ordinate Systems in Finite Element Method.		1,2	

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	1.2	1.2										

Prerequisites: Basic Knowledge in Number Theory and Calculus.

Contents:

Unit I

Introduction to Errors in Computation:
Introduction, Floating point representation, Errors in computations: Inherent errors, Local Round-off Errors, Local Truncation Error. **05 Hrs.**
Self study: Numerical computations using software packages

Unit II

Solution of Algebraic and Transcendental Equations:
Introduction, Bisection method, Muller's method, Bairstow method, System of Non-linear equations **05 Hrs.**
Self study: Solving various problems using C-Program.

Unit III

Solution of Linear System of Equations and Matrix Inversion:
Introduction, The relaxation method, Matrix inversion: Gauss-elimination method, Gauss-Jordon method. **05 Hrs.**
Self study: Finding trace, norm and inverse of a matrix using c-program.

Unit IV

Approximation of Functions:
Introduction, Least-Squares approximations, Chebyshev polynomial approximation, Economized power series, Pade approximation. **5 Hrs.**
Self study: Problems on Approximations of functions.

Unit V

Co-ordinate Systems in Finite Element Method:
Introduction, One-dimensional linear finite element, Galerkin Finite element method (Element Matrices) method, Local Coordinate systems, Natural Coordinate systems. **6 Hrs.**
Self study: Natural Coordinates for rectangular element

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Question Paper Pattern:

1) Each question will carry 10 marks with maximum of two sub divisions
2) Each unit will consists of two full questions
3) Students have to answer one full question from each unit and total five questions to be answered.
4) The question paper will have built in choice in the unit.

Reference Books:

1) **K. Sankara Rao**, Numerical Methods for Scientists and Engineers, Fourth edition, PHI Learning Private Limited, 2018.
2) **Dr. B.S. Grewal**, Numerical Methods in Engineering & Science with programs in C, C++ and Matlab, Khanna Publishers, 2013.
3) **Dr. B.S. Grewal**, Higher Engineering Mathematics, 44^{th} edition, Khanna Publishers, 2020.
4) **Richard Hamming**, Numerical Methods for Scientists and Engineers, Second edition, McGraw Publication, 1973.

21UHUC101/201	**Society, Environment and Engineering**	**(2-0-0) 2**

Contact Hours: 26 CIE: 50 Mark SEE: 50 Marks Exam Duration: 02 Hrs.

Course Learning Objectives (CLOs):

The student is expected to learn the societal structure, development processes, concern towards environment, appropriate technology and role of Engineers in providing engineering solutions for societal comfort.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Analyse the social structure and development needs	6,7		8
CO-2	Create awareness about the need of balanced ecosystems and identify the reasons for environment degradation.	6,7		8
CO-3	Apply mitigation techniques for conservation of environment	6,7		8
CO-4	Evaluate the need and impact of technology on social system and climate	6,7		8

CO-5	Recite his/her role as a facilitator for sustainable development	6,7		8

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level						3	3	1				

Prerequisites: Nil

Contents:

Unit I

Societal Structures and Dynamics: An analysis of basic sociology concepts and their applications to contemporary society; cultural heritage, occupation mobility and income distribution, social tensions and their causes; societal responsibility and social institutions.

Transformation of industrial society into information society, Development processes: parameters for development of interrelationship between social economic and scientific factors. Role of science and technology in development planning; its objectives and assessment. **06 Hrs.**

Unit II

Ecosystems: Natural ecosystems, Principles of eco-balance, Biosphere cycle, carbon dioxide cycle, causes of eco-imbalance - its effects and remedies.

Environmental Degradation: Causes of degradation– its effects, Control of air, water, soil, and pollutions, Solid waste management, Protection of ozone layer.

05 Hrs.

Unit III

Conservation of environment: Optimum utilization of natural resources, Renew able and non renewable resources, Conflict of resources, Global environmental issues, Climate change as a threat to human civilization and Mitigation measures.

05 Hrs.

Unit IV

Technology: Definition, Impact of technology on environment & society, Benefits of technology due to new inventions, Conflict of technology, technology creation for societal change, Appropriate technology, Intermediate technology, labor based and labor intensive technology, Shifts in employment due to technological advancement, Role of technology to unmask social problems, Impact of technology on culture, tradition and social values. **05 Hrs.**

Unit V

Technology for Sustainable development: Definition and concept, Technology for sustainable energy and materials. Agricultural age, industrial age and information age, Characteristics of information society, Information as power and wealth. Community management, Engineers role as facilitator. **05 Hrs.**

Question Paper Pattern:
1) Each question will carry 10 marks with maximum of two sub divisions
2) Each unit will consists of two full questions
3) Students have to answer one full question from each unit and total five questions to be answered.
4) The question paper will have built in choice in the unit.

Reference Books:

1. B. C. Punmia, Ashok Kumar Jain and Arun Kumar Jain, "Environmental Engineering", 16^{th} Edition, Laxmi Publications (P) Ltd., New Delhi, 2016
2. H.G. Wells, "Brief History of Civilization",
3. J. Neharu, "Glimps of World History", 2004

21UMAC200	**Engineering Mathematics-II**	**(2-2-0) 3**

Contact Hours:39 **CIE:50 Marks** **SEE:100 Marks** **Exam Duration:3 Hrs.**

Course Learning Objectives (CLOs):
The purpose of the course is to facilitate the students with concrete foundation of ordinary and partial differential equations, Laplace transforms, enabling them to acquire the knowledge of these mathematical tools.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1,12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	**Explain** various physical models through higher order differential equations and solve such linear ordinary differential equations.		1,2	
CO-2	**Solve** problems on partial differential equations by method of separation of variables.		1,2	

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CO-3	**Transform** the given function using Laplace transforms depending on the nature of engineering applications.		1,2	
CO-4	Apply Laplace transforms to solve differential equations.		1,2	
CO-5	Compute gradiant, divergence, curl vector valued functions and Illustrate the Engineering applications through vector Calculus.		1,2	

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	2	2										

Prerequisites: 1.Differentiation and integration of functions.
2. Differential Equations of first Order.

Contents:

Unit I

Differential Equations of Higher Order:

Second order linear ODE's with constant coefficients-Inverse differential operators, Method of Variation of Parameters, Legendre's homogeneous equations. Applications to oscillations of a spring and L-C-R circuits.

Self Study: Cauchy's homogeneous equations. **07L+ 01T**

Unit II

Partial Differential Equations (PDE's):

Formation of PDE's by elimination of arbitrary constants /functions. Solution of PDE by variable separable method. Derivation of one dimensional wave equations and solution of wave equation by the method of separation of variables and problems. Derivation of one dimensional heat equations and problems.

Self Study: Solution of heat equation by the method of separation of variables. **07L+ 01T**

Unit-III

Laplace Transforms:

Definition of Laplace transform, Laplace transform of elementary functions, properties of Laplace transforms. Laplace transform of $t^n f(t)$, Laplace transform of $\frac{f(t)}{t}$,Laplace transform of derivative of order *n*, Laplace transform of

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$\int f(t)\,dt$ .Laplace transforms of Periodic functions and unit-step function–problems. **07L+ 01T**

Unit-IV

Inverse Laplace Transforms:

Inverse Laplace transform-problems with standard formulae, computation of the inverse Laplace transform of $e^{-as}\bar{f}(s)$,Inverse transform by completing the square, Inverse transform by the method of partial functions, Inverse transform of logarithmic and inverse functions. Convolution theorem (without proof) to find the inverse Laplace transform and problems. **06L+01T**

Self study: Solution of linear differential equations using Laplace transform.

Unit V

Vector Calculus:-

Vector Differentiation: Scalar point function and vector point functions. Gradient, Directional Derivative, Curl and Divergence-physical interpretation. Solenoidal and irrotational vectors. Illustrative problems.

Vector Integration: Line integrals, Surface integrals and volume integrals. Green's theorem, Gauss divergence theorem (only statements).Illustrative example. **07L+ 01T**

Self study: Stoke's theorem.

Question Paper Pattern:

1) Each question will carry 20 marks with maximum of four sub divisions
2) Each unit will consists of two full questions
3) Students have to answer one full question from each unit and total five questions to be answered.
4) The question paper will have built in choice in the unit.

Reference Books:

1. **B.S. Grewal**: Higher Engineering Mathematics, Khanna Publishers, 44th Ed., 2017.
2. **E. Kreyszig**: Advanced Engineering Mathematics, John Wiley & Sons, 10th Ed. (Reprint), 2016.
3. **Srimanta Pal, Subodh Chandra Bhunia:** Engineering Mathematics, Oxford university Press, 2015.
4. **B.V. Ramana**: "Higher Engineering Mathematics" 11th Edition, Tata McGraw-Hill, 2010.

Academic Program: UG

Academic Year 2021-22

Syllabus

III & IV Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution approved by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465** **Fax:** **0836-2464638** **Web:** www.sdmcet.ac.in

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for III& IV semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2021-22 till further revision.

Principal | Chairman BoS & HoD

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SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- ❖ In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and Mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs)

1. **Engineering knowledge:**Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific outcomes (PSOs)

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for III Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC300	BS	Engineering Mathematics – III	3-0-0	3	50	100	3	-	-
18UCHC300	PC	Chemical Process Calculations	4-0-0	4	50	100	3		-
18UCHC301	PC	Technical Chemistry**	3-0-0	3	50	100	3	-	-
18UCHC302	PC	Fluid Mechanics	4-0-0	4	50	100	3	-	-
18UCHC303	PC	Particulate Technology	4-0-0	4	50	100	3	-	-
18UCHC304	PC	Chemical Engineering Drawing	2-0-2	3	50	100	3	-	-
18UCHL305	PC	Particulate Technology Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL306	PC	Technical Analysis Laboratory	0-0-3	1.5	50	-	-	50	3
Total			**20-0-8**	**24**	**400**	**600**		**100**	

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

** To be handled by the Chemistry department faculty

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Scheme for IV Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UMAC400	BS	Engineering Mathematics – IV	3-0-0	3	50	100	3	-	-
18UCHC400	PC	Process Heat Transfer	4-0-0	4	50	100	3	-	-
18UCHC401	PC	Chemical Reaction Engineering-I	4-0-0	4	50	100	3		
18UCHC402	PC	Chemical Engineering Thermodynamics	3-2-0	4	50	100	3	-	-
18UCHC403	PC	Pollution Control Engineering	3-0-0	3	50	100	3	-	-
18UCHC404	PC	Energy Technology and Management	3-0-0	3	50	100	3	-	-
18UCHL405	PC	Computational Methods & Simulation Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL406	PC	Fluid Mechanics Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL407	PC	Introductory Project	0-0-2	1	50	-	-	-	-
Total			**20-2-8**	**25**	**450**	**600**		**100**	

Total credits offered for the Second year: 49

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Total credits offered for the Second year: 49

III Semester

18UMAC300	Engineering Mathematics-III	(3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLO):

1. To have an insight into Laplace transforms, Fourier series, Fourier transforms, Difference equations and Z-transforms. To develop the proficiency in variational calculus and solving ODE's arising in engineering applications, using numerical methods.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)** Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Transform the given function using Laplace/Fourier transforms depending on the nature of engineering applications.			1
CO-2	Express periodic function as a Fourier series and obtain the various harmonics of the Fourier series expansion for the given numerical data.			1,2
CO-3	Solve difference equations using Z-transform.			1
CO-4	Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.		1,2	
CO-5	Determine the externals of functional using calculus of variations and solve problems arising in engineering.			1,2

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	1.2	1.3	-	-	-	-	-	-		-	-	-

Pre-requisites: A basic course on differentiation and integration of function.

Contents:

Unit-I

Laplace Transforms: Definition and Properties. Laplace transform of elementary functions. Laplace transforms of Periodic functions and unit-step function problems. **Laplace Transforms**: Inverse Laplace transform - problems, Convolution theorem(without proof) to find the inverse Laplace transform and problems, solution of linear differential equations using Laplace transform. **08 Hrs.**

Unit-II

Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions of period 2® and arbitrary period. Half- range Fourier series. Practical harmonic analysis, examples from engineering field. **08 Hrs.**

Unit-III

Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Simpleproblems.

Z-Transforms and Difference Equations: Z-transform- definition, Standard Z-transforms, Damping and shifting rules, Initial value and Final value theorems (without proof) with problems. Inverse Z-transform.Simple problems.Difference equations-basic definition.Application of Z-transform to solve Difference equation. **08 Hrs.**

Unit-IV

Numerical Solutions of Ordinary Differential Equations (ODE's): Numerical solution of ODE's of first order and first degree-Taylor's series method, Modified Euler's method. Runge–Kutta method of fourth order, Milne's predictor and corrector method (Noderivations of formulae).Problems. **07 Hrs.**

Unit-V

Numerical Solution of Second Order ODE's: Runge-Kutta method and Milne's predictor and Corrector method. (No derivations of formulae).

Calculus of Variations: Variation of function and functional, variational problems, Euler's equation (without proof), Geodesics (plane), hanging chain problems. **08 Hrs**

Reference Books:

1) B.S. Grewal "Higher Engineering Mathematics", Khanna Publishers, 44/e, 2017.
2) E. Kreyszig "Advanced Engineering Mathematics", John Wiley & Sons, 10/e (Reprint), 2016.
3) Srimanta Pal et al., "Engineering Mathematics", Oxford University Press, 3/e, 2016.

18UCHC300	Chemical Process Calculations	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To study and understand the importance of stoichiometry, material and energy balances and applying these principles to industrial and theoretical problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12) /PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the fundamental and derived units with dimensions and calculate compositions of solutions.	1	2,3	13
CO-2	State ideal gas law and study humidification using psychrometric charts.	2,3	1	-
CO-3	Evaluate problems on steady state material balance without chemical reactions.	13	2,3	1
CO-4	Develop steady state material balance with chemical reaction and determine conversion, yield and selectivity.	13	2,3	1
CO-5	Compute ultimate and proximate analysis of fuels and perform calculations on energy balances.	2,3	1	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.8	2.4	2.4	-	-	-	-	-	-	-	-	-	2.0	-	-

Course content:

Unit-I

Units and Dimensions: Fundamental and derived units, Conversion of units, Dimensional consistency of equations. Dimensionless groups and constants.Conversion of equations.

Basic Chemical Calculations: Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases.Concept of normality, molarity, molality, ppm.

10 Hrs.

Unit-II

Vapour - Gas Concepts: Ideal gas law, vapour pressure concepts and calculation for miscible and immiscible systems. Real gases, Cubic equations of state. Humidification, drybulb and wet bulb temperature, molal humidity, saturation humidity and psychrometric charts. **09 Hrs.**

Unit-III

Material Balance Without Reaction: General material balance equation for steady and unsteady states. Typical steady state material balances in mixing, evaporation drying distillation, absorption, extraction and Crystallization. Material balances involving bypass, recycle and purging operations. **09 Hrs.**

Unit-IV

Steady State Material Balance with Reaction: Principles stoichiometry, limiting and excess reactants. Effect of inerts, fractional and percentage conversion.Yield and selectivity for multiple reactions. **12 Hrs.**

Unit-V

Fuels and Combustion: Ultimate and proximate analysis of fuels. Calculations involving burning of solid, liquid and gaseous fuels.Excess air, air to fuel ratio calculations.

Energy Balance: General steady state energy balance equation. Heat capacity, enthalpy, heat of formation reaction and combustion.Determination of heat of reaction at standard and elevated temperatures. **12 Hrs.**

Reference Books:

1) Hougen, O.A., Waston, K.M. and Ragatz, R.A., “Chemical Process Principles Part – I, Material and Energy Balances”, 2/e, CBS publishers and distributors, New Delhi, 1995.
2) Himmelblau, D.M., “Basic Principles and Calculations in Chemical Engineering”, 6/e, Prentice Hall Of India, New Delhi, 1997.
3) Bhatt, B.L. and Vora, S.M., “Stoichiometry”, SI Units, 3/e, 1996, Tata McGraw Hill Publishing Ltd., New Delhi, 1996.
4) K.V. Narayanama B. Lakshmikutty, “Stoichiometry and Process calculations” Prentice Hall India Limited, New Delhi, 2006. ISBN: 978-81-203-2992-8

18UCHC301	Technical Chemistry	(3-0-0) 3

Contact Hours: 39

Course Learning Objective(CLO):

1. The students are expected to learn the diffrent types of behaviour of inorganic materials, understand the aspects of inorganic polymers, reaction kinetics of coordinated compounds. Besides they are also expected to understand the basic aspects of nanotechnology and spectroscopy.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs(1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the electric, electronic and optical behavior of inorganic materials.	1	-	-
CO-2	Realize the basic knowledge of chemical kinetics	-	2	-
CO-3	Apply the knowledge of inorganic polymers and their applicability in material use, optimization and in various engineering applications.	1	-	-
CO-4	Comprehend the aspects of nanotechnology and its use for synthesis of engineering materials.	1	-	-
CO-5	Demonstrate the knowledge of different types and the mechanisms involved in spectroscopy and apply them in the analysis of organic compounds	-	1, 2	-

PO's/PSOs	**PO -1**	**PO -2**	**PO -3**	**PO -4**	**PO -5**	**PO -6**	**PO -7**	**PO -8**	**PO -9**	**PO -10**	**PO -11**	**PO -12**	**PSO -13**	**PSO -14**	**PSO -15**
Mapping Level	2.75	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-

Prerequisite: Engineering Chemistry

Course content:

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Unit-I

Electronic, Electric and Optical Behaviour of Inorganic Materials: Metals, Insulators and Semiconductors, Electronic structure of solid, band theory, band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, doping of semiconductors and conduction mechanism, the bandgap, synthesis and purification of semi conducting materials, single crystal growth, zone refining, fractional crystallization, semiconductor devices, rectifier transistors, photoconductors, photovoltaic cells, solar batteries. **08 Hrs.**

Unit-II

Inorganic Polymers: Introduction, preparation, properties and applications of Phosphorous-based polymers-polyphosphonitrilic chlorides and ultraphosphate glasses. Sulphur-based polymers-polymeric sulphur nitride and chalcogenide glasses.Silicon-based polymers-fluid polysiloxanes gums and silicone resins.

08 Hrs.

Unit-III

Reaction Kinetics of Coordination Compounds: Introduction, electron transfer reactions: Outer-sphere reactions, ligand-bridged inner sphere reactions doubly bridged inner-sphere transfer, one electron and two electrons transfers, non-complementary reactions. Ligand exchange via electron exchange. Mechanisms of ligand substitution reactions-general considerations, substitution reactions of square planar and octahedral complexes. Base-catalyzed hydrolysis of cobalt (III) ammine complexes.

08 Hrs.

Unit-IV

Introduction to Nano-Technology: Introduction to Nano scale, Nano materials, Synthesis of Nano particles by various methods: Spontaneous growth, Evaporation and condensation growth, Vapor-liquid solid growth, stress induced recrystalization. Physical vapour deposition (PVD): Evaporation molecular beam expitaxy (MBE), sputtering. Comparison of Evaporation and sputtering Chemical vapour deposition (CVD), Wet chemical synthesis methods: sol-gel, hydrothermal, co-precipitation and solution combustion methods. Unique properties of nanomaterials and their applications in Engineering field. **08 Hrs.**

Unit-V

Introduction to Spectroscopy: Study of chromatography, Paper, Thin layer and Gas chromatography and their applications. FTIR and UV-visible spectroscopy and their applications in analysis of organic compound. **07 Hrs.**

Reference Books:

1) J.D. Lee “Concise Inorganic Chemistry”,5/e, Wiley’s Publication,2012.
2) Wahid U. Malik; G.D. Tuli; R. D. Madan, “Selected Topics in Inorganic Chemistry”, Publisher: S Chand & Co Ltd, 2010,ISBN 10: 8121906008 .

3) The text book of physical chemistry Samuel GlasstoneMcmillan publications 1st Edition, 1974.
4) Fundamental of Analytical Chemistry D.A. Skoog, D.M. West, Holler and Saunders College Publishing, 8th Edition, 2005.
5) Er. RakeshRathi S, “Nanotechnology”, Chand & Company Ltd., Ram Nagar, New Delhi, 2010.

18UCHC302	Fluid Mechanics	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To introduce the concepts, principles, laws, observations and models of fluids at rest and in motion.
2. To provide the basis for understanding the fluid behavior, engineering design and control of fluid systems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the nature of fluids along with the properties and its measuring devices.	1	3	-
CO-2	Interpret and analyze the parameters of fluid flow and understand the mechanical energy equations	3, 13	2	1
CO-3	Derive and interpret the equations of fluid flow for liquids and also use dimensional analysis for solving problems	3, 5, 13	2	1
CO-4	Derive and interpret the equations of fluid flow for gases and also use dimensional analysis for solving problems	3, 5, 13	2	1
CO-5	Elucidate and characterize the different pipe fittings, pumps and flow measuring devices.	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	2.8	-	3.0	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Fluid Statics and Applications: Introduction to momentum transfer and unit operations. Nature of fluids, pressure and its measurements. Hydrostatic equilibrium, barometric equation, measurement of fluid pressure-manometers (U tube manometer, Inverted manometer, differential manometer), continuous gravity decanter, centrifugal decanter **11 Hrs.**

Unit-II

Fluid Flow Phenomena: Newtonian and Non-Newtonian fluids, types of flows, Shear rate, Shear stress, Rheological properties of fluids. Flow in boundary layer-Boundary layer separation and wake formation. Basic Equations of Fluid Flow: Macroscopic momentum balances, Mechanical energy equations. **10 Hrs.**

Unit-III

Incompressible Fluids: Laminar flow of incompressible fluids in pipes and conduits. Shear stress and Velocity distribution-Maximum and average velocity-Hagen Poiseuille and Darcy equation.Turbulent flow of incompressible fluids in pipes and conduits-Universal velocity distribution equation. Friction factor and Reynolds number relationship and friction factor chart. Nikuradse and Karman equation-Blasius equation, Prandtl one seventh power law. Changes in velocity or direction-Sudden expansion and contraction. **11 Hrs.**

Unit-IV

Compressible Fluids: Continuity equation, Mach number, total energy balance, velocity of sound, Ideal gas equation, adiabatic and isothermal flow equations, Flow through convergent-divergent sections, stagnation properties, velocity of sound or pressure wave in ideal gas equation. **Dimensional Analysis:** Dimensional homogeneity, Rayleigh's and Buckingham-Pi methods, dimensionless numbers, models and prototypes. **10 Hrs.**

Unit-V

Transportation and Metering of Fluids: Pipes, fittings and valves. Performance characteristics of Pumps - positive displacement pumps and centrifugal pumps, fans, blowers, and compressors. Measurement of flowing fluids - full bore meters, area meter, insertion meters with flow rate equations. Flow through open channels- weirs and notches. Unsteady state flow- time taken to empty the liquid from the tank.

10 Hrs.

Reference Books

1) McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGraw Hill chemical engineering series. ISBN-10: 0072848235
2) Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1 and 2, 5/e. Butterworth publications. ISBN-10: 0750644451
3) Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4) R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 978813180294

18UCHC303	Particulate Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To study the basic principles of unit operations and its applications in process industries.

