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)

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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 2020-21 till further revision.

Principal Chairman BoS & HoD

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

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.

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.**

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	13	2,3	1

	balance, graphical and algebraic approach.			
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	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	9	8, 10	-

	discuss the results obtained with justification and conclusion in a report.			

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%

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.

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 manufacturing processes	13	7	2
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 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.

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.

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.

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	-	2, 3, 13	1

	problems.			
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	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.**

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 plant.	3	6,8	14
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	14	2, 7	-

	products.			
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

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 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	-	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	14	2	7

	advanced materials based on reaction method			
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.