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12) PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply the principles of particle size analysis and unit operations to solve industrial screening problems.	1,2	13	3
CO-2	Classify size reduction equipments and evaluate their performance using laws of size reduction.	1,2	13	3
CO-3	Analyze pressure drop through bed of solids immersed in fluids and demonstrate the knowledge of their application in filtration.	1,2	13	-
CO-4	Analyze and apply the concepts of motion of particles for the design of sedimentation system.	1,2	13	-
CO-5	Demonstrate the knowledge of agitation, mixing, storage and conveying of fluid-solid systems.	1	2	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.8	1.0	-	-	-	-	-	-	-	-	-	1.8	-	-

Course content:

Unit-I

Particle Technology: Particle shape, particle size, sphericity, mixed particles size analysis. Screens – ideal and actual screens, standard screens, differential and cumulative size analysis, effectiveness of screen, specific surface of mixture of particles, number of particles in a mixture. Industrial screening equipments- grizzly, gyratory screen, vibrating screen, trommels. Sub sieve analysis – Air permeability method, sedimentation and elutriation methods. **09Hrs.**

Unit-II

Size Reduction: Introduction, types of forces and criteria for communition, characteristics of communited products, laws of size reduction, open and closed circuit grinding. Equipments for size reduction – jaw crusher, gyratory crusher, smooth roll crusher, tooth roll crusher, impactors, attrition mill, ball mill, fluid energy mill, knife cutter. **10Hrs.**

Unit-III

Flow of Fluids Past Immersed Bodies: Drag, drag coefficient. Pressure drop – Ergun's, Kozeny – Carman and Burke – Plummer equations. Fluidization - conditions for fluidization, minimum fluidization velocity, types of fluidization, applications of fluidization, pneumatic conveying.

Filtration: Introduction, classification of filtration, cake filtration, batch and continuous filtration, pressure and vacuum filtration, constant pressure filtration, characteristics of filter media. Industrial filters - sand filter, filter press, leaf filter, rotary drum filter. Filter aids, application of filter aids. Principles of cake filtration, modification of Kozeny – Carman equation for filtration. **12 Hrs.**

Unit-IV

Motion of Particles Through Fluids: Mechanics of particle motion, equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, terminal velocity, motion of spherical particles in Stoke's region, Newton's region and intermediate region. Criterion for settling regime, centrifugal separators, cyclones and hydro cyclones.

Sedimentation: Batch settling test, application of batch settling test to design of continuous thickener. Coe and Clevenger theory, Kynch theory. Thickener design, determination of thickener area**.** **12 Hrs.**

Unit-V

Agitation and Mixing: Application of agitation, agitation equipment, types of impellers – propellers, paddles and turbines, flow patterns in agitated vessels, prevention of swirling, standard turbine design, power correlation and power calculation. Mixing of solids, types of mixers- change can mixer, Muller mixer, mixing index, ribbon blender, internal screw mixer, tumbling mixer. **Sampling, Storage and Conveying of Solids:** Sampling of solids, storage of solids, open and closed storage, bulk and bin storage. Conveyors – belt conveyor, chain conveyor, apron conveyor, bucket conveyor, bucket elevators, screw conveyor. **09Hrs.**

Reference Books:

1) McCabe, W. L., Smith, J. C. and Harriott, P., "Unit Operation of Chemical Engineering", 4/e, McGraw Hill International, Singapore, 2001.
2) Badger, W.L. and Banchero, J.T., "Introduction to Chemical Engineering", 3/e,McGraw Hill International, Singapore, 1999.
3) Coulson, J.M. and Richardson, J.F., "Chemical Engineering Vol.2", 5/e, Particle Technology and Separation Processes, 1998.
4) Foust, A.S. et.al, "Principles of Unit Operation", 3/e, John Wiley and Sons, NewYork, 1997.

18UCHC304	Chemical Engineering Drawing	(2-0-2) 3

Contact Hours: 52

Course Learning Objective (CLO):

1. To increase competency in drawing through. various conventions, equipment's and sectional view in engineering drawing

Course Outcomes (COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Demonstrate Symbols, proportionate equipment drawings	-	-	10
CO-2	Analyze sectional views and assembly drawing.	10	-	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	-	2.0	-	-	1.0	-	-

Course Content:

1. **Conventions:** Equipment and piping, colour codes, materials, nuts and bolts. **01L+03P Hrs.**
2. **Process Flow Diagram**: with conventions and blocks, P&ID. **01L+04P Hrs.**
3. **Proportionate Drawing of Process Equipment**: Jackets-types, Vessel Supports, Storage vessel, Reaction vessel, Heat Exchanger, Evaporator, Distillation column. **01L+03P Hrs.**
4. **Sectional Views:** Representation of the sectional planes, Sectional lines and hatching, Selection of section planes and types of sectional views. **02L+04P Hrs.**
5. **Assembly Drawings:**
   - **i.** Shaft Joints: Cotter joint with sleeve, Gib and Cotter joint, Socket and Spigot joint. **03L+05P Hrs.**
   - **ii.** Pipe joint: Flanged type, Union Joint, Expansion joint **03L+05P Hrs.**
   - **iii.** Valves: Stop valve, Lever safety valve, Rams Bottom safety valve, Non-return valve, Plug valve **04L+13P Hrs.**

Note:

- First angle projection to be followed.
- Drafter to be used for all drawings.

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Reference Books:

1) Gopal Krishna, K.R., "Machine Drawing," 2/e. Subhash Publication

2) Joshi, M.V., “Process Equipment Design” 3/e, Macmillan India publication.
3) Bhat N.D., “Machine Drawing”. Charotar Publishing, 50/e, 2011
4) VilbrantandDryden., “Chemical Engineering Plant Design” Publisher: New York, McGraw-Hill, 1959.

18UCHL305	Particulate Technology Laboratory	(0-0-3) 1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To get hands on experience on various unit operations by conducting experiments on size separation, size reduction, filtration etc.
2. To analyze experimental data and project in the form of a report and oral presentation.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the average particle diameter by sieve and sub-sieve analysis experiments.	4, 15	10	9
CO-2	Evaluate the energy consumed for the size reduction of solid samples by applying size reduction laws.	4, 15	10	9
CO-3	Calculate the medium and cake resistance in filtration equipment’s.	4, 15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Performance study of size reduction using Ball mill
2. Particle Size Analysis using ICI sedimentation
3. Particle Size Analysis using Beaker decantation
4. Separation of solids using Cyclone
5. Performance study of size reduction using Drop weight crusher

6. Performance study of size reduction using Jaw crusher
7. Determination of specific cake and medium resistance using Leaf filter
8. Determination of specific cake and medium resistance using Plate and frame filter
9. Screen effectiveness studies
10. Particle Size Analysis using Sieves
11. Batch Sedimentation Test and thickener design
12. Particle Size Analysis using Air Elutriator

Note: Minimum 10 experiments to be conducted

Reference Books:

1) McCabe and Smith, "Unit Operations of Chemical Engineering" 6/e, McGraw Hill International
2) Foust A.S. et al., "Principles of Unit Operations", John Wiley and Sons

18UCHL306	Technical Analysis Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To get hands on experience on various analysis of materials
2. To analyze experimental data and understand the importance of Chemical analysis

Course Outcomes(COs):

Description of the course outcome: At the end of course, the student will able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the various properties of the solids and fluids given.	4, 15	10	9
CO-2	Estimation and characterization of the given material.	4, 15	10	9
CO-3	Analysis of various fluids with the measuring techniques used.	4, 15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Conductometric titration an Acid vs Base.
2. Standardization of potassium permanganate.
3. Determination of percentage of available chlorine present in bleaching power sample.
4. Determination of moisture content of soil and ash content of coal.
5. Determination of calorific value of solid &liquid fuels by bomb colorimeter.
6. Estimation of hardness, calcium and chlorides in water sample.
7. Determination of optimum dosage of alum of raw water.
8. Determination of bulk density, porosity and specific surface area of a sample.
9. Estimation of oil in seeds by solvent extraction method.
10. Qualitative analysis of proteins and amino acids.
11. Qualitative analysis of carbohydrates and lipids.
12. Estimation of total loss on ignition of cement sample.
13. Estimation of reducing sugar by DNS method.
14. Estimation of sulphates and nitrates in a given water sample.

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jaffery, G.H., Basset, J., et al., “Vogel’s Text book of Quantitative Inorganic Analysis” 5/e, ELBX. 1998
2) Skoog, D.A., “Principles of Instrumental Analysis” 3/e, Saunders College publishing 1985.

IV Semester

18UMAC400	Engineering Mathematics-IV	(3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLO):

1. To provide an insight into applications of conformal mapping, integration of complex functions and application of probability distributions in Engineering.

Course Outcomes (COs):

Description of the Course Outcomes: At the end of the course the student will be able to:		**Mapping to POs(1-12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Construct and use the concepts of analytic function to solve the problems arising in Engineering field.			1
CO-2	Utilize conformal transformation and complex integral to transform irregular domain onto a relatively simple domain.		1	
CO-3	Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.		1	
CO-4	Make use of the correlation and regression analysis to fit a suitable mathematical model for the statistical data.		1,2	
CO-5	Estimate the correlation, covariance using joint probability distributions. Also use student's t-distribution, Chi-square distribution as a test of goodness of it.		1,2	

Pos	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	1.8	2	-	-	-	-	-	-		-	-	-

Pre-requisites: 1.A basic course on Differentiation and integration of function.
2. A basic course on probability and statistical averages.

Contents:

Unit-I

Calculus of complex functions: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms. Construction of analytic functions: Milne-Thomson method-Problems. **07 Hrs.**

Unit-II

Conformal transformations: Introduction. Discussion of transformations $w = e^z; w = z^2, w = z + \frac{1}{z}, z \neq 0)$. Bilinear transformations- Problems.

Complex integration: Line integral of a complex function, Cauchy's theorem and Cauchy's Integral theorem. **08 Hrs.**

Unit-III

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation-problems. Regression analysis- lines of regression–problems.

Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form = $ax + b; y = ax^2 + bx + c; y = ax^b$. **08 Hrs.**

Unit-IV

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions-problems (No derivation for mean and standard deviation)-Illustrative examples. **08 Hrs.**

Unit-V

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation and covariance.

Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness offit. **08 Hrs.**

Reference Books:

1) B.S. Grewal "Higher Engineering Mathematics", Khanna Publishers, 44/e, 2017.
2) E. Kreyszig "Advanced Engineering Mathematics", John Wiley & Sons, 10/e (Reprint), 2016.
3) Srimanta Pal et al., "Engineering Mathematics", Oxford University Press, 3/e, 2016.

18UCHC400	Process Heat Transfer	(4-0-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Solve heat transfer by conduction in solids and extended surfaces for steady state with estimation of critical insulation.	1	2	13
CO-2	Interpret and solve heat transfer by forced and natural convection	-	2	13
CO-3	Outline ofevaporators and solve heat transfer by radiation.	3	2	13
CO-4	Determine heat transfer in condensation.	13	2	3
CO-5	Analyze the performance of heat exchange equipments.	13	2	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	2.0	1.66	-	-	-	-	-	-	-	-	-	1.8	-	-

Course Content:

Unit-I

Introduction to three modes of heat transfer: Conduction convection & radiation. **Conduction:** Fourier's law, Thermal Conductivity – its variation with temperature, analogy between heat flow and electrical flow. heat transfer through composite walls, cylinders and spherical systems.Overall heat transfer coefficient. Different types of insulating materials, general properties & application of insulators,critical and optimum thickness of insulation, Extended surfaces: heat transfer from a fin, fin effectiveness and efficiency. **12 Hrs.**

Unit-II

Convection: Types of convection heat transfer**Forced Convection:**Significance of Prandtl No., Nusselt No., correlation equations for heat transfer in laminar and turbulent flows insidecircular tube and duct, Reynolds and Colburn analogy between momentum and heat transfer, **Natural Convection:** Natural convection from vertical and horizontal surfaces, Significance of Prandtl No., Nusselt No., Grashof No Grashof and Rayleigh numbers. **10Hrs.**

Unit-III

Radiation: Radiation laws-Kirchhoff's law Stefan Boltzmann's law, Wien's law, Plank's law etc. Black body, Grey body. Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: radiation transfer between surfaces, radiation shields.

Evaporation: Types of evaporators, single effect evaporator, multiple effect evaporators: forward, mixed, parallel and backward feeds, capacity and economy of evaporators. **09 Hrs.**

Unit-IV

Condensation: drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal and vertical tube, types of condensers **09 Hrs.**

Unit-V

Heat Exchangers: Types of heat exchangers, components of a double pipe & Shell-and Tube Heat Exchangers, LMTD and correction factor,standards,fouling. Analysis of HE's-LMTD, ε-NTU method **12 Hrs.**

Reference Books:

1) J.P.Holman," Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2) Rao Y.V.C., "Heat Transfer", Editionillustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3) McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4) Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1.6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

18UCHC401	Chemical Reaction Engineering- I	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To provide basic understanding of kinetic models and mechanisms for homogeneous chemical reactions.
2. To understand the interpretation of reactor data and thereby exploring the rate law for chemical reactions.
3. To provide an understanding and application of rate law in design of Ideal reactors and to assess their performances based on temperature effects.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine rate, rate constant, activation energy and order of reaction.	-	1	-
CO-2	Analyze and interpret batch reactor data	4	-	1
CO-3	Design batch reactor, ideal PFR and MFR	4	2	13
CO-4	Analyze the performance of reactors with multiple reactions, recycle reactor	4	2	13
CO-5	Interpretthe effect of temperature on reactor performance.	-	2	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.5	2.0	-	3.0	-	-	-	-	-	-	-	-	1.0	-	-

Course Content:

Unit-I

Kinetics of homogeneous reactions: Scope of Chemical Reaction Engineering, classification of reactions, Rate equation and rate of reaction. Molecularity and order of reaction Factors affecting the rate of reaction. Chemical kinetics and equilibrium constant. Temperature dependency of rate constant from Arrhenius, collision, and Transition state theories. Elementary and non-elementary reactions. Kinetic models for non- elementary reactions. **08 Hrs.**

Unit-II

Interpretation of Batch Reactor Data: Constant volume batch reactor. Analysis of total pressure data, Integral anddifferential methods of analysis for constant and variable volume reactions, Half life and method of excess. Reversible first and second order reactions, series, parallel and autocatalytic reactions. **12Hrs.**

Unit-III

Ideal Reactors for Single Reaction: Ideal batch reactor, steady-state mixed and plug-flow reactors, holding, space timeand space velocity for flow reactors. **12 Hrs.**

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Unit-IV

Multiple Reactions and Reactors: Design of Batch, plug and mixed flow reactors for parallel, series reactions. Recycle reactors, Yield and selectivity. **10 Hrs.**

Unit-V

Heat effects: Heat of reactions, equilibrium constant, optimum temperature progression. Conversion in reactors operated under adiabatic and nonadiabatic conditions. Reactor design by solving material and energy balance equations simultaneously. Choosing the right kind of Reactor. **10 Hrs.**

Reference Books:

1) Octave Levenspiel, "Chemical Reaction Engineering", 3/e, John Wiley & Sons, 2004, ISBN:978-81-265-1000-9
2) J. M. Smith, "Chemical Engineering Kinetics", 3/e, McGraw Hill, 1981.ISBN:0-07 066574-5
3) H. Scott Fogler, "Elements of Chemical Reaction Engineering", 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

18UCHC402	**Chemical Engineering Thermodynamics**	**(3-2-0) 4**

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To relate state changes in a system to the quantity of energy in the form of heat and work transferred across its boundaries.
2. Understanding of the laws of thermodynamics and their application in the analysis of chemical and engineering problems.
3. Calculating thermodynamic properties of fluids and fluid mixtures using equation of state.
4. Determining equilibrium compositions of chemical reactions and two-phase liquid/vapor mixtures.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	State thermodynamic laws, analyze and evaluate pressure, volume and temperature with equations of state for gases.	1	-	2, 13
CO-2	Evaluate the entropy changes associated with processes and	1	2, 13	3

	analyse the fundamental equations governing thermodynamics.			
CO-3	Differentiate between ideal and non- ideal solutions and calculate the partial molar properties.	1,2,3,13	-	-
CO-4	Generate VLE data for solutions using correlations and interpret their consistency.	1,2,3,13	-	-
CO-5	Determine the conversion at equilibrium and predict the effect of controllable variables on conversion.	1,2,3,13	-	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.4	2.5	-	-	-	-	-	-	-	-	-	2.4	-	-

Course content:

Unit-I

Basic Concepts and First Law of Thermodynamics: Types of properties, functions, reversible and irreversible processes, zeroth law of thermodynamics, general statement of first law of thermodynamics, first law for cyclic process and non-flow processes, heat capacity. Derivation for closed system and steady state flow process.
P-V-T Behaviour: P-V-T behaviour of pure fluids, equations of state and ideal gas law, processes involving ideal gas law, Equations of state for real gases: van der Waals equation, Redlich – Kwong equation, virial equations, principles of corresponding states. **9L+2T Hrs.**

Unit-II

Second Law of Thermodynamics: Statements, heat engines, heat pumps, concept of entropy, Carnot's principle, calculations of entropy change, Clausius Inequality, entropy and irreversibility, third law of thermodynamics.
Thermodynamic Properties of Pure Fluids: Types ofthermodynamic Properties, Work function, Gibbs free energy. Fundamental property relations: Exact differential equations, Fundamental property relations, Maxwell's equations, equations for U and H, entropy- heat capacity relations, Clapeyron equation, Gibbs-Helmholtz equation, fugacity and fugacity coefficient, determination of fugacity of pure fluids. **10L+2T Hrs.**

Unit-III

Properties of Solutions: Partial molar properties, Gibbs-Duhem equation, chemical potential, fugacity in solutions, Henry's law and dilute solutions, activity in solutions, activity coefficients, property changes of mixing, excess properties. **8L+2T Hrs.**

Unit-IV

Phase Equilibria: Criteria of phase equilibria and stability, phase equilibria in single and multicomponent systems, Duhem's theorem, vapor-Liquid equilibria, ideal and nonideal solutions, VLE at low pressures, VLE correlations, G-D equation for VLE, consistency tests, VLE at high pressures, liquid-liquid equilibrium. **8L+2T Hrs.**

Unit-V

Chemical Reaction Equilibria: Reaction stoichiometry, criteria of chemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature and pressure on equilibrium constants and other factors affecting equilibrium conversion, liquid phase reactions, heterogeneous reaction equilibria, phase rule for reacting system. **7L+2T Hrs.**

Reference Books:

1) Smith, J.M. and Vanness, H.C., "Introduction to Chemical Engineering Thermodynamics", 7/e, McGraw Hill, New York, 2005.
2) Narayanan, K.V., "Textbook of Chemical Engineering Thermodynamics", Prentice Hall of India Private Limited, New Delhi, 2001.
3) Rao, Y.V.C., "Chemical Engineering Thermodynamics", New Age International Publication, Nagpur, 2000.
4) Sandler and Stanley, "Chemical, Biochemical and Engineering Thermodynamics", 4/e, John Wiley, 2007. ISBN 0471661740.

18UCHC403	Pollution Control Engineering	(3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To create awareness on the various environmental pollution aspects and issues and give a comprehensive insight into natural resources, ecosystem, and biodiversity.
2. To understand the different parameters, treatment methods and control techniques of various environmental pollution.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the importance of the environment, standards and legislation of environment and interpret various waste water	-	14	3, 6, 7

	parameters.			
CO-2	Develop and design the different methods of waste water treatment techniques.	3, 6, 7	14, 15	-
CO-3	Identify the sources and effects of different types of air pollutants, their prevention and design of control techniques.	14	3, 6, 7	-
CO-4	Illustrate the different methods for handling and disposal of solid waste and control measures of noise pollution in industries	14	3, 6, 7	-
CO-5	Identify, interpret and suggest the treatment technology for different pollutants in a typical industry	14, 15	7	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	-	2.6	2.5

Course content:

Unit -I

Introduction: Importance of Environment for Mankind. Engineering, ethics and environment.Ecological systems and pollution, hydrological cycle and nutrient cycle.Damages from environmental pollution. Fundamental definition of pollution parameters- air, water and soil quality criteria, standards and legislation and acts, EIA, EIS and EMP. Air, water and soil pollution management through waste minimization. **Sources, Sampling and Analysis of Waste Water:**Water Resources. Wastewater Classification.Types of Water Pollutants. Waste Water Sampling, Methods of Analysis: DO, BOD, COD, TOC, Nitrogen, Phosphorus, Trace Elements and Alkalinity. **08 Hrs.**

Unit-II

Waste Water Treatment: Wastewater Treatment: Preliminary, Primary, Secondary and Tertiary. Advanced wastewater Treatment: Adsorption on Activated Carbon, Ion Exchange, Reverse Osmosis, Electro dialysis cell.Design of sedimentation tanks and biological treatment processes. **09 Hrs.**

Unit-III

Air Pollution and Treatment: Definition, Sources, Classification, Properties of air pollutants, Effects of air pollution on health vegetation and materials. Air pollution sampling: Ambient sampling and Stack sampling.Analysis of air pollutants.Air pollution meteorology (generation transportation and dispersion of air pollutants). Control methods and Equipment's for particulates and gaseous pollutants. Selection design and performance analysis of air pollution control equipment: gravity settling chambers, cyclone separator, ESPs, filters and wet scrubbers. **08 Hrs.**

Unit-IV

Solid Waste Treatment and Noise Pollution: Sources and Classification, Effect on public health, Methods of Collection, onsite handling, storage and processing techniques, Disposal Methods, Reuse, Recovery and Recycling of Solid Waste.Solids waste disposal– compositing, landfill, briquetting/gasification and incineration.Definition, Sources, Effects of Noise, and Equipment's used for Noise Measurement, Approaches for Noise Control. **07 Hrs.**

Unit-V

Case Studies: Industrial case studies – Diary, petroleum refinery, pulp and paper, fertilizer, distillery, textile processing, Cement, Thermal power plants, metallurgical industries. **07 Hrs.**

Reference Books:

1) C. S. Rao "Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2) S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill.
3) Metcalf and Eddy, "Waste Water Engineering Treatment Disposal Reuse" Tata McGraw Hill, 4/e, 2003.
4) Frank Kreith and George Tchobanoglous- "Hand book of Solid waste Management", Tata Mc-Graw Hill, 2/e.

18UCHC404	Energy Technology and Management	(3-0-0) 3

Contact Hours:39

Course Learning Objectives (CLOs):

1. Understand the utilization of conventional and non – conventional energy sources and the principle of working of related equipments.
2. Recognize the effects of current energy systems on the environment and society.
3. Study energy costs/waste minimization without affecting production and quality.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/ PSOs(13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and comprehend the effects of current energy systems	2	13	1

	based on solid and gaseous fuels.			
CO-2	Analyze the principles and concepts and explain basic principles involved in solar and wind energy conversion system.	1	, 13	3, 14
CO-3	Describe the challenges and problems associated with Bio-energy and fuel cell technology, and explain its basic principles and operations.	2	1	3, 14
CO-4	Summarize the basic principle and production process of ocean and tidal energy sources with regards to future energy supply and environmental concern.	3	1,13	2,14
CO-5	Discuss the principles and need of energy audit and management programs.	14	2,13	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.8	2.25	1.66	-	-	-	-	-	-	-	-	-	2.0	1.5	-

Course Content:

Unit-I

Introduction to Energy Sources: World energy futures, Indian energy scenario, Conventional and non-conventional energy sources.**Fuels:** Classification, properties and tests and analysis of solid, liquid and gaseous fuels. **08 Hrs.**

Unit-II

Solar Energy: Solar constant, Solar radiation at earth's surface, Solar radiation geometry, Solar radiation measurement. Solar water heating, space cooling, Solar distillation, pumping and Solar cooking- Basic principles, methods, applications, advantages and limitations.**Wind Energy:** Introduction, Basic components of WECS (wind energy conversion system). Classification of WEC Systems.Types of wind energy machines- (wind energy collectors) horizontal axis, vertical axis machines. **09 Hrs.**

Unit-III

Bio-Energy: Introduction, Biomass conversion technology, Wet and Dry process,Factors affecting Bio digestion or Generation of gases, Classification of Bio gas plants, Floating Drum, Fixed Dome plants -Basic principles, Construction and Working principles, Advantages and disadvantages. **Fuel Cells**:Design and Principle of operation, Classification, Types, Advantages and disadvantages, Conversion efficiency, Types of electrodes, Work output and EMF of Fuel Cells, Applications of Fuel Cells. **08 Hrs.**

Unit-IV

Geothermal and Ocean Energy: Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India**.Ocean Energy:** Principle of working, performance and limitations of Wave Tidal Energy. Ocean Thermal Energy-Availability, theory and working principle, performance and limitations. **07 Hrs.**

Unit-V

Energy Management: Principles and needs initiating and managing an energy management programs. **Energy Audit**: Elements and concepts, Types of Energy Audits, Energy Audit of any one chemical industries. **07 Hrs.**

Reference Books:

1) G.D. Rai, "Non-Conventional Energy Sources", 4/e Second Reprint, Khanna Publications", 1997.
2) P.C. Jain and M. Jain, "Engineering Chemistry", 10/e, 3rd Reprint, DhanpatRai and Sons, 1995.
3) S.P. Sukhatme, "Solar Energy", 2/e, 3rd Reprint, Tata McGraw Hill, New Delhi, 1998.
4) G.D. Rai, "Solar Energy Utilization", 4/e, Khanna Publications.
5) G.N.Tiwari and M.K.Ghosal, "Renewable Energy Resource: Basic Principles and Applications", Narosa Publishing House, 2004.

18UCHL405 Computational Methods and Simulation Laboratory (0-0-3) 1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the application of mathematics using computer to solve the simple Chemical Engineering problems.

Course Outcomes(COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Solve chemical engineering problems using the analytical methods and programming.	4, 5,15	10	9

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CO-2	Compute the chemical engineering problems with nonlinear-algebraic equations.	4, 5,15	10	9
CO-3	Compute the chemical engineering problems with numerical integration	4, 5,15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	3.0	-	-	2.0	1.25	2.25	-	-	-	-	3.0

List of Experiments:

1. Review of C – language program.
2. Conversion of pressure, temperature and volume.
3. Numerical integration of ordinary differential equation R-K method
4. Nonlinear algebraic equation - Newton Raphson method.
5. Numerical Integration – Simpson's1/3 rule.
6. Curve fitting – Least square method
7. Double pipe heat exchanger (Area, Length)
8. Bubble and dew point calculation.
9. Introduction to Unisim design Software
10. Simulation studies of flash drum
11. Simulation studies of CSTR
12. Simulation studies of Heat Exchanger.
13. Simulation studies of Mixer

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Jenson, V.J. and Jeffereys, G.V., "Mathematical Methods in Chemical Engineering", Academic Press, London and New York, 1977.
2) Mickley, H.S., Thomas. K. Sherwood and Road, C.E., "Applied Mathematics in Chemical Engineering", Tata McGraw-Hill Publications, 1957.
3) S. Pushpavanam, "Mathematical Methods in Chemical Engineering", PHI
4) E. Balagurusamy, "Programming in ANSI C", 6/e, TMH 2012.

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18UCHL406	Fluid Mechanics Laboratory	(0-0-3) 1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the principle, construction, working and analysis of different equipments in the fluid flow phenomena.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs(13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Calculate the discharge rate for flow measuring devices and pumps	4,15	10	9
CO-2	Distinguish the types of pipe fitting and identify their applications	4,15	10	9
CO-3	Identify the flow pattern of the fluid and evaluate the friction factor of the spiral coil	4,15	10	9
CO-4	Calculate the minimum fluidization velocity	4,15	10	9
CO-5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.2	2.2	-	-	-	-	3.0

List of Experiments:

1. Characteristics of fluidized bed.
2. Develop the characteristic curve for centrifugal pump
3. Local velocity measurement using Pitot tube.
4. Develop the characteristic curve for positive displacement pump
5. Characteristic of packed Bed
6. Significance of Reynolds number
7. Flow through spiral coil
8. Characteristics of Orifice meter and venturi meter
9. Friction in circular pipes
10. Different pipe fittings and its constant value

11. Weir characteristics
12. Pressure, velocity and elevation heads in Bernoulli's theorem

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) McCabe and Smith, "Unit operations of Chemical Engineering" 7/e, McGrawHill.
2) Coulson J.H and Richardson J.F, "Chemical Engineering" Vol-1, 5/e. Butterworth publications.
3) Kumar K.L., "Engineering Fluid Mechanics", 8/e, S. Chand and Co. Ltd. ISBN-10: 8121901006
4) R. K. Bansal, "A textbook of Fluid Mechanics" 2/e, Laxmi Publications. ISBN: 9788131802946

18UCHL407	Introductory Project	(0-0-2) 1

Contact Hours: 24

Course Learning Objective (CLO):

1. To identify and understand the community expectation in terms of possible engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) / PSOs(13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Identify the problem.	2,10	12	7, 14
CO-2	Compare the literature review and select suitable existing solutions.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Prepare work plan with economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report with proper guidelines and references.	10	8,15	9

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	3.0	3.0	3.0	3.0	-	1.0	2.0	1.0	2.25	2.5	2.0	-	1.0	2.7

Introductory project is introduced with an objective of understanding and identifying the community expectation in terms of possible Engineering solutions by applying the fundamental knowledge of basic sciences and basic engineering courses. The project shall be engineering oriented in terms of problem definition, related literature survey and existing solutions. The team consisting of 10-12 students shall be asked to identify problems related to community and try to propose a solution. The faculty members handling the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for introductory project.

Reference Books/Material:

1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field

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Academic Program: UG

Academic Year 2021-22

Syllabus

V & VI Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institution approved by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465** **Fax: 0836-2464638** **Web:** www.sdmcet.ac.in

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SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for V & VI semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2021-22 till further revision.

Principal | Chairman BoS & HoD

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College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

- ✣ In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs)

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

I. Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.

II. Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.

III. Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.

IV. Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific outcomes (PSOs)

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

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Scheme for V Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UHUC500	HU	Management, Entrepreneurship and IPR	4-0-0	4	50	100	3	-	-
18UCHC500	PC	Chemical Reaction Engineering-II	4-0-0	4	50	100	3	-	-
18UCHC501	PC	Mass Transfer – I	3-2-0	4	50	100	3	-	-
18UCHC502	PC	Chemical Equipment Design-I	3-0-0	3	50	100	3	-	-
18UCHC503	PC	Chemical Process Integration	3-0-0	3	50	100	3	-	-
18UCHE50X	PE	Program Elective – 1	3-0-0	3	50	100	3	-	-
18UCHL504	PC	Heat Transfer Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL505	PC	Environmental Engineering Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL506	PC	Minor Project-1	0-0-2	1	50	-	-	-	-
18UHUL507	HU	Soft Skills/Aptitude	0-0-2	1	50	-	-	-	-
Total			**20-2-10**	**26**	**500**	**600**		**100**	
Electives									
18UCHE508	PE	Petroleum and Petrochemicals	3-0-0	3	50	100	3	-	-
18UCHE509	PE	Polymer Science and Technology	3-0-0	3	50	100	3	-	-
18UCHE510	PE	Air Pollution and Control Engineering	3-0-0	3	50	100	3	-	-

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Scheme for VI Semester

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UCHC600	PC	Mass Transfer – II	4-0-0	4	50	100	3	-	-
18UCHC601	PC	Chemical Equipment Design-II	4-0-0	4	50	100	3	-	-
18UCHE60X	PE	Program Elective – 2	3-0-0	3	50	100	3	-	-
18UCHE60X	PE	Program Elective – 3	3-0-0	3	50	100	3	-	-
18UCHO60X	OE	Open Elective	3-0-0	3	50	100	3	-	-
18UCHL602	PC	Mass Transfer Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL603	PC	Chemical Reaction Engineering Laboratory	0-0-3	1.5	50	-	-	50	3
18UCHL604	PC	Minor Project– 2	0-0-4	2	50	-	-	50	3
18UHUL605	HU	Soft Skills/Aptitude	0-0-2	1	50	-	-	-	-
Total			**17-0-12**	**23**	**450**	**500**		**150**	
Electives									
18UCHE606	PE	Transport Phenomena	3-0-0	3	50	100	3	-	-
18UCHE607	PE	Catalyst Technology	3-0-0	3	50	100	3	-	-
18UCHE608	PE	Plant utilities and Industrial Safety	3-0-0	3	50	100	3	-	-
18UCHE609	PE	Drug and Pharmaceutical Technology	3-0-0	3	50	100	3	-	-
18UCHE610	PE	Food Engineering	3-0-0	3	50	100	3	-	-
18UCHE611	PE	Applied Mathematics in Chemical Engineering	3-0-0	3	50	100	3	-	-
18UCHO612	OE	Advanced Waste Water Treatment	3-0-0	3	50	100	3	-	-
18UCHO613	OE	Biology for Engineers	3-0-0	3	50	100	3	-	-
18UCHO614	OE	Composite Materials	3-0-0	3	50	100	3	-	-

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination

L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the third year: 49

V Semester

18UHUC500 Management, Entrepreneurship and IPR (4–0–0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. To understand the importance, development and different functions of management.
2. To provide basic concepts of entrepreneurship, intellectual property rights and legal issues.

Course Outcomes (COs):

Description of the course: At the end of course, the student will able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain historical development and levels of management along with importance of planning and organizing	7,8	9,10	6
CO-2	Explain staffing, directing and controlling in modern organization structures.	7,8	9, 10	6
CO-3	Summarize the role of entrepreneurs in economic development and asses impact of liberalization and globalization on SSI.	7,8	9, 10	-
CO-4	Identify Institutional support to small scale industries and prepare project report and its feasibility studies.	8,11	9, 10, 14	-
CO-5	Describe forms of intellectual property rights and procedure for registration, infringements and penalties.	10,12	6,7,8	-

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	-	-	-	-	-	1.3	2.75	2.8	2.0	2.2	3.0	3.0	-	2.0	-

Course Content:

Unit-I

Management: Meaning, nature and characteristics of management. Levels of management, development of management thoughts, modern management approaches.

Planning and Organizing: Nature, importance, purpose and objectives of planning. Types of plans, decision making and hierarchy of plans. Types of organization, departmentation, committees, organization levels and span of control. **12 Hrs.**

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Unit-II

Staffing and Directing: Nature, importance, selection and recruitment. Leader ship styles, motivation, communication and coordination.

Controlling: definition, steps in controlling, essentials of a sound control system and methods of establishing controlling. **11 Hrs.**

Unit-III

Entrepreneurship: Evolution, meaning and characteristics of entrepreneur. Functions and types of entrepreneurs, role of entrepreneurship in economic development and barriers of entrepreneurship.

Small Scale Industry: Role of SSI in economic development, advantages SSI, steps to start a SSI. Impact of liberalization, privatization and globalization. Ancillary and tiny industries. **10 Hrs.**

Unit-IV

Institutional Support: Introduction, Institutions to assist SSI. Objectives and functions of SSIDC, SSIB, DICs, TCOs, ICICI, NSIC, SIDO, IDBI and SIDBI etc.

Preparation of Project Report: Project identification, selection, contents, feasibility studies and network analysis. **10 Hrs.**

Unit-V

Intellectual Property Rights: meaning and forms of IPR, international conventions, world court. Copy right, patents, Industrial designs and trademarks. Procedure for registration, infringements and remedies. Offenses and penalties. **9 Hrs.**

Reference Books:

1) Thomas W. Zimmerer, “Essentials of Entrepreneurship”, PHI, 2005.
2) Veerabhadrappa Havinal, “Management and Entrepreneurship”, 1/e, ISBN (13): 978-81-224-2659-5, New Age International, 2009.
3) Peter Drucker, “The Practice of Management”, ISBN-10: 0060878975 Harper Business Reissue edition, 2006
4) N.K. Acharya, “Text book on Intellectual Property Rights”, 4/e, Asia Law House.

18UCHC500	Chemical Reaction Engineering-II	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand Non-Ideal flow behavior in Chemical reactors.
2. To provide the forum to understand the Principles and concepts involved in Catalytic reactions.
3. To understand kinetics of heterogeneous reactions (Non-Catalytic) and apply the same for reactor design.

Course Outcomes (COs):

Description of the course outcome: At the end of the course, student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Define residence time distribution and determine conversion using single parameter models for real reactors.	2	-	1
CO-2	Apply various models for fluid-particle reactions and design reactors for ideal flow patterns.	3, 13	2	4
CO-3	Develop rate equations for fluid-fluid reactions and design reactors for ideal flow patterns.	3, 13	2	4
CO-4	Select various methods to estimate properties of solid catalyst, controlling mechanisms and reactor design.	3, 4, 13	1	-
CO-5	Develop deactivation kinetics and design catalytic reactor with regeneration.	3	4	-

POs/PSOs	**PO -1**	**PO -2**	**PO -3**	**PO -4**	**PO -5**	**PO -6**	**PO -7**	**PO -8**	**PO -9**	**PO -10**	**PO -11**	**PO -12**	**PSO -13**	**PSO -14**	**PSO -15**
Mapping Level	1.5	2.3	3.0	1.75	-	-	-	-	-	-	-	-	3.0	-	-

Prerequisite: Chemical Reaction Engineering-I

Course content:

Unit-I

Non-ideal Flow: Causes for non-ideal flow, the residence time distribution (RTD), E, C and F. Curves, Experimental methods for finding extent of non-ideal behavior, Micro and macro mixing, conversion in non-ideal flow reactors from tracer information, dispersion model and tanks-in-series model. **12 Hrs.**

Unit-II

Fluid-Particle Reactions: Introduction to heterogeneous non-catalytic reactions, industrial examples, overall rate expression, Ideal contacting patterns, progressive conversion and shrinking core model, overall rate expression for various controlling mechanisms from shrinking core model, conversion – time expressions, Design of reactors for particles of single size and different sizes under ideal flow patterns. **10 Hrs.**

Unit-III

Fluid – Fluid Reactions: Industrial examples, Rate equations for straight mass transfer and mass transfer with chemical reaction, various kinetic regimes, liquid film enhancement factor, Role of Hatta number, Design of reactors for fluid-fluid reactions under co current and counter current operations based on ideal flow patterns. **10 Hrs.**

Unit-IV

Solid Catalyzed Reactions: The nature and mechanism of catalytic reactions, Adsorption isotherms, physical, chemical dynamic and mechanical properties of solid catalyst and their determination, catalyst preparation, overall rate expressions for various controlling mechanisms. Experimental methods to determine rate equation. **10 Hrs.**

Unit-V

Catalyst Deactivation: Causes for deactivation, mechanisms of deactivation, Experimental methods to find deactivation kinetics using Batch- solids and Batch-fluids, Batch solids and Mixed constant and variable flow of fluid, Batch solids and plug constant and variable flow of fluid. Deactivation with regeneration. **10 Hrs.**

Reference Books:

1) Octave Levenspiel, "Chemical Reaction Engineering", 3/e, John Wiley and Sons, 2004, ISBN:978-81-265-1000-9
2) J. M. Smith, "Chemical Engg Kinetics", 3/e, McGraw Hill, 1981. ISBN:0-07-066574-5
3) H. Scott Fogler, "Elements of Chemical Reaction Engineering", 3/e, Prentice Hall 2006. ISBN: 978-81-203-3416-8

18UCHC501 Mass Transfer- I (3-2-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the fundamentals and principles of diffusion mechanism in all the phases of matter along with equilibrium diffusion between the phases with an insight of interphase mass transfer.
2. To understand and apply analogy between transport processes along with an insight of interphase mass transfer applied to industrial diffusion separations, obtain transfer coefficients to propose and evaluate experimental investigations on mass transfer.

Course Outcomes (COs):

Description of the course outcome: At the end of the course, student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Appraise of the mechanisms of molecular and turbulent diffusion both in fluids and solids and develop mathematical expressions for one dimensional steady state diffusion.	3	1,7,13	-

CO-2	Apply interphase concept using transfer coefficients to evaluate stage efficiencies.	3	1,13	-
CO-3	Analyze using interphase concept in crystallization along with stoichiometric calculations to evaluate performance of crystallizers.	3	1,7,13	-
CO-4	Apply interphase concept to humidification process, configurations and design of cooling tower for air-water system.	3	1,13	-
CO-5	Apply interphase concept to drying and adsorption along with stoichiometric computations and analyze stage wise operations.	3	1,7,14	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.0	-	3.0	-	-	-	2.0	-	-	-	-	-	2.0	2.0	-

Course content:

Unit-I

Diffusion: Types, importance, molecular versus turbulent diffusion, molecular diffusion in fluids, rates of diffusion, Fick's I-law. Diffusion in a binary system, steady state unidirectional diffusion in the fluids at rest and laminar flow. Cases with examples: 1. Unicomponent diffusion and 2. Equimolal counter diffusion. Pseudo steady state diffusion. Diffusivity of gases, empirical treatment. Convective mass transfer, Local and Overall mass transfer coefficients and correlations. Analogies; Reynold's, Prandtl's, Von Karman's, and Chilton and Colburn J-factor. Theories of convective mass transfer; Diffusion in solids, importance, types with different geometrical shapes **8L+2T Hrs.**

Unit-II

Interphase Mass Transfer: Introduction, concentration profile. Use of Film Transfer Coefficients in unicomponent diffusion and equimolal counter diffusion. Use of Overall Transfer Coefficients. Graphical approach, equilibrium diffusion between the phases, types of operations. Material balance in each process. Stages, efficiencies

8L+2T Hrs.

Unit-III

Crystallization: Introduction, importance with examples, solubility concept, equilibrium solubility etc. Saturation/equilibrium, super saturation, mechanism of crystallization etc. Myer's theory of super saturation, Methods of generating super saturation. Nucleation types, crystal breeding, growth regimes. Ostwald's ripening, crystal growth and coefficients, crystal size and shape factors. Material and balance calculations, ΔL law of crystal growth, caking of crystals. **8L+2T Hrs.**

Unit-IV

Humidification: Importance and terminology, Psychrometric chart for air-water system. Measurement of Wet Bulb Temperature, Adiabatic Saturation Temperature, Lewis relation. Cooling towers, Theory of cooling towers. Types, construction and working. Design of cooling towers, NTU and HTU. **8L+2T Hrs.**

Unit-V

Drying: Importance with examples. Terminology in drying. Graphical representations of various terms. Typical rate of drying curve. Drying time calculations. Mechanism of drying, use of heat transfer and mass transfer coefficients. Theories of moisture movement. Industrial Dryers. **Adsorption**: Introduction, importance with examples, applications. Types of adsorption; nature of adsorbents, Adsorption equilibria; isotherms, isobars and isosteres. Adsorption calculations, Stage wise calculations and graphical representation. Adsorption equipments. **10L+2T Hrs.**

Reference Books:

1) Robert E. Treybal, “Mass Transfer Operations”, 3/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 1981 ISBN: 0-07-066615-6.
2) Warren L. McCabe, Julian C. Smith and Peter Harriott, “Unit Operations of Chemical Engineering”, 6/e., McGraw-Hill International Editions, Chemical Engineering Series, Singapore; 2001; ISBN: 0-07-118173-3.
3) Christie J. Geankoplis, “Transport Processes and Unit Operations”, 3/e., Prentice Hall of India, New Delhi; 1993; ISBN: 13: 978-0139304392.
4) Binay K. Dutta, “Principles of Mass Transfer and Separation Processes”, PHI Learning, New Delhi; 2009; ISBN-13-9788120329904.

18UCHC502	Chemical Equipment Design-I	(3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To develop key concepts and techniques with relevant codes and standard procedures of different equipment’s.
2. To study the detailed design considerations of different types of equipment’s used in chemical industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Congregate the data from relevant code books and identify the standard procedures for the design of chemical equipment.	13	1	3
CO-2	Congregate the data from relevant code books to design and evaluate the pressure vessels and its components	3, 13	2	1
CO-3	Design and evaluate the reaction vessels and its components.	3, 13	2	1
CO-4	Design and evaluate tall vertical vessels and its components.	3, 13	2	1
CO-5	Estimate the pipe size; pump rating with accessories and Congregate the data to design the storage vessels.	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.2	2.0	2.6	-	-	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Introduction: Design procedure, equipment classification and components, design parameters, pressure vessel codes. Design considerations: Material selection, factors affecting design, stresses due to static and dynamic loads (Internal and External), temperature effects, and economic considerations. **07 Hrs.**

Unit-II

Design of Pressure Vessels: Design parameters, conditions and stresses. Design of shell and other vessel components. Vessel at low and high operating temperatures. Design of components, supports and selection of vessels accessories and mountings. Numerical problems. **09 Hrs.**

Unit-III

Design of Reaction Vessels: Design of reaction tanks-agitators, baffles, jackets, tank dimensions. Power calculations. Drive calculations and accessories. Support calculations for the system. Numerical problems. **07 Hrs.**

Unit-IV

Design of Tall Vertical Vessels: Vessels subjected to wind loads. Multi shell constructions. Determination of shell thickness. Supports for columns. Numerical problems. **07 Hrs.**

Unit-V

Pipe Line Design: Pipe thickness, pipe diameter. Optimum size of delivery line in pumping operations. Pump rating. Numerical problems.

Design of Storage Vessels: Process conditions and design parameters for storage of volatile, nonvolatile fluids and gases. Design of components, supports and selection of vessels accessories and mountings. Roofs for vessel. Numerical problems. **09 Hrs.**

Note: IS code book 2825 for pressure vessel design is permitted in the examinations for reference.

Reference Books:

1) V. V. Mahajani and S. B. Umarji, “Joshi’s Process Equipment Design” – Trinity Press, Delhi, India 4/e.
2) S. D. Dawande, “Process Design of Equipment”, Vol 1, Central Techno Publications. 3/e, 2003.
3) Brownell and Young, “Process equipment design” Willy student, 1/e, 2009
4) Don W. Green and Robert H. Perry, “Chemical Engineers Handbook”, 6/e, McGraw Hill, 2014.
5) Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, New Delhi, 1969.

18UCHC503	**Chemical Process Integration**	**(3-0-0) 3**

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To teach students basic principles and methodologies for energy, mass and material integration for sustainable process synthesis and design.
2. It helps in understanding the usage of material, Heat and Mass effectively for the profit of Industry using pinch analysis.
3. It helps in formulating the design and optimizing the process in plant for the integrated approach.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and explain the importance of process integration and its types.	6,7	3	14
CO-2	Evaluate and analyze the direct recycle strategy through material balance, graphical and algebraic approach.	13	2,3	1
CO-3	Illustrate and develop heat			

	exchange network by pinch diagram and through algebraic approach	13	2,3	1
CO-4	Predict and evaluate the visualization strategies of mass integrated system through graphical and algebraic approach	13	2,3	1
CO-5	Formulate and optimize the different process integration networks along with combined heat and power integration	5,13	-	1,2

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	1.75	2.0	-	3.0	3.0	3.0	-	-	-	-	-	3.0	1.0	-

Course content

Unit-I

Introduction to Process Integration: Importance of process integration, Process synthesis and analysis, Categories of process integration. Mass targeting for minimum discharge of waste and minimum purchase of fresh utilities. **07 Hrs.**

Unit-II

Direct Recycle Strategies: Source-Sink mapping diagram, Multicomponent source sink mapping. Graphical and algebraic approach for direct recycle strategies. Property based pinch diagram. **09 Hrs.**

Unit-III

Heat Integration: Design and synthesis of heat exchange network (HENs). Heat exchange pinch diagram and algebraic approach for pinch point. Grand composite curves (GCC). **08 Hrs.**

Unit-IV

Mass Integration: Synthesis of mass exchange network (MEN). Design and cost optimization of mass exchangers. Algebraic and graphical approach to targeting mass exchange (Mass Integration) **08 Hrs.**

Unit-V

Optimization: Overview of optimization, classification and formulation of optimization programs. Different methods of optimization programming. Approach for direct recycle and synthesis of mass and heat exchange network using a programming language. **Combined heat and power integration** (Heat Pumps and Engines). Cogeneration process targeting. **07 Hrs.**

Reference Books:

1) Mahmoud Halwagi, “Process Integration”, 1/e, Elsevier, 2006.
2) I. C. Kemp, “Pinch analysis and process Integration” 2/e, Butterworth, 2006.
3) Robin smith, “Chemical Process Design and Integration”, 1/e, Wiley, 2005

18UCHL504	Heat Transfer Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To study the phenomena of conduction, convection and radiation effects in different equipments and know the rate of heat transfer.
2. To study the working, construction and analyze the efficiency and performance of heat exchangers.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) / PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Demonstrate and outline the heat transfer coefficient and the performance of DPHE and Cross flow heat exchanger.	4,15	8, 10	9
CO-2	Determine the thermal conductivity of solids and liquids.	4,15	8, 10	9
CO-3	Elucidate and examine the effects of radiation using Stefan Boltzmann apparatus.	4,15	8, 10	9
CO-4	Evaluate the performance and efficiency of extended surfaces and packed bed heat exchanger and recognize the boiler characteristics.	4,15	8, 10	9
CO-5	Evaluate the performance and efficiency of the helical coil and jacketed vessel heat exchangers using the steam and recognize the boiler characteristics.	4,15	8, 10	9

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping level	-	-	-	3.0	-	-	-	2.0	1.0	2.0	-	-	-	-	3.0

List of Experiments:

1. Heat transfer coefficient of Double pipe heat exchanger.
2. Heat Transfer coefficient of Cross flow heat exchanger.
3. Thermal conductivity of liquids
4. Thermal conductivity of solids through lagged pipe.
5. Emissivity determination
6. Stefan – Boltzmann constant using Stefan-Boltzmann apparatus
7. Heat Transfer coefficient and efficiency of Extended surfaces
8. Heat transfer coefficient and Reynolds number effect in Packed bed vertical condenser

9. Heat Transfer coefficient through helical coil
10. Biot number in Unsteady state heat transfer
11. Natural and forced convection in a jacketed vessel
12. Thermal performance of Evaporator

Note: Minimum 10 experiments to be conducted

Reference Books:

1) J.P. Holman, "Heat Transfer", 9/e, Tata McGraw-Hill. New Delhi, 2004, ISBN-13: 9780070634510
2) Rao Y.V.C., "Heat Transfer", Edition illustrated, reprint, University Press. 2001, ISBN 13: 9788173713842
3) McCabe and Smith "Unit Operations of Chemical Engineering".7/e, McGraw-Hill Education, ISBN-13: 978-0072848236
4) Coulson and Richardson, "Unit Operations of Chemical Engineering" Vol.1. 6/e, Butterworth-Heinamann (2006), ISBN-13: 978-8131204535

18UCHL505	Environmental Engineering Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objective (CLO):

1. To understand the employability of instruments in determining various parameters of solid, liquid and gas samples to analyze completely and present a good technical report.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) / PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Reproduce theory and apply into practice for using high precision instruments for analysis.	4,15	10	9
CO-2	Characterize the samples through the use of pollution indicators and report the results.	4,15	10	9
CO-3	Comprehend the use of instruments in projects.	4,15	10	9
CO-4	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report.	9	8, 10	-

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POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.5	2.0	-	-	-	-	3

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List of Experiments:

1. Analysis of effluents for pH, alkalinity and turbidity.
2. Determination of COD and BOD of waste water
3. Volatile, Fixed, Filterable and Dissolved solid analysis of waste water
4. Measurements of particulate matter in ambient Air
5. Analysis of exhaust gas by Orsat Apparatus.
6. Dissolved Oxygen Measurement of water sample
7. Moisture content in liquid sample using KF Auto Titrator
8. Concentration of elements using Flame Photometer
9. Turbidity measurement of water sample using Turbidometer
10. Viscosity measurement of given oil using red wood viscometer
11. End point of titration using mV Titrator

Note: Minimum 10 experiments to be conducted

Reference Books:

1) C. S. Rao “Environmental Pollution Control Engineering" 2/e, New Age International 2006. ISBN: 81-224-1835-X
2) Metcalf and Eddy - "Waste Water Engineering Treatment Disposal Reuse” 4/e, Tata McGraw Hill, 2003.
3) Jaffery, G.H., Basset, J., et. al., “Vogel’s Text book of Quantitative Inorganic Analysis” 5/e, ELBX, 1998.
4) Skoog, D.A., “Principles of Instrumental Analysis” 3/e, Saunders College publishing 1985.

18UCHL506	Minor Project -1	(0-0-2) 1

Contact Hours: 40

Course Learning Objectives (CLOs):

1. To carry out the experimental/design tasks of relatively minor intensity and scope as compared to the major project and in line with the guidelines formulated by the DUGC.
2. To see that this project could be a prologue for the upcoming major projects in the final year.

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Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic related to problems in community under chemical engineering work.	2,10	8, 12	7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	**PO -1**	**PO -2**	**PO -3**	**PO -4**	**PO -5**	**PO -6**	**PO -7**	**PO -8**	**PO -9**	**PO -10**	**PO -11**	**PO -12**	**PSO -13**	**PSO -14**	**PSO -15**
Mapping Level	-	2.0	3.0	2.0	3.0	-	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

The project is undertaken to focus on the domain related problem definitions, building prototypes which can lead to take up the project in the higher semester(s). The work based on the core courses studied shall be used to formulate the problem. The team consisting of 10-12 students shall be asked to identify the problems related to community and try to propose the solution. The faculty members handling the courses for that semester shall guide the students. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE. There is no SEE for Minor project-1.

The Project shall be evaluated with due weightage on:

Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

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Reference Books/Material:

1. Offline/online chemical engineering and its related field Journals.
2. Books in the area of chemical engineering and its related field.

18UHUL507	Soft skill/Aptitude	(0-0-2) 1

Contact Hours: 24

Course Learning Objectives (CLOs):

1. This is included with the objectives of improving the communication skills, proficiency in English language and aptitude ability of the student to enhance the employability.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the significance of communication in the profession		10	
CO-2	Use the English language with proficiency		10	12
CO-3	Solve Aptitude related problems		9	12
CO-4	Demonstrate the competency in the placement activities		9	

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.0	-	1.0	-	-	-

Contents: Training on communication skills, proficiency in English language and aptitude ability involving the internal and external resource.

Evaluation: Both the internal and external resource persons shall be engaged in imparting the related knowledge and shall have only CIE as the evaluation component. There shall be one test conducted at the end for 25 marks in Aptitude testing and there shall be one presentation by the student for 25 marks or any other suitable testing components. The arrangement for CIE evaluation is to be done by the department and maintain the relevant documents

18UCHE508	Petroleum and Petrochemicals	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. Studying this subject, the students will learn about the extraction and production of oil and gas to meet energy needs, as well as refining of crude oil for a wide spectrum of useful products such as petrochemicals, Chemicals, Plastics.

Course Outcomes:

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the Indian petroleum industry and world scenario, and characterize the crude.	6	2	1
CO-2	Identify and characterize the different products of hydrocarbon.	2	14	3
CO-3	Apply the basic procedure and role of all fundamental system used in petroleum industry.	1,2	3	13
CO-4	Analyze the measuring parameters to be measured according to the operational conditions	13	1	4
CO-5	Describe basic principle, operation and analyze the key issues and optimization of petrochemical production system.	1	2, 13	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.25	2.5	1.3	1.0	-	3.0	-	-	-	-	-	-	2.0	2.0	-

Course Content:

Unit-I

Indian Petroleum Industry: prospects & future, major companies, world production, markets, offshore and onshore, oil well technology.

Petroleum Crude Characterization: Composition and classification, UOP K factor, TBP analysis, EFV Analysis, Average Boiling points, ASTM Curves, Thermal properties, Pour Point. **07 Hrs.**

Unit-II

Product Properties and Test Methods: Characterization -Flash point, Fire point, Reid vapor pressure Analysis, Octane Numbers, Cetane Index, smoke point, Burning quality, Carbon Residue, Viscosity Index, Softening point, Penetration Index, Oxidation Stability, Volatility, Aniline point, Pour point . Various Petroleum products & Additives for Naphtha, Gasoline, Gas, ATF, LPG, Kerosene, Diesel, Lubricating oils, Bitumen. **09 Hrs.**

Unit-III

Crude Pretreatment: Crude receiving, Storing, Pumping, dehydration, comparison, petroleum furnaces and comparison, Refining of petroleum – Atmospheric and vacuum distillation. **07 Hrs.**

Unit-IV

Treatment Techniques: Removal of sulphur compounds, storage and stability, product treatment using solvent, dewaxing, clay treatment and hydro refining.

Thermal Cracking: Visbreaking, Coking, Catalytic cracking (FCC), Hydro cracking, Air blowing of bitumen. Catalytic reforming, Extraction of Aromatics.

08 Hrs.

Unit-V

Petrochemicals: Definition, importance and growth potential of the field, raw materials for petrochemical industries, sources, economics and advantages. Production of petrochemicals like dimethyl terephathalate (DMT), ethylene glycol, synthetic glycerin, LAB, acrylonitrile, methyl methacrylate (MMA), phthalic anhydride, maleic anhydride, phenol acetone, formaldehyde, production of carbon black. **08 Hrs**.

Reference Books:

1) B.K. Bhaskar Rao, “Modern Petroleum Processes”, 3/e, Oxford IBH publisher.
2) Ram Prasad, “Petroleum Refining Technology”, Khanna Publishers, 2000.
3) W.L. Nelson, “Petroleum Refinery Engineering” 4/e, McGraw Hill, 1985.
4) B. K. Bhaskar Rao, “A text book on petrochemicals” 1/e, Khanna Publishers, New Delhi, 1987.

18UCHE509	**Polymer Science and Technology**	**(3-0-0) 3**

Contact Hours: 39

Course Learning Objectives (CLO):

1. To provide a broad and fundamental knowledge of the polymers and their chemical, physical and mechanical behavior.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Classify the Classification of polymers, kinetics, characteristics of polymers. Types and kinetics of polymerization	1	-	13
CO-2	Comprehend the different methods of polymerization and analyze the different properties of polymers.	13	-	2
CO-3	Describe the different Processing Technology of polymers	13	-	1, 2
CO-4	Interpret different polymer manufacturing processes	13	7	2

CO-5	Apply the polymer recycling, frontiers and challenges and engineering applications.	14	6, 7	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.66	1.0	-	-	-	2.0	2.0	-	-	-	-	-	2.5	3.0	-

Course content:

Unit-I

Polymer Science: Introduction, IUPAC names, Classification of polymers (source, occurrence, elemental composition, geometry and tacticity, stereo regularity), Definition of polymerization, characterization, Chain polymerization (free radical, ionic and co-ordination polymerizations), Step (condensation) polymerization, copolymerization.

Polymerization Kinetics: Definition of reaction rate, order, molecularity, kinetics of step reaction polymerization, kinetics of addition polymerization. **07 Hrs.**

Unit-II

Methods of Polymerization*:* Bulk, solution, Suspension, Emulsion, solid phase, gas phase polymerizations (formulation, mechanism, properties of the polymer produced, advantages and disadvantages).

Polymer Properties: Tensile strength, Impact strength, glass transition temperature, melting temperature, testing: sample preparation, testing standards and methods, analysis of polymer. **08 Hrs.**

Unit-III

Processing Technology: Extrusion, Injection moulding, blow moulding Compression moulding, rotational moulding, thermoforming, Calendering, Compounding. **09 Hrs.**

Unit-IV

Polymer Manufacturing: Industrial production methods of PE, PP, PS, PVC, UF, PF, PU, Poly butadiene, Nylon 6 and Nylon 66. **08 Hrs.**

Unit-V

Frontiers of Polymer Materials: Biodegradable polymers, Biomedical polymers, Conducting polymers, Polymers for space, Thermoxidative degradation, fire hazards, toxicity, effluent disposal, Recycle and reuse of polymers. **07 Hrs.**

Reference Books:

1) R.J.Young and P.A. Lovell, “Introduction to polymers”, Chapman and Hall, London. 2/e. 1992.
2) Fried W.Billmeyer, “Text book of Polymer Science”, J.R.John Wiley and Sons, New York. 3/e. 1984.

3) F. Rodrignek, et al., “Principles of Polymer Systems”, CRC Press. Taylor and Francis, Washington Dc. 5/e. 2003
4) Gowarikar, “Polymer Science”, New Age International Pvt. Ltd. 1/e. 1986. Reprint in 2005.

18UCHE510 Air Pollution and Control Engineering (3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand the knowledge on the concepts of air pollution and its emerging trends.
2. To understand and deal with sampling and analysis, design of control of air pollution and modeling approaches.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Summarize the basics of air pollution, legislation and its impact	6	7	3
CO-2	Comprehend the monitoring, meteorology and modelling of air pollution.	3, 5	-	14
CO-3	Design and analyze the control systems for particulate emissions.	3	-	14
CO-4	Design and analyze the control systems for gaseous emissions.	3	-	14
CO-5	Demonstrate the vehicular emission and its control system, indoor air pollution and typical control system of any industry.	3	7	6

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.6	-	3.0	2.0	2.0	-	-	-	-	-	-	1.0	-

Course content:

Unit-I

Introduction: Structure and composition of Atmosphere. History of Air pollution and episodes. Causes of air pollution and types. Sources and classification of air pollutants. Effects of air pollutants on human health, vegetation and animals, Materials and Structures. Effects of air Pollutants on the atmosphere, Soil and Water bodies. Long- term effects on the planet, Global Climate Change, Ozone Holes. Ambient Air Quality and Emission Standards and air quality legislations. Air Pollution Indices – Emission Inventories. **07 Hrs.**

Unit-II

Air Pollution Monitoring, Meteorology and Modeling: Air Sampling and monitoring methods. Physico chemical processes governing the spread of pollutants from point, non-point, line, and area sources. Generation, transport and decay of air pollutants. Introduction to meteorology toxicology and transport of air pollution. Ambient and Stack Sampling and Analysis of Particulate and Gaseous Pollutants. Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability, Inversion, Wind profiles and stack plume patterns- Transport and Dispersion of Air Pollutants - Modeling Techniques – Mathematical Modeling of dynamics of pollutants. Different dispersion models. **08 Hrs.**

Unit-III

Control of Particulate Contaminants: Factors affecting Selection of Control Equipment - Gas Particle Interaction, Working principle, Design and performance equations of Gravity Separators, cyclones, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators - Operational Considerations - Process Control and Monitoring - Costing of APC equipment - Case studies for stationary and mobile sources. **08 Hrs.**

Unit-IV

Control of Gaseous Contaminants: Control Equipment, Factors affecting Selection of Control Equipment - Working principle, Design operation and performance of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Bio filters - Process control and Monitoring - Operational Considerations - Costing of APC Equipment - Case studies for stationary and mobile sources. **08 Hrs.**

Unit-V

Automobile, Noise and Indoor Pollution: Vehicular Pollution: Types of emissions-Exhaust emissions, evaporative emissions, crank-case emissions. Prevention and control of vehicular pollution. Noise Pollution due to automobiles and in general. Sources types and control of indoor air pollutants and health effects. Air pollution legislation and regulations. **Case studies:** Few industrial pollution control systems like coal, cement, petroleum etc. **08 Hrs.**

Reference Books:

1) Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Air Pollution Control Engineering, Handbook of Environmental Engineering Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Edition, Tokyo, 2004.
2) Noel de Nevers, Air Pollution Control Engg, Mc. Graw Hill, New York, 3/e. 1995.
3) David H.F. Liu, Bela G. Liptak, Air Pollution, CRC Press. 1/e. 2000. ISBN-10: 1566705134.
4) Anjaneyulu. Y, Air Pollution & Control Technologies, BS Publication, 2/e. 2000. ISBN: 9789387593053.
5) M.N. Rao and H. V. Rao, Air Pollution, McGrew Hill Publications, 2007. ISBN-13- 9780074518717.

VI Semester

18UCHC600	Mass Transfer - II	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the principles and mechanism of diffusion mass transfer in applying to various separation processes viz. distillation, absorption, extraction and leaching.
2. To propose and evaluate the performance of the related equipment for separations involving diffusion.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Outline the principles of different mass transfer equipment and Interpret the concept and mechanism of the absorption tower and its sizing	1, 3	2	13
CO-2	Describe the phenomena of vapor-liquid equilibria, principle and types of distillation process	3, 13	2	1
CO-3	Design and Calculate the no of stages for distillation process by different methods	3, 13	2	1
CO-4	Illustrate the extraction concepts and design the process to determine the no of stages required	3, 13	2	1
CO-5	Illustrate the leaching concepts and design the process to determine the no of stages required.	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	3.0	-	-	-	-	-	-	-	-	-	2.6	-	-

Prerequisite: Mass Transfer-I

Course content:

Unit-I

Gas Liquid Contacting Systems: Types, construction and working of equipment – Distillation, Absorption.

Gas Absorption: introduction, Solvent selection for absorption. Material balance and concept of driving force and minimum solvent rates. Multistage absorption columns. Design of Plate columns. Absorption and desorption factors. Construction details. HETP and HTU concepts. Liquid phase hold up and pressure drop in absorption towers. Operating line and minimum solvent flow rates. Design of packed towers (height and diameter).Multi-component absorption. Absorption with chemical reaction. **12 Hrs.**

Unit-II

Distillation: Introduction. Vapour liquid equilibrium (T-x,y, P-x,y. H-x,y and x-y diagrams for binary mixtures). Relative volatility. Prediction of VLE from vapour pressure data using Raoult's law. VLE for multi-component systems. Non-ideal systems. Azeotropes. Immiscible systems. Steam distillation. Flash and simple distillation. **10 Hrs.**

Unit-III

Multistage Distillation: Multi-stage rectification column. Design using McCabe Thiele method for binary mixtures. Ponchon-Savarit method. Efficiencies–overall, local, and Murphree plate efficiencies. Multicomponent distillation. Vacuum, molecular, extractive and azeotropic distillations. **10 Hrs.**

Unit-IV

Liquid-Liquid Extraction: Liquid-Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Equipment for liquid-liquid extraction. **10 Hrs.**

Unit-V

Leaching Operation: Solid-liquid extraction (Leaching), various types with application, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Leaching equipment: Selection, construction, and operation. **10 Hrs.**

Reference Books:

1) Robert. E. Treybal, "Mass Transfer Operation", 3/e, McGraw Hill, 1981.
2) McCabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/e, Mc Graw Hill, 2001.
3) Coulson and Richardson, "Chemical Engg Vol. 2 and Vol 4, 4/e. Pergamon press, 1998.
4) Geankoplis, C.J., "Transport Processes and Unit Operations", 3/e, Prentice Hall (I).

18UCHC601	Chemical Equipment Design-II	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To develop key concepts and techniques to design process equipment in a process plant.
2. To expose students to the practices followed in the design of chemical equipment and their drawing.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Congregate and analyze the data from the hand book, code book to design and evaluate the heat transfer equipment	3, 13	2	1
CO-2	Congregate and analyze the data from the hand book, code book to design and evaluate the mass transfer equipment	3, 13	2	1
CO-3	Congregate and analyze the data from the hand book, code book to design and evaluate the simultaneous heat and mass transfer equipment	3, 13	2	1

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	1.0	2.0	3.0	-	-	-	-	-	-	-	-	-	3.0	-	-

Prerequisites: Process Heat Transfer, Chemical Engineering Drawing, Mass Transfer I and II

Course content:

- Detailed Chemical Engineering Process Design of the following equipment.
- Necessary aspects studied in "Chemical Equipment Design" is to be applied for mechanical design.
- Use of standard code books to be taught.

1. Double Pipe Heat Exchanger
2. Shell and Tube Heat Exchanger.
3. Condenser
4. Distillation Column.
5. Evaporator
6. Absorption Column.
7. Rotary Dryer.

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NOTE:

1. The question paper to contain two full design problems (100 Marks each) for the equipment from the above list and **student to answer any One full question.**

2. Perry's Chemical Engineer's Handbook shall be allowed in the examination as reference. IS Code 4503 for Heat Exchangers (if required) shall be permitted.
3. The answer shall include detailed process design steps using the data given in the problem, mechanical design for component dimensions.

Reference Books:

1) R. H. Perry and D. W. Green "Chemical Engg Hand Book", 6/e, McGraw Hill, 1998.
2) Donald Q. Kern, "Process Heat Transfer", McGraw Hill, 1997.
3) Robert E. Treybal, "Mass Transfer Operations", 3/e, McGraw Hill, 1981.
4) J. M. Coulson & J. F. Richardson, "Chemical Engineering", Vol. 6 Pergamon Press, 1993.
5) Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, New Delhi, 1969; IS Code 4503 for Heat Exchangers.

18UCHL602	**Mass Transfer Laboratory**	**(0-0-3)1.5**

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To provide an understanding of extending the theory into practice through various experiments related to diffusion, both molecular and convective; transfer coefficients and other diffusion based separation processes.
2. To analyze experimental data from the experiment conducted and present a good technical report, thereby demonstrating skills in communication through mandatory oral presentations.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) / PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Evaluate Rayleigh's equation, vaporization and thermal efficiencies using distillation principles.	4, 15	10	9
CO-2	Estimate the percentage recovery for types of Extraction equipments.	4, 15	10	9
CO-3	Calculate the Diffusion coefficient for Diffusion of organic vapour experiment, and height of cooling tower	4, 15	10	9
CO-4	Interpret the temperature dependency on ternary phase diagram.	4, 15	10	9
CO-5	Evaluate Freundlich equation	4, 15	10	9

	using adsorption principles			

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	-	1.0	2.0	-	-	-	-	3.0

List of Experiments:

1. Diffusion coefficients of organic vapors in air.
2. Efficiency determination in Steam distillation unit.
3. Rayleigh's expression using Distillation - Simple (Differential) distillation
4. Extraction studies using single and multiple stages in Solid - liquid leaching
5. Himus expression using Surface evaporation
6. Freundlich expression verification using adsorption studies
7. Generation the VLE data on Liquid - Liquid / Vapor - Liquid systems
8. Extraction studies in Liquid extraction - (Cross current: single and 2 or 3 Stage)
9. Liquid phase transfer coefficient calculation using Wetted wall column
10. Height of packing calculation by NTU and HTU concepts using Cooling tower
11. Rate of dissolution by conducting Solid dissolution

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Robert E. Treybal, "Mass Transfer Operation" 3/e, Mc Graw Hill.
2) Coulson and Richardson, "Chemical Eng Vol. 1 and Vol. 2", 4/e.
3) Geankoplis C.J, "Transport Processes and Unit Operations", 3/e, Prentice Hall (I).
4) Mc Cabe and J.M.Smith, "Unit Operations in Chemical Engineering", 7/e Mc Graw Hill

18UCHL603	Chemical Reaction Engineering Laboratory	(0-0-3)1.5

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To study the reaction kinetics for lab scale reactors by applying the knowledge of chemistry and engineering into practice.
2. To analyze and interpret the experimental data to find the rate law and project in the form of a report and oral presentation.

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Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Determine the kinetics of the reaction for batch, semi batch and flow reactors	4, 15	10	9
CO-2	Evaluate the activation energy of the reaction	4, 15	10	9
CO-3	Characterize the non ideal behavior in the reactors	4, 15	10	9
CO-4	Analyze and interpret the data for reactor design	4, 15	10	9
CO-5	Compile the data from the experiments conducted and discuss the results obtained with justification and conclusion in a report	10	8,9	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	2.0	1.2	2.2	-	-	-	-	3.0

List of Experiments

1. Saponification reaction in a Batch Reactor (Equimolar and Non-Equimolar Mixture)
2. Study the performance of Plug Flow Reactor.
3. Study the performance of Semi Batch Reactor
4. Study the performance of Mixed Flow Reactor
5. Study the performance of Adiabatic Batch Reactor
6. Study the performance of Packed Bed Reactor
7. RTD Studies in Tubular Reactor
8. Determination of activation energy using Arrhenius law.
9. RTD Studies in Mixed Flow Reactor
10. Study the performance of CSTRs in series
11. RTD studies on Spouted Bed Reactor

Note: Minimum10 experiments to be conducted.

Reference Books

1) Octave Levenspiel, “Chemical Reaction Engineering”, 3/e, John Wiley and Sons, 1999.
2) J. M. Smith, “Chemical Engg Kinetics”, 3/e, Mc Graw Hill, 1984.

18UCHL604	Minor Project-2	(0-0-4) 2

Contact Hours: 40

Course Learning Objectives (CLOs):

1. To carry out the experimental/design tasks of relatively minor intensity and scope as compared to the major project and in line with the guidelines formulated by the DUGC.
2. To see that this project could be a prologue for the upcoming major projects in the final year.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical engineering or integrated problems (allied fields).	2,10	8, 12	7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	-	2.0	3.0	2.0	3.0	-	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

The project work is to be taken up having had an exposure to the project work in the previous semesters. The students are expected to locate the state-of-the-art technology in his/her domain of interest by an extensive literature survey and select a topic from an emerging area relevant to their branch/interdisciplinary and define the problem for the project work. The problem could be defined to develop prototypes for industrial needs. A team consisting of not more than 4 students shall be guided by a faculty member. This project work is to supplement and prepare the students to take up major project work at higher semesters. A committee consisting of minimum 3 faculty members shall evaluate at the end for CIE with suitable rubrics. The weightage of marks shall be 50% for the committee and 50% for the guide. There is a SEE (viva voce) examination which shall be examined by two internal examiners appointed by COE based on the suggestions by the respective HoD.

The Project shall be evaluated with due weightage on:
Literature survey- 20%
Synopsis (plan of work and PERT charts)-10%
Project Topic/Work-35%
Presentation-15%
Conclusion and Final report-20%

Reference Books/Material:
1) Offline/online chemical engineering and its related field Journals.
2) Books in the area of chemical engineering and its related field.

18UHUL605	**Soft skill/Aptitude**	**(0-0-2) 1**

Contact Hours: 24

Course Learning Objectives (CLOs):
1. This is included with the objectives of improving the communication skills, proficiency in English language and aptitude ability of the student to enhance the employability.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Explain the significance of communication in the profession		10	
CO-2	Use the English language with proficiency		10	12
CO-3	Solve Aptitude related problems		9	12
CO-4	Demonstrate the competency in the placement activities		9	

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.0	-	1.0	-	-	-

Contents: Training on communication skills, proficiency in English language and aptitude ability involving the internal and external resource.

Evaluation: Both the internal and external resource persons shall be engaged in imparting the related knowledge and shall have only CIE as the evaluation component. There shall be one test conducted at the end for 25 marks in Aptitude testing and there shall be one presentation by the student for 25 marks or any other suitable testing components. The arrangement for CIE evaluation is to be done by the department and maintain the relevant documents

18UCHE606	Transport Phenomena	(3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide basic understanding of laws governing transport processes and effect of various parameters.
2. To provide an understanding of steady state shell balances for velocity, temperature and concentration distribution under laminar flow.
3. To deal with equations of change and analogies amongst transport processes along with their applications

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	State laws of momentum, energy and mass transport. Discuss effect of temperature and pressure on transport properties of fluid.	1	-	-
CO-2	Formulate velocity distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-3	Formulate temperature distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-4	Formulate concentration distribution equations under laminar flow conditions and solve transport problems.	-	2, 3, 13	1
CO-5	Apply equations of change for isothermal systems and write analogies between momentum, heat and mass transport problems.	-	2, 3, 13	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	2.0	-	-	-	-	-	-	-	-	-	2.0	-	-

Prerequisites: Fluid Mechanics, Heat and Mass Transfer

Course content:

Unit-I

Introduction: Importance of transport phenomena in chemical engineering, Momentum, Energy and Mass transport, Newton’s law of viscosity, Newtonian and Non-Newtonian fluids. Fourier’s law of heat conduction, Ficks law of diffusion, effect of temperature and pressure on transport properties of fluids. Numerical problems using all law. **07 Hrs.**

Unit-II

Velocity Distribution in Laminar Flow: Steady state shell momentum balance, boundary conditions applicable to momentum transport problems, flow over a flat plate, flow through circular tube, flow through annulus, flow between parallel plates and slit. Numerical problems using the equation derived above. **09 Hrs.**

Unit-III

Temperature Distribution in Laminar Flow: Steady state shell balance, boundary conditions applicable to energy transport problems, heat conduction through compound walls, heat conduction with internal generation by electrical source, nuclear and viscous energy sources. Heat conduction in a cooling fin, Forced and free convection heat transfer. Numerical problems using equation derived above. **08 Hrs.**

Unit-IV

Concentration Distribution in Laminar Flow: Steady state shell balance, Boundary conditions applicable to mass transport problems, Diffusion through stagnant gas and liquid films, Equimolar counter diffusion, Diffusion into falling film, Forced convection mass transfer, Diffusion with homogeneous and heterogeneous reaction. Numerical problems using the equation derived above. **08 Hrs.**

Unit-V

Equation of Change of Isothermal Systems: Non isothermal systems and Multicomponent systems. Application of these equations in solving steady state problem. **Analogies and Navier Stokes equation:** Simple numerical problems on it. Analogies between Momentum, Heat and mass transport and their numerical problems. **07 Hrs.**

Reference Books:

1) Bird, Stewart and Lightfoot, “Transport Phenomena”, John Wiley, 2/e. 1994.
2) Robert Brodkey and Henry C. Hershey, “Transport Phenomena Unified Approach”, International Edition- 1988. ISBN-10: 0070079633
3) Bennet and J. E., “Momentum Heat and Mass Transfer”, Myer- McGraw Hill. 3/e. 1982.
4) Suryavanshi and Dongre, “Transport Phenomena”, Nirali Prakashan. 7/e. 2012. ISBN: 978-81962-56-5.

18UCHE607	Catalyst Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand controlling mechanisms in solid catalyzed reactions, characterization of catalyst properties and is preparation.
2. To provide catalytic reactor design concepts involving solid catalyzed reaction and catalyst deactivation.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline catalyst technology development, economic importance and develop overall rate expressions.	1,2	-	-
CO-2	Classify makeup of solid catalyst and its various properties.	1,2	-	-
CO-3	Outline catalyst preparation and its characterization.	1,2	-	-
CO-4	Formulate performance equation for ideal flow patterns and apply the same for reactor design.	1,2,3	13, 14	-
CO-5	Analyze causes and mechanisms of catalyst deactivation and determine deactivation kinetics.	1,2,3	13	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	3.0	3.0	-	-	-	-	-	-	-	-	-	2.0	2.0	-

Course content:

Unit-I

Fundamentals of Catalytic Phenomena: Brief history of catalyst technology development and its economic importance. Various controlling mechanisms involved in solid catalyzed reactions, overall rate expressions. **07 Hrs.**

Unit-II

Catalyst Materials and Properties: Makeup of a typical heterogeneous catalyst and their functions. Molecular sieves and zeolites. Physical, Chemical, Dynamic and Mechanical properties of solid catalyst and adsorption isotherms. **07 Hrs.**

Unit-III

Catalyst Preparation and Characterization: Various catalyst preparation methods and equipments used, catalyst activation and forming**.** Catalyst characterization.

08 Hrs.

Unit-IV

Reactor Design: Basic approaches to reactor design, performance equations, collection of data form laboratory reactors, experimental methods to find rate equations and reactor design. **08 Hrs.**

Unit-V

Catalyst Deactivation: Causes and mechanisms of catalyst deactivation, prevention and regeneration. Experimental methods to find rate of deactivation, design and operation strategies with deactivating catalysts. **09 Hrs.**

Reference Books:

1) Prof. I.P. Mukhlyonov, " Catalyst Technology", MIR Publishers.
2) R.P. Farrauto and C.H. Bartholomew, "Fundamentals of Industrial Catalytic Processes".
3) Hamid Al-Mergen and Tian Cum Xiao, " Petrochemical Catalyst Materials, Processes and Emerging Technologies", IGI Global Series Book, 2016, ISBN:97814666699755.

18UCHE608	Plant Utilities and Industrial Safety	(3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand the utilities in a chemical process plant, types, role and their selection.
2. To understand the principles of safety with insight of safety analysis techniques and application of safety devices.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the selection and role of utilities and appraise the generation, handling and role of water and steam.	-	3	14
CO-2	Appraise the generation, handling and role of air with the use of devices.	3	14	-
CO-3	Assess refrigerants, evaluate the performance and apply refrigeration.	3	7,14	-
CO-4	Prioritize safety aspects, plan and use safety devices in defiant situations in a chemical	3	6,8	14

	plant.			
CO-5	Interpret safety analysis tools and techniques and translate to hazardous conditions.	3	7	14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.8	-	-	2.0	2.0	2.0	-	-	-	-	-	1.4	-

Course content:

Unit-I

Introduction: Utilities and their role, selection criteria etc. **Water and Steam:** Resources, Cooling water-requirements and treatments, Process water-Ion Exchange, Water softening methods-Ion exchange, Reverse osmosis, Electro dialysis, Water pretreatment, recycle and reuse, various pumps. Generators, Efficiency, Feed water Treatment and Steam quality, Steam consumption, Steam distribution, Condensate removal, condensate recovery. **08 Hrs.**

Unit-II

Air: Compressed air for process and instruments, Blowers and Fans- Characteristics, Compressed- Positive displacement and Centrifugal features, Multistage Compression-features, Vacuum pumps, Air Drying-Pressure swing Adsorption with applications, Skarstrom cycle. **08 Hrs.**

Unit-III

Refrigeration: Carnot Cycle and Reverse Carnot Cycles, Tonnage, Primary and Secondary refrigerants, Vapor Compression Refrigeration; various refrigerants, Tonnage. Vapor Absorption Refrigeration- Characteristics, Comparison. **08 Hrs.**

Unit-IV

Process Safety and Devices: Safety aspect, safe design, Intrinsic and Extrinsic safety, Hazards, Risk, Toxicity, Flammability, Fire, Explosion, TLV, Sources of ignition, Hazardous materials and conditions, Reactive chemicals, Combustion and Flammability, Gas explosion, Dust Explosion, UCVCE, Static Electricity, Vacuum Hazards, Inert Gas Hazards, Gas Dispersion, Safety Devices; Pressure Relief Systems, Emergency relief devices, Flame arrestors, storage and handling.

08 Hrs.

Unit-V

Safety Analysis and Case Studies: Hazard Analysis (HAZAN), Hazard and Operability studies (HAZOP), Comparison, Risk Analysis and Estimation, Safety check list. Case Studies: Vishakapatnam, Bhopal, Jaipur, Flixborough, Seveso, Piper Alpha, Mexico [LPG Fire] **07 Hrs.**

Reference Books:

1) Perry's "Handbook of Chemical Engineers" 7/e, Mc-Graw Hill Publications.
2) Frank P. Lees, "Loss Prevention", Vol 1 and Vol 2.
3) Jack Broughton, "Process Utilities", I Chem publications.

18UCHE609 Drug and Pharmaceutical Technology (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide students with the basics of drug and pharma technology and develop the skills for understanding the constituents of drug and its production.
2. To understand the parameters, kinetics and its analysis and transformation in the body.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Develop nomenclature for upcoming drugs and gain knowledge of therapeutic agents to be used for treatment.	1	-	14
CO-2	Estimate the pharmacokinetic parameters and analyze the transformation of drugs in the body.	14	2, 7	-
CO-3	Employ standards of hygiene in the manufacturing processes of drugs and pharmaceuticals.	14	2, 7	-
CO-4	Examine the constituents present in pharmaceutical and microbiological products.	14	2, 7	-
CO-5	Formulate drug delivery systems to transport pharmaceutical agents in the body to achieve therapeutic effect.	14	2, 7	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	2.0	-	-	-	-	2.0	-	-	-	-	-	-	2.6	-

Course content:

Unit-I

Introduction: Development, sources, and characteristics of drugs; Important terms used in chemistry of drugs- Medicinal Chemistry, Pharmacology, Pharmacophore, Gram positive and negative bacteria, virus, fungi; Classification and nomenclature of drugs. **07 Hrs**

Unit-II

Pharmacokinetics and Pharmacodynamics: Physico - chemical principles; Pharmacokinetics - Absorption Distribution, Metabolism and Excretion of Drugs; Bioavailability measurement - Plasma level-time and Urinary excretion studies; Basic Pharmacodynamics. **08 Hrs**

Unit-III

Manufacturing Principles: Compressed tablets and coating, Wet granulation, Dry granulation or Slugging, Capsules, Parenteral solutions, Oral liquids, Ointments, Good Manufacturing Practice as per Drugs and Cosmetics Act. **08 Hrs**

Unit-IV

Pharmaceuticals, Microbiological Products: Laxatives, Radiopharmaceuticals, Cardiovascular agents, Central Nervous System stimulants, External Antiseptics, Analgesics, Antacids, Antibiotics, Antineoplastic drugs, Antidiabetic drugs, Hormones, Vitamins. **08 Hrs**

Unit-V

Drug Delivery: Transdermal drug delivery, Polymers in drug delivery, Liposomal drug delivery, Nano drug delivery, Opthalmic drug delivery, Design of Controlled Drug Delivery Systems. **08 Hrs**

Reference Books:

1) G. R. Chatwal. “Synthetic Drugs”. 2/e. Himalaya Publishing House, Delhi, 2009. ISBN: 978-93-5097-253-3.
2) D. M. Brahmankar and S. B. Jaiswal. “Biopharmaceutics and Pharmacokinetics - A Treatise”, Vallabh Prakashan, New Delhi. 2015.
3) Felton, Linda A., Remington: “Essentials of Pharmaceutics”, College of Pharmacy, Philadelphia, 1/e. Pharmaceutical Press. 2013.
4) Juergen Siepmann, Ronald A. Siegel, Michael J. Rathbone, “Fundamentals and Applications of Controlled Release Drug Delivery”, Springer New York, 2011.
5) L. Lachman, Lieberman H.A. and Kanig J.L., “”he Theory and Practice of Industrial Pharmacy”, 3/e. Indian Edition, Varghese Publishing House, Mumbai, 2013.

18UCHE610	Food Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand the basic principles of Food Science and Technology and applying it to the growing and dynamic engineering needs of the Food Industries.

2. To study the application of unit operations and modern trends in food processing industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (1,2,3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the general food properties and its unit operations in industries.	1	-	13
CO-2	Comprehend on food preserving techniques, food contamination and food safety aspects.	14	6, 7	1
CO-3	Outline and distinguish the different techniques of food preservation in industries	14	6, 7	1
CO-4	Identify and discuss the different food additives and its safety	14	6, 7	1
CO-5	Interpret and apply the different food processing techniques and food packing	14	6, 7	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	-	-	-	-	2.0	2.0	-	-	-	-	-	1.0	3.0	-

Course content:

Unit-I

Introduction to Food Engineering: Introduction: general aspects of food industry, world food demand and Indian scenario, Physical properties of food materials: Rheological models, Water activity, Fluid Flow in Food Processing: Liquid Transport Systems; Pipes for Processing Plants, Pumps for food plants; Numerical on fluid flow in food processing. **07 Hrs**

Unit-II

Food Preservation: Food deterioration – Causes, Aims and objectives of preservation and processing. **Food Contamination and Adulteration:** Types of adulterants and contaminants, Intentional adulterants, Metallic contamination, Incidental adulterants, Nature and effects, food laws and standards, Hazard analysis and critical control points or HACCP**,** Food Safety and Standards Authority of India (FSSAI) **08 Hrs**

Unit-III

High-Temperature Preservation: Introduction to Thermal Processing; Pasteurisation; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Numericals; Batch & continuous Retorts for Thermal processing; Cold sterilization: Gamma irradiation; Microwave & Ohmic heating. **08 Hrs**

Low-Temperature Preservation: principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidized bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank‟s equation and Nagaoka‟s equation. **08 Hrs**

Unit-IV

Food Additives: Introduction and need for food additives, Types of additives – antioxidants, chelating agents, colouring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives: types and applications, Stabilizers and thickeners, other additives, Additives and food safety. **08 Hrs**

Unit-V

Food Processing process: Introduction to Extrusion, Basic Principles, Extrusion Systems, Cold Extrusion, Extrusion Cooking, Single Screw Extruders, Twin-Screw Extruders. **Packaging Concepts:** Introduction to packaging, food protection, product containment, commutation, convenience, mass transfer in packaging materials, and permeability of packaging material to fixed gases, innovations in food packaging, passive packaging, active packaging, intelligent packaging, food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labelling. **08 Hrs**

Reference Books:

1) R. Paul Singh and Dennis R. “Introduction to Food Engineering, Elsevier Science and Technology”, 5/e, 2013. ISBN: 9780123985309.
2) P.G. Smith, “Introduction to Food Process Engineering” 2/e, Springer Press New York, 2009. ISBN 978- 1-4419-7661-1.
3) Subbulakshmi G. and Shobha A. Udupi, “Food Processing and Preservation”, New Age International Pvt. Ltd., 2001. ISBN: 8122412831.

18UCHE611	Applied Mathematics in Chemical Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLOs):

1. To understand the Computational techniques and use computers to solve problems by step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand calculations for application in Chemical Engineering.
2. To provide the insight of the ODE and PDE to solve chemical engineering problems with unit operation and process.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (1,2,3)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and apply mathematical methods to solve chemical engineering problems	1	2	3
CO-2	Evaluate and analyse different chemical engineering problems using interpolation techniques	3, 5, 13	2	1
CO-3	Interpret and develop the relationship in chemical engineering using different numerical differentiation techniques	3, 5, 13	2	1
CO-4	Formulate and optimize with different methods of ODE to solve chemical engineering problems unit operation and process.	3, 5, 13	2	1
CO-5	Formulate and optimize with different methods of PDE to solve chemical engineering problems unit operation and process.	3, 5, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.4	2.0	2.6	-	3.0	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Computation and Error Analysis: Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation. Linear Systems and Equations Matrix representation, Calculation of Eigen Values and Eigen vectors, Solution by Cramer's rule; Iterative Method-- Jacobi iteration; Gauss-Seidel Method, Chemical Engineering Examples: Material and energy balance problems involving at least 3 simultaneous equations Non-linear Algebraic Equations (single and multivariable) Secant, Multivariate Newtons method Chemical Engineering Examples: Equation of state (van der Waals, Beattie-Bridgeman, etc.), Friction factor equation etc. **07 Hrs**.

Unit-II

Regression and Interpolation: Polynomial regression, Newtons Difference Formulae, Cubic Splines Chemical Engineering Examples: Free settling velocity of particles, Arrhenius Equation, Specific heat w.r.to temperature etc. **08 Hrs**

Unit-III

Numerical Differentiation: Numerical differentiation; higher order formulae. Integration and Integral Equations Two and Three point Gaussian quadrature formula Chemical Engineering Examples: Rayleigh's equation, Rate equation.

08 Hrs

Unit-IV

Ordinary Differential Equations: Initial Value Problems Runge – Kutta method for second order differential equations, Explicit Adams-Bashforth technique, Implicit Adams-Moulton technique, Predictor-Corrector technique. Stiffness of ODE‟s ODEs: Boundary Value Problems: Orthogonal Collocation, shooting techniques. Chemical Engineering Examples: Rate equation, Steady-state material or energy balance equations etc. **08 Hrs**

Unit-V

Solution of Partial Differential Equations: Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, implicit and explicit methods, Cranks Nicolson Method, Chemical Engineering Examples: unsteady-state one dimensional heat conduction. Use of MATLAB with chemical engineering examples. **08 Hrs**

Reference Books:

1) Gupta S.K , "Numerical Methods for Engineers", 3/e, ISBN : 978-81-224-3359-3, New Age International, 1995
2) Alkis Constantinides and Navid Mostoufi, "Numerical Methods for Chemical Engineers with MATLAB Applications", ISBN-10: 0130138517, Prentice Hall, 1999.
3) Steven Chapra and Raymond Canale, "Numerical Methods for Engineers.", 6/e, McGrew Hill Publication, 2010.
4) M. K. Jain, S. R. K. Iyengar, and R. K. Jain, "Numerical Methods", 6/e New Age International Publishers, New Delhi, 2012

18UCHO612	Advanced Waste Water Treatment	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To create awareness on the water pollution aspects and understand the kinetics and the designing system of the plant.
2. To understand the different parameters, treatment methods and control techniques of water pollution.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Cognize the different characteristics of waste water and regulatory standards with basic design criteria for waste water treatment	-	14	3, 6, 7
CO-2	Comprehend the reaction kinetics, reactor selection and its process analysis.	13, 14	3, 6, 7	5

CO-3	Design and operational concepts of secondary treatment systems	13, 14	3, 6, 7	-
CO-4	Design and operational concepts of tertiary treatment systems	13, 14	3, 6, 7	-
CO-5	Learn the wastewater treatment criteria based on the regional requirement to understand the sewage management of the city.	3, 6, 7	14, 15	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	3.0	2.6	2.0

Course content:

Unit-I

Introduction of Wastewater Treatment: Flow measurements and Composition. Characterization -properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central. Theoretical principles and design considerations - screens, equalization basin, grit chamber, primary and secondary settling tanks. **07 Hrs.**

Unit-II

Microbiology of Waste Treatment: Growth and inhibition of bacteria. Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization. Effects of endogenous metabolism and kinetics Monod's and Michaclis menton kinetics and their applications. Determination of biokinetic constants in batch and continuous system. **08 Hrs.**

Unit-III

Secondary Waste Water Treatment: Aerobic, anaerobic, suspended and attached growth systems. Activated sludge process standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds, bio-towers, RBC. Treatment disposal of sludge- Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation. Reactor configurations. Case studies. **08 Hrs.**

Unit-IV

Tertiary Waste Water Treatment: Introduction, Need of Tertiary Waste Water Treatment, Purpose of Advanced Waste Water Treatment. Nitrogen and Phosphorus Nitrogen Removal: Nitrification, Denitrification Simultaneous nitrification and denitrification Phosphorus Removal. Membrane Bioreactor with Membrane Module Submerged in the Bioreactor. Electro-coagulation, Electro dialysis, Reverse osmosis, Ion exchange, Adsorption, absorption, Evaporators. Case studies. **08 Hrs.**

Unit-V

Sewage Treatment and Disposal: Introduction, importance of sewage, Characteristics of sewage, Sampling and analysis of sewage, Sewage treatment and disposal: Skimming, Grit chamber, Sedimentation tanks, Septic tank, Secondary treatment-types of filters, rate of filter loading, Activated sludge process, sludge digestition, Sludge disposal. **08 Hrs.**

Reference Books:

1) Metcalf and Eddy. "Waste water Engineering: Treatment and Reuse". McGrew Hill Publication. ISBN-10: 9780070495395. 4/e. 2017
2) A. F. Gaudy and E. T. Gaudy. "Microbiological for environmental Scientist and engineers" McGraw Hill 1/e. 1980.
3) T. McGhee. "Water Supply and Sewerage", McGraw Hill. 6/e. 1991. ISBN-10: 0070609381
4) G. S. Bridie and J.S. Brides. "Water Supply and Sanitary Engineering". Dhanpat Rai & Sons 2010. ISBN-10: 8187433795.

18UCHO613	**Biology for Engineers**	**(3-0-0)3**

Contact Hours: 39

Course Learning Objective (CLO):

1. Gain vivid knowledge in the fundamentals and uses of biology, human system and plant system

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Describe the fundamentals of living things.	1	-	-
CO-2	Apply the concept of plant, animal and microbial systems and growth in real life systems.	13	2,3	1
CO-3	Comprehend genetic and the immune system	-	4	5
CO-4	Analyze the cause of symptoms, diagnosis and treatment of common diseases.	2	-	6
CO-5	Illustrate the application of biology system in relative industries.	1,2	3	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.33	2.66	2.0	2.0	1.0	1.0	-	-	-	-	-	-	2.0	-	-

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Course Content:

Unit-I

Introduction to Life: Characteristics of living organisms-Basic classification-cell theory-structure of prokaryotic and eukaryotic cell-Introduction to biomolecules: definition-general classification and important functions of carbohydrates-lipids-proteins-nucleic acids vitamins and enzymes-genes and chromosome. **07 Hrs.**

Unit-II

Biodiversity: Plant System: basic concepts of plant growth-nutrition-photosynthesis and nitrogen fixation-Animal System: elementary study of digestive-respiratory-circulatory-excretory systems and their functions-Microbial System: history-types of microbes-economic importance and control of microbes. **07 Hrs.**

Unit-III

Genetics and Immune System: Evolution: theories of evolution-Mendel's cell division–mitosis and meiosis-evidence of laws of inheritance-variation and speciation- nucleic acids as a genetic material-central dogma immunity-antigens-antibody-immune response. **08 Hrs.**

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Unit-IV

Human Diseases: Definition- causes, symptoms, diagnosis, treatment and prevention of diabetes, cancer, hypertension, influenza, AIDS, Hepatitis and COVID-19 **08 Hrs.**

Unit-V

Biology and Its Industrial Applications: Transgenic plants and animals-stem cell and tissue engineering-bioreactors-biopharming-recombinant vaccines-cloning-drug discovery-biological neural networks-bioremediation-biofertilizer-biocontrol-biofilters-biosensors-biopolymers- bioenergy- biomaterials-biochips-basic biomedical instrumentation **09 Hrs.**

Reference Books:

1) Biology for Engineers: As per Latest AICTE Curriculum Wiley Editorial, ISBN: 9788126576340.
2) A Text book of Biotechnology, R.C.Dubey, S. Chand Higher Academic Publications, 2013
3) Diseases of the Human Body, Carol D. Tamparo and Marcia A. Lewis, F.A. Davis Company, 2011.
4) Biomedical instrumentation, Technology and applications, R. Khandpur, McGraw Hill Professional, 2004

18UCHO614	Composite Materials	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLOs):

1. To understand the nature, properties, structure and processing of composite materials and their engineering applications.
2. To distinguish different composite materials and the processing techniques.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)/ PSOs (1,2,3)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Illustrate the composites and the properties of composites	2,14	6	-
CO-2	Analyse and compile the different manufacturing method for preparing the materials	14	2	7
CO-3	Compare and assess the different processing techniques for advanced materials	14	2	7
CO-4	Compare and assess the different processing techniques for advanced materials based on reaction method	14	2	7
CO-5	Distinguish between different specific composite materials, their manufacturing process and applications	14	2	7

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.2	-	-	-	2.0	1.0	-	-	-	-	-	-	3.0	-

Course content:

Unit-I

Introduction: Definitions, Composites, Reinforcements and matrices, Types of reinforcements, Types of matrices, Types of composites, Carbon Fibre composites, Properties of composites in comparison with standard materials, Applications of metal, ceramic and polymer matrix composites. **Advanced material and properties:** Semi-conducting and Super-conducting materials with superior structural, mechanical, optical and electrical properties. **07 Hrs.**

Unit-II

Manufacturing Methods: Hand and spray lay - up, injection molding, resin injection, filament winding, pultrusion, centrifugal casting and prepregs. Fibre/Matrix Interface, mechanical. Measurement of interface strength. Characterization of systems; carbon fiber/epoxy, glass fiber/polyester, etc. **08 Hrs.**

Unit-III

Processing Techniques: Sintering, hot pressing, hot isostatic pressing, tape-casting sol-gel processing for the formation of monolithic ceramics, composites (ceramic, ceramic metal, as well as metal matrix), SiO_2, Glasses from above powders. **08 Hrs.**

Unit-IV

Processing Techniques Based on Reaction Methods: Chemical vapour deposition (CVD), vapour phase epitaxy, plasma-enhanced chemical vapour deposition (PECVD), chemical vapour infiltration (CVI), self-propagating high temperature synthesis (SHS) for the preparation of monolithic ceramics, composites, coating, thin films, whiskers and fibers and semi conducting materials such as Si and gallium arsenide. **08 Hrs.**

Unit-V

Reinforced Metal Matrix: Methods for preparation of powdered metal matrix, fiber reinforced metal matrix. Types and Properties of matrix materials and its industrial application **Ceramic Reinforced Matrix:** Cold pressing & sintering method, liquid silicon infiltration technique for synthesis of ceramic reinforced matrix, Types and properties of ceramic Matrix and its industrial applications. **Polymer Composites:** Stress-Strain modulus relationship for fiber reinforced polymer composites, **Manufacturing Methods:** Hand layouts, filament winding, pultrusion, SMC and DMC. Applications of polymer reinforced composites in marine, aerospace, automobile, building & computer industry. **08 Hrs.**

Reference Books:

1) W.D. Kingery. “Introduction to Ceramics”. 2/e. Willey- Blackwell Publication. 1976. ISBN-10: 0471478601
2) K. K. Chawla. “Advanced Composites”. 2/e. Springer New York. Publication. 1987.
3) James.T.Schockel Ford. “Introduction to Material Science for Engg.” 2/e. McMillan publications.
4) L.H. Vanvlack. “Elements of Material Science and Engineering” 6/e. Pearson Education. 2002. ISBN-10: 8131706001.
5) M.N. Rahaman. “Ceramic processing and sintering” 2/e, Marcel Dekker, Inc, New York. 1995.

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18UMAO675	Applied Mathematics	(3 - 0 - 0) 3

Contact Hours: 39

Course Learning Objectives (CLO):

1. The students are expected to learn about mathematical modelling, use of numerical techniques to deal with engineering systems. Further, they need to learn LPP and statistical tools for interpretation. They are also expected to carry out sampling distribution analysis and use of graph theory for engineering problems.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs(1-12)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Obtain Mathematical model of Engineering Systems using different domains.		1,2	
CO-2	Formulate LPP and obtain optimal solutions using different tools.		1,2	
CO-3	Apply statistical tools to Interpret the data using different tools.		1,2	
CO-4	Determine type errors and test for goodness of fit using different methods.		1,2	
CO-5	Use graph theory to obtain solution for engineering problems.		1,2	

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	2	2	-	-	-	-	-	-		-	-	-

Pre-requisites:

1. A basic course on the concepts of algebra, geometry, calculus, trigonometry and laws of physics, Statistical averages and probability theory.

Contents

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Unit I

Introduction to Mathematical Modelling and Numerical Techniques: Introduction, Modelling technique, classification and characteristics. Mathematical modelling through algebra, geometry, calculus, trigonometry. Mathematical model of engineering system. **8 Hrs**.

Unit II

Linear and Non-Linear programming:
Introduction, Mathematical formulation of a L.P.P, basic solution. Geometric (or graphical) method, Simplex method. Assignment problem. Non Linear Programming –Constrained extremal problems-Lagrange's multiplier method-Kuhn- Tucker conditions and solutions. **8 Hrs**.

Unit III

Statistical Techniques: Co-efficient of Variation, Skewness, Karl Pearson's co-efficient of Skewness, Moments, Pearson's Beta and Gamma co-efficient, Kurtosis. Time series and Forecasting. **7 Hrs.**

Unit IV

Sampling distribution: Introduction, population and samples. Type-I and Type- II errors. Test of hypothesis for means, student's t-distribution, Chi-square Distribution as a test of goodness of fit. **8Hrs**.

Unit V

Graph Theory: Definition of a graph theory, incidence and degree, walks, paths, circuits, Connectedness, Eulerian and Hamiltonian graphs, Trees, basic properties of trees, Binary trees, Preorder and post order traversals, Spanning and Minimal spanning trees, Connectivity and Separability, fundamental circuits and cut sets Isomorphism of graphs, Matrix representation of graphs, adjacency and incidence matrix Graph theoretical algorithms: Dijkstra, Prims and Kruskal. **8 Hrs.**

Reference Books:

1) B.S. Grewal "Higher Engineering Mathematics", Khanna Publishers, 44/e, 2017.
2) E. Kreyszig "Advanced Engineering Mathematics", John Wiley & Sons, 10/e (Reprint), 2016.
3) Srimanta Pal et al., "Engineering Mathematics", Oxford University Press, 3/e, 2016.
4) Dougas B. West, Introduction to Graph theory, 2/e, PHI Learning Private Limited, 2009.

Academic Program: UG

Academic Year 2021-22

Syllabus

VII & VIII Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002

(An Autonomous Institution approved by AICTE & Affiliated to VTU, Belagavi)

Ph: **0836-2447465** **Fax: 0836-2464638** **Web:** www.sdmcet.ac.in

SDM College of Engineering & Technology, Dharwad

It is certified that the scheme and syllabus for VII & VIII semester of UG program in Chemical Engineering is recommended by Board of Studies of Chemical Engineering Department and approved by the Academic Council, SDM College of Engineering & Technology, Dharwad. This scheme and syllabus will be in force from the academic year 2021-22 till further revision.

Principal | Chairman BoS & HoD

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SDM College of Engineering & Technology, Dharwad
Department of Chemical Engineering

College Vision and Mission

SDMCET –Vision

To develop competent professionals with human values.

SDMCET – Mission

- To have contextually relevant curricula.
- To promote effective teaching learning practices supported by modern educational tools and techniques.
- To enhance research culture.
- To involve industrial expertise for connecting classroom content to real life situations.
- To inculcate ethics and impart soft skills leading to overall personality development

SDMCET- Quality Policy

❖ In its quest to be a role model institution, committed to meet or exceed the utmost interest of all the stake holders.

SDMCET- Core Values

- Competency
- Commitment
- Equity
- Team work and
- Trust

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Vision and mission of Department

Vision

To develop proficient Chemical Engineers to meet industrial and societal needs.

Mission

1. To design the curricula in tune with industry.
2. To inculcate research culture with ethics to disseminate knowledge.
3. To collaborate with industry and academia for sustainable growth.

Program Educational Objectives (PEOs):

The Chemical Engineering UG Programme at SDMCET is framed and designed such that within first few years after graduation, the graduates will be able to:

- **I.** Analyze, design and professionally practice in the area of Chemical Engineering and allied disciplines by acquiring good knowledge of basic sciences and Chemical Engineering.
- **II.** Create applications to solve real-life problems of Chemical Engineering in a broad range of career path to fulfill ethical, economical, environmental and social responsibilities.
- **III.** Pursue higher studies and carry out research in Chemical Engineering and allied Engineering and Management.
- **IV.** Work in multidisciplinary teams with good communication skills and leadership qualities to solve engineering problems and develop entrepreneural skills.

Program Outcomes (POs):

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific outcomes (PSOs):

13. **Plant operations and Control:** Conceptualize the knowledge and information gained in mass and energy balance, thermodynamics, transport phenomena, kinetics, unit operations, process control, equipment design that can be used in design, control and optimizing the Chemical processes.
14. **Quality, Feasibility and impact studies:** Develop an integrated process and modify it attributing to economy, environmental friendly, ethics coupled with safety by applying principles of chemical engineering.
15. **Development of engineering solutions through experiments:** Apply knowledge of chemical engineering in solving both industry and academic problems using experimental methods including design of experiments and simulation to analyze, interpret and present the data.

Scheme for VII Semester B. E

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UCHC700	PC	Process Dynamics and Control	3-2-0	4	50	100	3	-	-
18UCHC701	PC	Chemical Technology	4-0-0	4	50	100	3	-	-
18UCHE70X	PE	Program Elective -4	3-0-0	3	50	100	3	-	-
18UCHO70X	OE	Open elective	3-0-0	3	50	100	3	-	-
18UCHL702	PC	Process Control Laboratory	0-0-2	1	50	-	-	50	3
18UCHL703	PC	Major Project – 1	0-0-4	2	50	-	-	50	3
18UCHL704	PC	Internship	4 Weeks	2	50	-	-	50	3
Total			**13-2-6**	**19**	**350**	**400**		**150**	
Electives									
18UCHE705	PE	Novel Separation Techniques	3-0-0	3	50	100	3	-	-
18UCHE706	PE	Process Instrumentation	3-0-0	3	50	100	3	-	-
18UCHE707	PE	Process Modeling and Simulation in Chemical Engineering	3-0-0	3	50	100	3		
18UCHO708	OE	Biochemical Engineering	3-0-0	3	50	100	3	-	-
18UCHO709	OE	Instrumental Methods of Analysis	3-0-0	3	50	100	3	-	-
18UCHO710	OE	Nanotechnology	3-0-0	3	50	100	3	-	-

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical
*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

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Scheme for VIII Semester B. E

Course Code	Course category	Course Title	Teaching		Examination				
			L-T-P (Hrs/Week)	Course Credit	CIE	Theory (SEE)*		Practical (SEE)	
					Max Marks	Max Marks	Duration in Hrs	Max Marks	Duration in Hrs
18UCHC800	PC	Process Engineering Economics and Management	4-0-0	4	50	100	3	-	-
18UCHE80X	PE	Program Elective -5	3-0-0	3	50	100	3	-	-
18UCHO80X	OE	Open elective	3-0-0	3	50	100	3	-	-
18UCHL801	PC	Technical Seminar	0-0-2	1	50	-	-	-	-
18UCHL802	PC	Major Project –2	0-0-12	7	50	-	-	50	3
Total			**10-0-16**	**18**	**250**	**300**		**50**	
Electives									
18UCHE803	PE	Sugar Technology	3-0-0	3	50	100	3	-	-
18UCHE804	PE	Advance Bioprocess Engineering	3-0-0	3	50	100	3	-	-
18UCHE805	PE	Scale up in Chemical Process	3-0-0	3	50	100	3	-	-
18UCHO806	OE	Solid Waste Management	3-0-0	3	50	100	3	-	-
18UCHO807	OE	Green Technology	3-0-0	3	50	100	3	-	-
18UCHO808	OE	Environmental Impact Assessment	3-0-0	3	50	100	3	-	-

CIE: Continuous Internal Evaluation **SEE**: Semester End Examination
L: Lecture **T**: Tutorials **P**: Practical

*SEE for theory courses is conducted for 100 marks and reduced to 50 marks.

Total credits offered for the Fourth year: 37

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VII Semester B.E.

18UCHC700	Process Dynamics and Control	(3-2-0) 4

Contact Hours: 52

Course Learning Objective (CLO):

1. The purpose of this course is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the basic principles and importance of process control in industrial process plants.	13	1	-
CO-2	Formulate dynamic models based on fundamental laws and analytically solve linear dynamic models of first and second order system.	-	2,3	13
CO-3	Predict the closed-loop behavior using block diagram and control valves.	-	2,10	13
CO-4	Predict closed loop behavior using block diagram and analyze control valves.	-	2	13
CO-5	Analyze controllers and determine the stability of a closed-loop feed-back control system.	-	2,3	13

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.0	2.0	2.0	-	-	-	-	-	-	2.0	-	-	1.4	-	-

Course Content:

Unit-I

Introduction: Classification of variables, control configuration, classification of control systems. Laplace Transform, types of inputs- step, impulse, linear and sinusoidal. **07L+02T Hrs.**

Unit-II

Process Dynamics: First order systems, transfer functions - mercury in glass thermometer, level, mixing tanks, stirred tank reactors, Response of first order system in series: Interacting and non-interacting systems, Linearization of non-linear first order systems. **10L+02T Hrs.**

Unit-III

Second Order Systems: U-tube manometer, damped oscillator, response equations, terms of second order under damped system, Transportation lag**.**

07L+02T Hrs.

Unit-IV

Block Diagram: Importance, reduction rules, steps, servo and regulator problem, overall transfer function for set-point change and load change.

Final Control Element: control valves, types, actuators, positioners, valve characteristics. **08L+02T Hrs.**

Unit-V

Controllers: Transfer functions for two position, proportional, Proportional +Reset (P+I), Proportional + Rate (P+D), Proportional + Reset +Rate controller (P+I+D), servo and regulator control system.

Stability: Concept of Stability, Stability criterion, Routh Herwitz test for stability, Root Locus method. Stability of linear control system, Routh –Hurwitz, Root Locus methods. **10L+02T Hrs.**

Reference Books:

1) Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2) Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.
3) Coulson and Richardson, "Chemical Engineering" Vol, III, 3/e, Pengeman Press.
4) George Stephanopoules, "Chemical Process Control" An Introduction to Theory and Practical, Prentice Hall, New Delhi, 1998.

18UCHC701	Chemical Technology	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the industry protocols used in the manufacture of chemicals both inorganic and organic with the use of reference flow sheets.
2. Identify major engineering problems associated with manufacturing processes.
3. Overcoming bottlenecks and trouble shooting.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the impetus of Chemical Industry globally and summarize production process of industrial gases.	6,7	12	1

CO-2	Apply the concepts of unit operations and processes, reaction kinetics to Chlor-Alkali and acids production.	12,13,1	9,10, 14	3
CO-3	Illustrate the technology of manufacturing fertilizers and phosphorous compounds.	14	9, 12	--
CO-4	Interpret the concept of operation, process reactions and unit operation to pulp and paper and fermentation industries.	14	3, 6, 7	--
CO-5	Prioritize trouble shooting to overcome the bottlenecks in a process and develop the technology within realistic constraints of oils and fats and soap industries.	13,14	12	---

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.0	-	1.5	-	-	2.5	2.5	-	2.0	2.0	-	2.25	3.0	2.75	-

Course contents:

Unit-I

Introduction to Chemical Process Industries: Chemical Industry in this millennium, Scenario of Indian and World chemical industry.

Industrial and Fuel Gases: H_2, O_2, N_2, CO_2, Water gas, Producer gas. **10 Hrs.**

Unit-II

Chlor-Alkali Industry: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder

Acids: Sulfuric, Nitric, Hydrochloric and Phosphoric acids. **12 Hrs.**

Unit-III

Fertilizer Industry: Ammonia, Urea, Ammonium Nitrate, Ammonium Sulfate, DAP, Potash fertilizers, Bio-fertilizers.

Phosphorous Industry: Red and White phosphorous, Phosphorous pentoxide, Phosphate fertilizers, Super phosphate and Triple super phosphate. **10 Hrs**.

Unit-IV

Pulp and Paper Industry: Raw materials, manufacture of pulp and paper, recovery of chemicals.

Fermentation and Distillery: Manufacture of alcohol, beer, wine, vinegar.**10 Hrs**.

Unit-V

Oils and Fats Industry: Manufacture of oils (vegetable and industrial) processing and refining, essential oils and uses,
Soaps Industry: Types of soaps and fatty acid, manufacturing process and uses

10 Hrs.

Reference Books:

1) George T Austin: Shreves, “Chemical Process Industries”, Mc Graw Hill International ltd.
2) Gopal Rao and Marshall, “Dryden’s Outlines of Chemical Technology”, East-West Press.
3) S.D. Shukla and G.N. Pandey, “Text book of Chemical Technology” Vol.1 and 2, Vikas Publishing House Pvt. Ltd. New Delhi.
4) S.C. Bhatia, “Chemical Process Industries”, Vol.1 and 2, CBS Publishers, New Delhi

18UCHL702	**Process Control Laboratory**	**(0-0-2)1**

Contact Hours: 30

Course Learning Objective (CLO):

1. The purpose of this laboratory is to introduce the key concepts in automatic control and instrumentation of process plants.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Apply fundamentals of industrial processes, process measurement and process control theory.	4, 15	9,10	-
CO-2	Analyse transient behavior of simple systems.	4, 15	9,10	-
CO-3	Analyse data from experiments and prepare well organized laboratory report.	4, 15	9,10	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	3.0	-	-	-	-	2.0	2.0	-	-	-	-	3.0

List of Experiments:

1. Step response of first order systems (Thermometer).
2. Step response for Single Tank System - first order System.
3. Step & Impulse response for two first order systems arranged in Non - Interacting mode.
4. Step & Impulse response for first order systems arranged in Interacting mode.

5. Level Control Trainer– P, PI, PD, PID action.
6. Temperature Control Trainer– ON/OFF, P, PI, PD, PID action.
7. Control Valve Characteristics.
8. Temperature sensors characteristics – RTD, Thermocouple, Thermistor.
9. Characteristics of Temperature Transmitter.
10. Characteristics of I/P and P/I converters.
11. Analysis of Flapper-Nozzle system.

Note: Minimum 10 experiments to be conducted.

Reference Books:

1) Coughanour and Koppel, "Process System Analysis and Control", 2/e, McGraw Hill, New Delhi, McGraw Hill 1991.
2) Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", 2/e, McGraw Hill, 1990.

18UCHL703	Major Project – 1	(0-0-4) 2

Contact Hours: 72

Course Learning Objectives (CLOs):

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical engineering or integrated problems (allied fields).	2,10	8, 12	6, 7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9

CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.0	3.0	2.0	3.0	1.0	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

Course Content:

Major project-1 in which the students are expected to locate the state of the art technology in his domain of interest by an extensive literature survey and Select a topic from an emerging area relevant to their branch/interdisciplinary and define the problem for the project work. The material collection, survey, visits, data collection, preliminary design, analysis etc. is to be done in this phase. The project shall consist of a team of students not more than 4. Each batch shall be assigned with a guide. A committee consisting of minimum 3 faculty members of which guide is a member shall evaluate at the end for CIE. The weightage of marks shall be 50% for the committee and 50% for the guide. There is a SEE (viva voce) examination which shall be examined by two internal examiners appointed by COE based on the suggestions by the respective HoD.

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.

Books in the area of chemical engineering and its related fie

18UCHL704	Internship	(4 Weeks) 2

Contact Hours: 30

Course Learning Objective (CLO):

1. The purpose of internship is student should be able to learn how to apply the knowledge acquired during internships in his future workplace.
2. The student should demonstrate to work in the interdisplinary approach and in a team with good communication skills.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12)/PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Analyze and gain knowledge on the recent developments in the area of chemical and allied engineering and integrate his theoretical knowledge with practical processes.	13, 15	11, 12	4, 6, 7

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CO-2	Enhance his communication skills to work in interdisciplinary teams in industry.	9, 10	-	-
CO-3	Realize professional and ethical responsibility to work in a team and project management.	6, 7, 8	11, 12	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Internship: The students are to undergo internship in Private industries/R&D organizations/Centres of Excellence/Laboratories of Reputed Institutions/Govt. & Semi Govt. organizations, PSUs, construction companies, entrepreneurial organizations, inter departments within the college etc. to get en exposure to the external world for a period of 4 weeks in the summer vacation after VI sem and before start of VII semester. The students are to prepare a report on the internship work carried out. The internal faculty shall monitor the student and award CIE marks. There is a SEE in which the student shall present his work before a panel of examiners consisting of HoD, Guide and one faculty member during VII semester. The performance shall be communicated to the CoE office and the same shall reflect in the VII semester grade card

18UCHE705 Novel Separation Techniques (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide an understanding of novel/newer separations using mass transfer and thermodynamic considerations.
2. To provide an understanding of their applications at different levels in industry, viz. refineries, biochemical processing, pharmaceuticals, gaseous separations, metallurgical etc.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the use of separation factors and understand continuous adsorption processes with advanced chromatographic techniques.	4, 14	-	-
CO-2	Classify membrane based separations and explain their mass transfer and thermodynamic considerations with applications.	-	4,12	-

CO-3	Interpret the surfactant based micellar and foam separations with applications.	14	4, 12	-
CO-4	Comprehend Super Critical Fluid Extraction process with applications.	-	4, 12	14
CO-5	Outline the processes of gaseous diffusion, thermal diffusion, and electrophoresis.	4	-	14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO- 14	PSO -15
Mapping Level	-	-	-	2.4	-	-	-	-	-	-	-	2.0	-	2.0	-

Course content:

Unit-I

Introduction to separations: Importance, principles and separation factors, economic significance etc.

Adsorptive Separations: Thermal swing adsorption, gradient chromatography, Ligand chromatography and unsteady state fixed bed adsorption etc. **08 Hrs.**

Unit-II

Membrane Separation Processes: Classification, structure and characteristics of membranes, membrane modules, concentration polarization and fouling of membranes, R.O., U.F, Pervaporation, and gaseous separations. **08Hrs.**

Unit-III

Surfactant Based Separations: Fundamentals of surfactants at surfaces and in solutions. Liquid membrane permeation, foam separations, micellar separations. **08 Hrs.**

Unit-IV

Super Critical Fluid Extraction: Physicochemical principles, thermodynamics, process description. Applications and case study. **08 Hrs.**

Unit-V

Miscellaneous Separations: Gaseous diffusion, Thermal diffusion, electrophoresis and types. **07 Hrs.**

Reference Books:

1) P.C. Wankat, “Large scale adsorption chromatography” CRC Press,1986.
2) R.W. Rousseu, “Handbook of separation process technology”, John Wiley and sons 1987.
3) S.Sourirajan and T. Matsura, “Reverse osmosis and Ultra filtration process principle”, NRC publication Ottawa, 1985.

4) Richard Baker, "Membrane Technology and Applications", 2/e, ,John Wiley and Sons Ltd.

18UCHE706	Process Instrumentation	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. To make students understand the Identification, classification construction, working principle and application of various transducers used for Displacement, Temperature, Level, flow and Miscellaneous measurement

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the fundamentals of instrumentation to control chemical processes.		1,13	3
CO-2	Explain process control instrumentation with principles and theory		1	3,13
CO-3	Apply correct practice to installation, calibration of instrument and analyze limitations of each measuring instruments.		3	1,13
CO-4	Troubleshoot, isolate and fix electronic instrumentation problems.		1,3,13	
CO-5	Design a simple instrumentation system.	3	1	13

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	2.0	-	2.6	-	-	-	-	-	-	-	-	-	1.4	-	-

Prerequisite: Chemistry and Fundamentals

Course content:

Unit-I

Introduction: classification, characteristics of instruments- static and dynamic. Sensor and Transducer: Definition, classification (active, passive, primary, secondary, mechanical, electrical, analog, digital).Transducer specifications. Transmitters, Converters, Control panel, Recorders and monitors. Error: definition, classification**. Flow Measurement:** Head Type: orifice, venturi, nozzle, pitot tube. Variable Area Type: Rotameter type. Other flow meters: Turbine, electromagnetic, ultrasonic, positive displacement, anemometers, solid flow measurements. **08 Hrs**.

Unit-II

Pressure Measurement: Pressure scales, units and relations, classification, U-tube types, well type, inclined type manometer, micro manometer, bellows, diaphragm, bourdon tube,. Vacuum Measurement Units and relations, McLeod gauge, Pirani gauge, thermocouple gauge, hot cathode ionization gauge, Knudsen gauge. **08 Hrs.**

Unit-III

Level Measurement: Need for Level Measurement, Classification of Level Measurement Techniques. Construction and working of Dipstick, displacer, float system, bubbler, capacitive devices for level measurement, ultrasonic level gauge, DP cell, vibrating type, radar, radioactive type level gauges, LASER type transducers, fiber optic level sensors. **07 Hrs.**

Unit-IV

Temperature Measurement: Temperature scales, classification of Temperature Sensors, a) Thermometers: Classification, Construction and working of glass thermometers, liquid expansion thermometer, gas thermometer (filled system thermometer), bimetallic thermometer, Specifications. b)Resistance temperature detector (RTD):Principle, types, Configurations, construction and working of RTD, Material for RTD, Lead wire Compensation in RTD, Specifications, advantages, disadvantages and applications of RTD. c) Thermistors: Principle, types (NTC and PTC), characteristics, Construction and working, materials, specifications of Thermistor, applications **Thermocouples:** Principle, thermoelectric effect, See beck effect, Peltier effect, laws of thermocouple, types of thermocouple with characteristic curve, thermocouple table, Sensitivity, constructional features of Thermocouples, Thermo couple specifications, cold junction Compensation method, thermopile, thermocouple emf measurement method, Thermo well. Pyrometers: Principle, Construction and working of Radiation and optical pyrometers and its Applications **08 Hrs.**

Unit-V

Displacement Measurement: a) Resistance potentiometer: piezo-resistive effect, ultrasonic transducer. LVDT, RVDT. Selection and properties of materials for LVDT, and general electromagnetic sensors. b) Capacitance type transducers: with applications, materials for capacitive, ultrasonic and elastic transducers. c) Digital transducer: translational and rotary encoders, Optical and magnetic pickups. d) Pneumatic transducer: flapper- nozzle transducer. **Miscellaneous Transducers:** Transducers for Position, speed, acceleration, humidity, and moisture measurement.

Electronic measuring instruments, Electronic voltmeters, Principle of A/D and D/A converters **08 Hrs.**

Reference Books:

1) Donald Eckman,"Automatic Process Control", Wiley Eastern Limited
2) John P. Bentley, "Principles of Measurement Systems", 3/e, Addison Wesley Longman Ltd., UK, 2000.
3) Doebelin E.O, "Measurement Systems - Application and Design", 4/e, McGraw-Hill International Edition, New York, 1992.
4) Stephanopoulos George, Chemical Process Control.

18UCHE707 Process Modeling and Simulation in Chemical Engineering (3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To study basic concepts of modeling and formulation of mass and energy balance relationships and thereby it helps for the development of complex models.
2. To understand the advanced technologies in simulation field and the applicability in industries.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)/ PSO (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Compare and apply the different fundamentals to develop the models for chemical engineering system.	1,3	2	5
CO-2	Interpret and develop different mathematical methods for chemical engineering system.	3,13	1, 2	5
CO-3	Apply and assess different relevant software and models for solving chemical engineering problems.	5, 13	2,3	-
CO-4	Identify the different simulation tools and Ability to solve chemical engineering problems using numerical techniques	5, 13	2,3	-
CO-5	Demonstrate and analyse the different model solving ability for	5, 13	2, 3	-

	various chemical engineering process.			

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	2.5	2.0	2.4	-	2.2	-	-	-	-	-	-	-	3.0	-	-

Course content:

Unit-I

Modeling in Chemical Engineering: Introduction, Principles of Formulation, Fundamental laws; Continuity Equation, Energy Equation, Equation of motion, Transport Equations, Equation of States, Equilibrium, Chemical Kinetics, Classification of Mathematical models. **08 Hrs.**

Unit-II

Numerical Techniques: Iterative convergence methods like bisection and secant method, Newton raphson method, Numerical integration of ordinary differential equations like Euler and Runge Kutta method. Numerical solution of partial differential equations of first order approximation with examples. **08 Hrs.**

Unit-III

Models in Chemical Engineering: Introduction, Series of Isothermal, Constant-Holdup CSTRs, CSTRs with Variable Holdups, Two Heated Tanks, Gas-Phase, Pressurized CSTR, Non-isothermal CSTR, Single-Component Vaporizer, Multicomponent Flash Drum, Batch Reactor, Reactor With Mass Transfer, Ideal Binary Distillation Column, Multicomponent Non-ideal Distillation Column Batch Distillation With Holdup. **08 Hrs.**

Unit-IV

Computer Simulation: Introduction to Simulation, Role of Computers and Numerical Methods in simulation, Iterative convergence methods, Explicit Convergence methods, Explicit Numerical Integration algorithm, Implicit Methods, Numerical examples. **08 Hrs.**

Unit-V

Specific Simulation/ Model Development: Batch reactor, CSTR, Bioreactor, activity coefficient models, Distillation and equilibrium Flash vaporization. **07 Hrs.**

Reference Books:

1) William L. Luyben, “Process modeling, simulation and control for Chem. Engg.”, Mc. Graw Hill, 1990.
2) Edger TF and Himmelblau D M, “Optimization of chem. Process” Mcgraw Hill, 1989.
3) Asghar Hussain, “Chemical process simulation”, Wiley Eastern Ltd, 1986.
4) Roger G.E Franks, “Modeling and Simulation in Chemical Engineering” Wiley Inter science. New York, USA, 1972.

18UCHO708	Biochemical Engineering	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide the forum to understand the principles and concepts of microbiology, cell biology and biochemistry and thereby apply chemical engineering principles to asses and evaluate the cell as a reactor.
2. To incorporate the principles of chemical engineering in understanding the upstream and downstream processing techniques in a biochemical industry.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the microorganisms in the context of industrial and environmental microbiology and explain the chemicals of life with the properties and their derivates.		7	2
CO-2	Interpret and evaluate the enzyme kinetic parameters with different effects of the reactors.	13	3	2
CO-3	Analyze cell growth kinetics and solve problems of upstream bio processing.	13	3	2
CO-4	Explain the various configurations of bioreactors along with fermentation technology	12,13	3	2
CO-5	Identify and explain the methods involved in product recovery and purification	12,14	3	2

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	-	1.0	2.0	-	-	-	2.0	-	-	-	-	3.0	3.0	3.0	-

Course content:

Unit-I

Microbiology: Scope, structure of cells: Prokaryotic and Eukaryotic, characterization and classification of microorganisms - Taxonomy and Whitaker's 5-Kingdom concept, environmental and industrial microbiology, control of microorganisms.

Biochemistry: Chemicals of life - Lipids, sugars and polysaccharides; amino acids, proteins and enzymes; vitamins, biopolymers, nucleic acids and their derivatives. **08 Hrs.**

Unit-II

Enzyme Catalyzed Reactions: Enzyme Nomenclature and classification, enzyme kinetics, Mechanism and kinetics of enzymatic reactions, evaluation of kinetic parameters, factors affecting enzyme activity, Inhibitors and inhibition kinetics, Industrial enzymes and applications, methods of immobilization of enzymes. **08 Hrs.**

Unit-III

Biomass Production in Cell Cultures: Ideal reactors for kinetic measurements - batch and continuous reactors, Monod's growth kinetics, Transient growth kinetics, Cell growth and kinetic patterns, Reactors and their configurations. **09 Hrs.**

Unit-IV

Fermentation Technology: Ideal bioreactors, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations. **07 Hrs.**

Unit-V

Downstream Processing: Steps involved in product recovery, operations involved - centrifugation, chromatography and emerging technologies including membrane separation techniques. **07 Hrs.**

Reference Books:

1) Jay Bailey, James Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill, 1986.
2) Michael L. Shuler and Fikret Kargi, "Bioprocess Engineering - Basic Concepts", 2/e, Prentice Hall of India (2003).
3) Michael J. Pelczar, E. C.S. Chan and Noel R. Krieg, "Microbiology Concepts and Applications", 5/e, McGraw Hill reprint 2001.
4) Syed Tanveer Ahmed Inamdar, "Biochemical Engg: Principles and Concepts" 3/e, Prentice Hall of India Learning Pvt. Ltd. (2012), New Delhi.

18UCHO709	Instrumental Methods of Analysis	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. To understand the principles and concepts behind the qualitative and quantitative analysis of molecules and compounds using instrumental methods with their applications.

2. To illustrate the working and analysis of the different instrumental techniques of AAS, Spectrophotometer, electrochemical, chromatography etc.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Demonstrate and analyze Flame photometry and AAS techniques and its application.	13	2	1
CO-2	Explain and analyze the electrochemical techniques and its application	13	2	1
CO-3	Identify the concepts for analysis of molecules and compounds using instrumental methods.	13	2	1
CO-4	Interpret and analyze the different spectroscopic techniques.	13	2	1
CO-5	Interpret and analyze the chromatography technique and its applications.	13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	2.0	-	-	-	-	-	-	-	-	-	-	3	-	-

Prerequisite: Chemistry and Fundamentals

Course content:

Unit-I

Introduction to Flame Photometry and Atomic Absorption Spectroscopy: Introduction, Principle, Flame and flame spectra, variation of emission intensity with flame, Metallic spectra in flame, flame ground, Role of temperature on absorption emission and fluorescence. Comparative study of Flame Emission electroscopy (FES) and Atomic Absorption Spectroscopy (AAS) Instrumentation and Applications. Qualitative and quantitative determination of alkali and alkaline earth metals. **08 Hrs.**

Unit-II

Electrochemical Techniques: Introduction to Electrochemistry, Electrode Potential, Measurement, sign convention, Standard electrode potential, Cell Potential: Liquid junction potential, Effect of current. Polarization: Sources, over voltage, concentration polarization, Mechanism of mass transport. Potentiometric Methods: reference Electrodes- calomel electrode Ag- AgCl (s) electrode, Hydrogen electrode, Potentiometric titrations and applications. Membrane Electrodes: Classification of properties, Principle design, theory of ion selective electrodes Membrane potential, Selectivity, Crystalline liquid membrane and electrodes. **08 Hrs.**

Unit-III

Nuclear Magnetic Spectroscopy: Introduction, Chemical shifts, Mechanism of shielding and deshielding. Types of nuclei, Theory of population of nuclear magnetic energy levels, Spin –spin coupling, Rules of governing the interpretation of first order spectra, Low and high resolution NMR, Instrumentation and application to structure elucidation of simple organic molecules. **08 Hrs.**

Unit-IV

Mass Spectroscopy: Introduction, theory, Instrumentation of mass spectrometer, Methods of generation of positively charged ions, Mass analyzers, Resolving power, Molecular ion peak, Base peak, Metastable peak, Modes of fragmentations, Application of mass spectrometry in Qualitative and Quantitative analysis. Structural elucidation of simple organic molecules **08 Hrs.**

Unit-V

Chromatography: Introduction to chromatographic techniques, General descriptions, definitions, terms and parameters used in chromatography. Classification of chromatographic methods, working principles, Instrumentation and applications of Thin layer chromatography (TLC), Gas chromatography(GC), High pressure liquid chromatography (HPLC). **07 Hrs.**

Reference Books:

1) Jaffery, G.H., Basset, J., et. al., "Vogel's Text book of Quantitative Inorganic Analysis", 5/e, ELBX, 1998.
2) Skoog, D.A., "Principles of Instrumental Analysis", 3/e, Saunders College publishing, 1985.
3) W.H. Willard, "Instrumental Methods of analysis", 7/e, L.L., Merritt and J.A. Dean, 1988.
4) B.K. Sharma ,"Instrumental Methods of Chemical Analysis", Goel Publishing House Meerut, 2000.

18UCHO710	Nanotechnology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide students with the knowledge of techniques used for synthesis and surface modification of nanomaterials.
2. To understand the structural, morphological, and surface composition of nanomaterials and their applications.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:	**Mapping to POs (1,12)/ PSOs (13-15)**		
	Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**

CO-1	Describe the fundamentals of nanoscience and nanotechnology	-	2	1
CO-2	Analyze physical and chemical methods used for synthesis and processing of nanomaterials	13	2	1
CO-3	Compare and select suitable techniques for characterization of a given nanomaterial	1	2	-
CO-4	Use different techniques to process different types of nanocomposites and know the limitations of each process	1, 13	2	5
CO-5	Learn the importance and applications of Nanotechnology in chemical industries	-	7	6

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2	2	-	-	1	1	1	-	-	-	-	-	3	-	-

Course Content:

Unit-I

Introduction to Nanotechnology: Nanomaterials and its classification, Zero dimensional, one-dimensional and two dimensional nanostructure materials - classification of solids: conductor, semiconductors, insulator, types of semiconductor, doping, diodes, current flow in semiconductors, ceramics and nanocomposites, Properties of individual nanoparticles, Methods of synthesis, Reactivity of nanoparticles. **7 Hrs.**

Unit-II

Methods of Synthesis of Nanomaterials: Ball Milling, physical and chemical vapour deposition methods and Electro deposition, Solution based Synthesis of Nanoparticles, Inert gas condensation, Arc discharge, RF plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis and Molecular beam epitaxy, co-precipitation, sol-gel method, chemical reduction, photochemical synthesis, electrochemical synthesis, Spray pyrolysis method, flame spray pyrolysis, gas phase synthesis. **8 Hrs.**

Unit-III

Characterization Techniques: Optical Microscopy, Electron Microscopy, Secondary electron scattering, back scattering, Scanning Probe Microscopes, Focussed Ion Beam Technique, X-ray imaging, Transmission Electron Microscope (TEM), Scanning Probe Microscope (SPM)- Atomic Force Microscope (AFM), Scanning Tunneling Microscope (STM), UV-VIS Spectrophotometers, IR/FTIR Spectrophotometers, and Raman spectroscopy. **8 Hrs.**

Unit-IV

Nanocomposites and their Applications: Need for composite materials. Classification of composites; Matrix: Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC); Reinforcement: particle reinforced composites, Fibre reinforced composites. Applications of composites. Fibre production techniques for glass, carbon and ceramic fibres. **8 Hrs.**

Unit-V

Nanomaterials For Chemical Industry: Nanocatalysts, Smart materials, Heterogenous nanostructures and composites, Nanoparticles for water purification-Photocatalytic mechanism, general pathways and kinetics-Treatment of Arsenic, Removal of Heavy metal ions by Iron and polymeric based nanoparticles, Magnetic Nanoparticles, Nanoscale carbon for contaminant separation -Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes), Molecular Encapsulation and its applications – Nanoporous zeolites, Self assembled Nanoreactors. **8 Hrs.**

Reference Books:

1) M. H. Fulekar, “Nanotechnology importance and applications”, I. K. International Publishing House Pvt. Ltd., New Delhi, 2013.
2) Manasi Karkare, “Nanotechnology, Fundamentals and Applications”, I.K. International Publishing, New Delhi, 2008.
3) Jr. Poole, P. Charles and J. W. Frank, “Introduction to nanotechnology”, John Wiley & Sons, 2003.
4) G. Cao, “Naostructures and Nanomaterials: Synthesis, properties and applications”, Imperical College Press, 2004.
5) C. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2/e 2007.

VIII Semester

18UCHC800 Process Engineering Economics and Management (4–0–0)4

Contact Hours: 52

Course Learning Objective (CLO):

1. Prepare the students to analyse cost/revenue data and carry out economic analysis in the decision-making process to justify alternatives/projects on an economic basis and prepare to function in the business and management side of professional engineering practice.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1,12)/ PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the concepts of plant location, layout, and feasibility survey and perform cost estimation.	-	9,10	12
CO-2	Apply economic concepts viz. depreciation, cash flow, profitability, replacement, breakeven analysis etc. in solving chemical engineering problems.	10,11	9,14	12
CO-3	Interpret production management with its virtues inclusive of automation, work study and method study applied to a chemical industry.	10,11	9,14	12
CO-4	Interpret material management with its virtues inclusive of value engineering applied to a chemical industry.	10,11	9	12
CO-5	Interpret marketing management with its virtues inclusive of product life cycle applied to a chemical industry.	10, 11	9	12

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.8	3.0	1.0	-	2.0	-

Course content:

Unit-I

Introduction Importance of economics and management, plant location and plant layout, feasibility survey.

Cost Estimation Factors involved in project cost estimation, methods employed for the total cost estimation, Cost Index. **12 Hrs.**

Unit-II

Depreciation: Different methods of Depreciation. Time value of money and its equivalence. Cash flow diagrams. Taxes and Insurance.

Profitability and Methods of Evaluation: Replacement and alternative investments. Break even analysis. Financial statements. **12 Hrs.**

Unit-III

Production Management: Types of production and planning, manufacturing planning, factory planning, production planning, schedule, work study, method study, incentives and bonus, Automation. Organization of production, planning and control department. **10 Hrs.**

Unit-IV

Material Management: Functions of purchasing. Quality standards and Inspection. Sources of supply, Inventory management. ABC analysis, EOQ model. Value analysis and engineering. **09 Hrs.**

Unit-V

Marketing Management: Functions of marketing, marketing and sales, marketing engineer, and Market research. Product life cycle, Promotion of sales. Pricing methods, advertisements etc. **09 Hrs.**

Reference Books:

1) Peters and Timmerhaus, “Plant design and Economics for Chemical Engineers”, McGraw Hill, 1991.
2) Banga and Sharma, “Industrial Organization and Engineering Economics”, Khanna Publications, 1999.
3) Tripathi and Reddy, “Principles of Management”, 5/e, Tata McGraw-Hill Education, 2004.

18UCHL801	Technical Seminar	(0-0-2)1

Contact Hours: 26

Course Learning Objectives (CLOs):

1. To provide platform to focus on knowledge of technical data collection, communication skills and report writing.
2. To develop intellectual and professional competence and work on the chosen topic to improve skills in writing and oral presentation.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		Mapping to POs (1-12) /PSOs (13-15)		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review and acquire knowledge on the chemical engineering topic outside the scope of curriculum	14	6,7,8,9,12	4, 5
CO-2	Outline and consolidate the required information on chosen topic	9	6,7,8	-
CO-3	Organize the technical matter in the required format and compile the same	12	9	-
CO-4	Interpret and communicate the topic with proper justification and conclusion	9, 10	-	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	-	1.0	1.0	2.0	2.0	2.0	2.5	3.0	-	2.5	-	3.0	-

Course content:

Technical Seminar/ Independent study: The students are expected to learn how to carry out literature survey to locate the state of the art technology in engineering domain of their interest. They are required to carry out selection of an emerging topic beyond the syllabus relevant to the branch of study, understand the concept, analyze and present effectively for 15-20 minutes followed by 5 minutes of questions and answers before their classmates and faculty. They can also present the technical innovative/novel work carried out in the laboratory. They are also required to learn the effective communication and modalities of technical interactions. Further, they have to submit the seminar material in the form of a paper in IEEE format. All the students are required to attend all the session throughout the semester.

Procedure to conduct technical Seminar:

- All the students are informed to select a topic from the field of their interest from their branch or relevant to their branch and register the topic with the faculty(ies) In charge of Seminar.
- Two faculty members assigned to carry out this activity. The faculty members prepare the schedule of the seminar spread over the entire semester and display the same in the notice board.
- Change of seminar topic is not allowed once registered, however in the case of genuine reasons only once change of topic may be permitted.
- Based on the number of hours mentioned in the scheme, 4-6 students shall present the seminar in one slot of 2/3 hours.
- The faculty members shall conduct the seminar session every week as per the schedule in the slot mentioned on the time table and carry out the evaluation.
- Attendance is compulsory for all the students for all the seminars.
- The students are required to submit two hard copies of report not exceeding 6

pages and one soft copy of seminar report one week prior to their date of presentation.

- Report shall be in IEEE format viz A4 size paper, Title**:** Bold, Times new Roman Font 14, Sub heading & Body of the text**:** Times new Roman font 12. Margin for left should be 1 ½.
- Student name, USN, seminar date should be mentioned on the report.
- Presentation is for about 15-20 minutes, followed by 5 minutes for questions and answers.
- Typical evaluation methodology: The seminar shall be evaluated for maximum 50 marks. The breakup of marks shall be:
  Presentation: a) 40 marks b) Report: 10 marks.

For presentation, the following points not limited to may be considered.
Concept, understanding, depth of the knowledge, originality of the topic, Quality of PPT, communication skills etc.
For report evaluation, the following points not limited to may be considered
Adherence to IEEE format, relevance of topic, subject depth and originality in writing etc.
The seminar is aimed at as an educative program for the students. This is because, the students shall listen to 60- 70 seminars on different topics from emerging areas is as good as undergoing a course on latest happenings in the related branch of Engineering.
The departments going for **Independent study** in place of technical seminar shall plan, prepare the modalities and take the approval from Dean (AP).

Reference Books/Material:

Offline/online chemical engineering and its related field Journals.

Books in the area of chemical engineering and its related field.

18UCHL802	Major Project – 2	(0-0-12)7

Contact Hours: 100

Course Learning Objectives (CLOs):

1. To identify the problems in thrust areas of chemical engineering.
2. To plan experimental or theoretical work using multidisciplinary knowledge.
3. To apply the science, mathematical computational engineering and economics knowledge for solution of the problem selected.
4. To use various advanced instruments for the analysis with techniques.
5. To interact with industries, research centers and other colleges.
6. To understand the principle to work in teams and the concept of leadership.
7. To learn flow sheeting, designing and report writing skills.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the topic of chemical engineering or integrated problems (allied fields).	2,10	8, 12	6, 7, 14
CO-2	Compare the literature review and select suitable materials and methodologies for selected topic.	3,4,5,15	8,11,12	7, 10, 14
CO-3	Interpret the experimental results with discussion and economic analysis.	11,15	8,10,12	9
CO-4	Prepare a precise report on the work done with proper guidelines and references.	10	8,15	9
CO-5	Organize and present the work carried out to justify the results obtained with conclusion	9, 10, 12	8, 11	2, 4

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.0	3.0	2.0	3.0	1.0	1.0	2.0	1.66	2.4	2.33	2.0	-	1.0	2.66

Course Content:

Major project-2 is the continuation from phase –I in which the students are expected to go for material collection, survey, visits, data collection, preliminary design, analysis, model development, code writing, field work etc. The same project team formed for phase –I will continue the work under the guidance of the same faculty member. For all the projects, problems may be domain specific or interdisciplinary also in nature. A committee consisting of minimum 3 faculty members of which guide is a member shall evaluate at the end for CIE. There is a viva voce examination which shall be examined by two examiners one internal and one external to the college appointed by COE based on the suggestions by the respective HoD.

The reference materials for the project work are as listed below but not limited to:

Reference materials/books:

1. Engineering books.
2. Journals.
3. Manuals and data sheets.
4. Software packages.
5. Previous project reports.
6. Product information brochures.
7. Interaction with academia and industrial experts.
8. Internet etc.

18UCHE803	Sugar Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. To understand different cultivation and analytical methods, various unit operations and unit processes with practical difficulties encountered during the production of sugar.

Course Outcomes (COs):

Description of the course outcomes: At the end of the course student will be able to		**Mapping to POs (1-12) /PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend overall scenario, sugar cane cultivation, analysis and milling process.	5	-	-
CO-2	Classify various purification methods and advantages.	1	-	-
CO-3	Outline various unit operations, equipments and advantages.	-	14	-
CO-4	Compare various production methods and distillation types.	3	-	5
CO-5	Develop co-generation systems and efficiency along with pollution control measures.	7	3	-

POs/PSOs	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-13	PSO-14	PSO-15
Mapping Level	3.0	-	2.5	-	2.0	-	3.0	-	-	-	-	-	-	-	-

Course content:

Unit- I

Over view of Sugar Industry: Overall scenario of sugar industry both globally and in India. Factory site, layout of the factory. Sugar cane, sugar plantation, plant protection of sugar cane crop. Sugar cane cultivation, harvesting and milling process. Composition of cane and juice, properties of sucrose and reducing sugars. Various analytical methods used in sugar industry. **08 Hrs.**

Unit- II

Purification: clarifying and bleaching agents, defecation process. Classification of sulphitation and carbonation methods. Advantages of carbonation over sulphitation. Methods for the clarification of the syrup. Filtration of scums. **08 Hrs.**

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Unit- III

Unit Operations: Evaporation, multiple effect evaporation, various features of evaporation design, causes of entrainment, incrustation formation and removal, crystallization, boiling syrup massecuites, requirements of good pan boiling, rate of crystallization, factors affecting the crystal growth, various types of crystallizers, boiling schemes, condensers, centrifugal operation, dryers, grading of sugar.**08 Hrs.**

Unit- IV

Distillery: Molasses, storage, utilization, various distillation types, advantages. Production of ethanol by fermentation process, factors influencing the production of alcohol, design considerations for distillation column, distillery wastes, treatment, disposal. **08 Hrs.**

Unit- V

Co-generation: Types of co-generation systems, quality of bagasse and boilers used, efficiency, production of steam, quality of steam, pollution control measures for water, air, solid wastes and noise in sugar industries. **07 Hrs.**

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Reference Books:

1) Honing P (Ed), "Principles of Sugar Technology", Vol I to III, Elsevier publishing company, 1953.
2) Jenkinos. G.H., "Introduction to cane sugar Technology", Elsevier, 1966.
3) Mathur.R.B.L, "Handbook of cane Sugar Technology", 2/e, Oxford and I.B.H. Publishing Co., 1997.
4) R.K. Rajputh, "A text book on Power Plant Engineering", 2/e, Laxmi publications (p) Ltd., New Delhi, 2001.

18UCHE804 Advance Bioprocess Engineering (3-0-0)3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide the students with the basics of bioreactor engineering.
2. To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)/ PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Select appropriate bioreactor configurations and operation modes based upon the nature of bioproducts and cell lines and other	-	3, 7	2

	process criteria.			
CO-2	Design and analyse the scale up criteria for the different bioreactors.	5	2, 3, 7	-
CO-3	Understand the enzyme kinetics and design the immobilized enzyme bioreactors.	13	3, 7	-
CO-4	Apply modeling and simulation of bioprocesses so as to reduce costs and to enhance the quality of products and systems.	5	3, 7	-
CO-5	Identify the different cell cultivation system to apply in the different bioreactors.	13	3, 7	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	1.5	2.0	-	3.0	-	2.0	-	-	-	-	-	3.0	-	

Course content:

Unit-I

Operational Modes of Bioreactors: Fed batch cultivation, Cell recycle cultivation, Cell recycle cultivation in waste water treatment, two stage cultivation. Packed bed reactor, airlift reactor, fluidized bed reactor and bubble column reactor. **08 Hrs**.

Unit-II

Bioreactor Scale-Up: Regime analysis of bioreactor processes, oxygen mass transfer in bioreactors microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors based on oxygen transfer, power consumption and impeller tip speed. **08 Hrs.**

Unit-III

Bioreactor Consideration in Enzyme Systems: Analysis of film and pore diffusion effects on kinetics of immobilized enzyme reactions; formulation of dimensionless groups and calculation of effectiveness factors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors. **08 Hrs.**

Unit-IV

Modeling and Simulation of Bioprocesses: Study of structured models for analysis of various bioprocess – compartmental models, models of cellular energetic and metabolism, single cell models, plasmid replication and plasmid stability model. Dynamic simulation of batch, fed batch, steady and transient culture metabolism. **08 Hrs**

Unit-V

Recombinant Cell Cultivation: Different host vector system for recombinant cell cultivation strategies and advantages. E.coli, yeast Pichia pastoris/ Saccharomyces cereviseae, Animal cell cultivation, plant cell cultivation, Insect cell cultivation. High cell density cultivation, process strategies, reactor considerations in the above system. **07 Hrs.**

Reference Books:

1) Jens Nielson, John Villadsen and Gunnar Liden, "Bioreaction engineering principles", 2/e, Kulwer Academic, 2002
2) Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, 2/e, CRC press, London. 1995.
3) James E. Bailey and David F. Ollis, "Biochemical Engineering Fundamentals", 2/e, McGraw Hill. Singapore. 1986
4) Atkinson, B, Mavituna, F, "Biochemical Engineering and Biotechnology Handbook" 2/e, Macmillan Publishers Ltd, New York, 1992.

18UCHE805	Scale up in Chemical Process	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To learn how to create and conduct a pilot plant study, analyze and evaluate pilot plant results, and apply process scale-up methods.
2. To study proper designs, modeling and processing and the importance of the process geometry.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and explain the need for pilot plant and its demonstration with economic evaluation.	3	-	14
CO-2	Identify and develop different models and similarity studies for scale up methods.	5	2	13
CO-3	Illustrate and compare the different concepts of regime in scale up studies.	3	2	13
CO-4	Interpret and analyse different approaches for scale up studies in chemical engineering mixing system.	2, 3	5	13, 14
CO-5	Interpret and analyse different approaches for scale up studies in heat and mass transfer system.	2, 3	5	13, 14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	2.5	3.0	-	2.3	-	-	-	-	-	-	-	1.0	1.0	-

Course contents:

Unit-I

Introduction: Process development, Need for pilot plants, Scale-up procedures, basic terminologies- prototypes, models, scale ratios and elements. Major issues, fundamental principles, Demonstration, Economic evaluation of scaling up. **08 Hrs.**

Unit-II

Dimensional Analysis and Principles of Similarity: Significance of Dimensionless Numbers**,** Generalized dimensionless equations from Differential equation for static systems, flow systems, thermal systems, mass transfer processes, Homogeneous and heterogeneous chemical processes. **Principles of Similarity:** Geometric similarity, Distorted similarity, Static, dynamic, kinematics, thermal and chemical similarity with examples. **08 Hrs.**

Unit-III

Regime: Static regime. Dynamic regime. Mixed regime concepts. Criteria to decide the regimes. Equations for scale criteria of static, dynamic processes, Extrapolation. Boundary effects. **08 Hrs.**

Unit-IV

Scale up of Mixing Process and Chemical Reactors: Mixing Processes: Scale-up relationships, Scale-up of polymerization units, Continuous stages gas liquid slurry processes. Fluid-fluid Reactors: Scale-up considerations in packed bed absorbers and bubble columns, Applicability of models to scale-up. **08 Hrs.**

Unit-V

Scale up of Mass and Heat Transfer Processes: Continuous Mass Transfer Process: Fundamental considerations scale-up procedure for distillation, Absorption, Stripping and extraction units. Scale up of momentum and heat transfer systems. **07 Hrs.**

Reference Books:

1) Attilio Bisio, Robert L. Kabel, “Scale up of Chemical Processes”, John Wiley Interscience publication, 1985.
2) Ibrahim and Kuloor, “Pilot plant and Scale up Studies”.
3) Johnstone and Thring, “Pilot Plants Models and scale up method in Chemical Engineering”, McGraw Hill, 1962.
4) Marko Zlokarnik, “Dimensional Analysis and Scale-up in Chemical Engg.", Springer Verlag, Berlin, Germany, 1986.

18UCHO806	Solid Waste Management	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To provide students with a comprehensive understanding of integrated solid waste management from an environmental and public health perspective.
2. To study the detailed engineered system of solid waste management system.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the components and characteristics of a solid waste management system.	6	7	3
CO-2	Identify the various collection, transfer and transport mechanisms of municipal solid waste management.	6	3,7	-
CO-3	Explain various processing, material and energy recovery facilities.	14	3	
CO-4	Describe different methods and safety precautions used in disposal of MSW.	6,7	14	
CO-5	Explain types of hazardous solid waste and Discuss safe methods of disposal of hazardous waste & their management principles.	6,7	14	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	1.5	-	-	3.0	2.5	-	-	-	-	-	-	2.3	-

Course content:

Unit I

Introduction to Solid Wastes: Definition, Characteristics, Types of solid waste, Physical, Chemical and Biological properties of Municipal Solid Waste, Overview of materials flow in society and 4R concept of solid waste management. Evolution of SWM, Effect on health and environment. Legislation and government agencies. **08 Hrs.**

Unit II

Engineered Systems for Solid Waste Management: Generation of solid waste, Quantities of solid Waste, Methods to measure solid waste quantities, Solid waste generation and collection, Factors affecting solid waste generation rate, Onsite

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handling, Storage and Processing, Transfer and transport, Collection system and devices. **08 Hrs.**

Unit III

Processing Techniques and Recovery of Energy: Objectives of waste processing, component separation and volume reduction, various processing technologies — biological and chemical conversion methods, Composting, Factors affecting composting, Aerobic composting and anaerobic Digestion, Details of energy recovery system, heat recovery, gasification, pyrolysis and refuse derived fuels (RDFs). Municipal incinerators, Grates, Furnances of solid waste. Recovery, Material and Energy recovery operations. **08 Hrs.**

Unit IV

Disposal of Solid Wastes: Various disposal methods, landfills — site selection, site infrastructure, essential components of landfill; types of landfilling methods, landfill planning –leachate management and gas control; Environmental monitoring systems for landfill sites, closure and post-closure plans for landfills, landfill site rehabilitation, reclamation and remediation. **08 Hrs.**

Unit V

Hazardous Wastes: Definition, identification and classification of hazardous solid waste, Origin and reduction at source, Collection and handling, Management issues and planning methods, Environmental Act, E-waste handling and disposal.
Industrial Solid Waste Management: Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units. **07 Hrs.**

Reference Books:

1) George Tchobanoglous, “Integrated Solid waste Management-Engineering Principles and Management issues”, McGraw Hill, 1993.
2) Howard Peavy, “Environmental Engineering”, McGraw Hill,1986.
3) Dutta, “Industrial Solid waste Management and landfilling practice”, Narose Publication, 1999.

18UCHO807	Green Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. To understand the principles and concepts of green technology with laws and standards.
2. To illustarte and demonstarte the tool and design of environmnetal freidnly technology.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		Mapping to POs (1,12)/ PSOs (13-15)		
		Substantial Level (3)	Moderate Level (2)	Slight Level (1)
CO-1	Illustrate environment laws, carbon credits, ISO 14000 series	14	2	1
CO-2	Comprehend the principles of green chemistry.	-	2	1
CO-3	Summarize the importance of green technology in sustainable development	7, 14	-	-
CO-4	Apply and compare the tools of green technology and life cycle assessment.	7	-	1
CO-5	Conduct pollution prevention planning and develop the environment friendly design.	7	-	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1	2	-	-	-	-	3	-	-	-	-	-	-	3	-

Course content:

Unit I

Introduction: Green chemistry and technology for sustainable development, Environmental laws, carbon credits, environmental management system standards-ISO 14000 series. **08 Hrs.**

Unit II

Green Chemistry: Principles of Green Chemistry, Atom efficiency, Energy conservation, Waste minimization, Substitution. **08 Hrs.**

Unit III

Life-Cycle Assessment: History, Process, Methodology, Streamlining and Application. **08 Hrs.**

Unit IV

Pollution prevention planning: Structure of the pollution prevention process, Environmental Audits, toxic release inventory. **08 Hrs.**

Unit V

Design for the environment and improvement in manufacturing operations, design for disassembly/DE manufacturing, Packaging, case studies. **07 Hrs.**

Reference Books:

1) Paul L. Bishop, Pollution Prevention: Fundamentals and Practice, McGraw Hill, 2000.
2) Anastas P.T., Warner J.C., Green Chemistry: Theory and Practice. Oxford Science Publications, Oxford, 1998.
3) Mike Lancaster, Green Chemistry- An Introductory Text, Royal Society of Chemistry Publishing, 2010 55
4) Boyle, Godfrey, Bob Everett, Janet Ramage, Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University Press, 2004.

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Contact Hours: 39

Course Learning Objective (CLO):

1. To understand the various aspects of Environment Impact Assessment methodologies and impact of development activities.
2. To study the Impact assessment on surface water, air and biological Environment.

Course Outcomes (COs) :

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify the environmental attributes to be considered for the EIA study	6	2	1
CO-2	Prepare the audit report of the EIA	6, 14	-	1
CO-3	Identify the suitable methodology and prepare Rapid EIA.	7, 14	2	1
CO-4	Indentify and incorporate mitigation measures of impact studies	6, 7, 14	-	1
CO-5	Formulate assessment report of impact studies on water and air	7, 14	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1	2	-	-	-	3	3	-	-	-	-	-	-	3	-

Course content:

Unit - I

Basic concept of EIA : Objectives of EIA, Initial environmental Examination, Elements of EIA, - factors affecting EIA Impact evaluation and analysis, preparation of Environmental Base map, Classification of environmental parameters. Types of

EIA, Various types of Environmental Impacts: Direct Impacts, Indirect Impacts, Cumulative Impacts, Induced Impacts, EIA Methodologies: introduction, Criteria for the selection of EIA Methodology, EIA methods, Ad-hoc methods, matrix methods, Network method Environmental Media Quality Index method, overlay methods, cost/benefit Analysis. **08 Hrs**.

Unit- II

Environmental Audit and Environmental legislation: Objectives of Environmental Audit, Types of environmental Audit, Audit protocel, stages of Environmental Audit, onsite activities, evaluation of Audit data and preparation of Audit report, Post Audit activities. Related environmental legislation **08 Hrs**.

Unit- III

Creation of EIA Data Base, Compilation, Environmental Inventory: Baseline Data Generation, Environmental Monitoring Networking Design (EMND), Monitoring Stations, Data Products and Sources, Impact Identification (II) Methodologies, Interaction-Matrix Methods, Use of the Leopold Matrix, Checklist Methodologies: Simple Checklists, Descriptive Checklists, Uses of Checklists, Network Methodologies. **08 Hrs**.

Unit – IV

Impact Assessment: Assessment of impact of development activities on Vegetation and wildlife, environmental Impact of Deforestation, Soil quality, Impact prediction, Assessment of Impact significance, Identification and Incorporation of mitigation measures. **08 Hrs**.

Unit - V

Case studies: Impact Assessment, Significance and Assessment of the Impacts, Impact Mitigation Measures, Impacts on Water Environment, air environment. Case studies and preparation of Environmental Impact assessment statement for various Industries. **07 Hrs.**

Reference Books:

1) R.R. Barthwal., “Environmental Impact Assessment” New Age International Publications. 2012.
2) Canter, L,W., “Environmental Impact Assessment”, McGraw Hills New York, 1977.
3) M. Anji Reddy, “Environmental Impact Assessment: Theory and Practice”, BS Publications.
4) N.S.Raman , A.R. Gajbhiye, S.R. Khandeshwar Environmental Impact Assessment” 1/e, IK International publishing Ltd., 2014
5) Bhatia, H. S. - Environmental Pollution and Control, Galgotia Publication (P) Ltd, Delhi.