Academic Program: UG

Academic Year 2023-24

Syllabus

V & VI Semester B.E.

Chemical Engineering

SHRI DHARMASTHALA MANJUNATHESHWARA COLLEGE OF ENGINEERING & TECHNOLOGY,
DHARWAD – 580 002
(An Autonomous Institute 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 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 2023-24 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.

SDM COLLEGE OF ENGINEERING AND TECHNOLOGY, DHARWAD
Department of Chemical Engineering
V Semester
Scheme of Teaching and Examinations 2023 – 24

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
21UHUC530	HU	Management, Entrepreneurship and IPR	3 - 0 - 0	3	50	100	3	-	-
21UCHC500	PC	Mass Transfer-I	3 - 0 - 0	3	50	100	3	-	-
21UCHC501	PC	Chemical Reaction Engineering-II	2 - 2 - 0	3	50	100	3	-	-
21UCHC502	PC	Computational Methods in Chemical Engineering	3 - 0 - 0	3	50	100	3	--	--
21UCHE5XX	PE	Program Elective-1	3 - 0 - 0	3	50	100	3	--	--
21UCHL503	PC	Computational Methods in Chemical Engineering Laboratory	0 - 0 - 2	1	50	--	--	50	3
21UCHL504	PC	Chemical Reaction Engineering Laboratory	0 - 0 - 2	1	50	--	--	50	3
21UAEE530	AE	Principles in Chemical Engineering-II	2 - 0 - 0	2	50	50	2	--	--
21UCHL505	PC	Minor Project-1	0 - 0 - 2	1	50	--	--	--	--
21UCHL506	PC	Internship-1	Minimum 2 Weeks	1	50	--	--	--	--
Total			**16- 2 -6**	**21**	**500**	**550**	**17**	**100**	**6**
Electives									
21UCHE507	PE	Polymer Science and Technology	3 - 0 - 0	3	50	100	3	-	-
21UCHE508	PE	Chemical Equipment Design	3 - 0 - 0	3	50	100	3	-	-
21UCHE509	PE	Air Pollution and Control Engineering	3 - 0 - 0	3	50	100	3	-	-

SDM COLLEGE OF ENGINEERING AND TECHNOLOGY, DHARWAD
Department of Chemical Engineering
VI Semester
Scheme of Teaching and Examinations 2023 – 24

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
21UCHC600	PC	Mass Transfer-II	3 - 0 - 0	3	50	100	3	-	-
21UCHC601	PC	Process equipment Design	2 - 2 - 0	3	50	100	3	-	-
21UCHC602	PC	Chemical Technology	3 - 0 - 0	3	50	100	3	-	-
21UCHE6XX	PE	Program Elective-2	3 - 0 - 0	3	50	100	3	-	-
21UCHE6XX	PE	Program Elective-3	3 - 0 - 0	3	50	100	3	-	-
21UCHO6XX	OE	Open Elective-1	3 - 0 - 0	3	50	100	3	--	--
21UCHL603	PC	Mass Transfer Laboratory	0 - 0 - 2	1	50	--	--	50	3
21UCHL604	PC	Simulation Laboratory	0 - 0 - 2	1	50	--	--	50	3
21UCHL605	PC	Minor Project-2	0 - 0 - 3	1	50	--	--	50	3
21UHUL606	HU	Soft skills and Aptitude	0 - 0 - 2	1	50	--	--	--	--
Total			**17 - 2 – 9**	**22**	**500**	**600**	**18**	**150**	**9**
Electives									
21UCHE607	PE	Chemical Process Integration	3 - 0 – 0	3	50	100	3	-	-
21UCHE608	PE	Biochemical Engineering	3 - 0 – 0	3	50	100	3	-	-
21UCHE609	PE	Petroleum and Petrochemical Engineering	3 - 0 – 0	3	50	100	3		
21UCHE610	PE	Novel Separation Techniques	3 - 0 – 0	3	50	100	3	-	-
21UCHE611	PE	Pharmaceutical Technology	3 - 0 – 0	3	50	100	3	-	-
21UCHE612	PE	Food Technology	3 - 0 – 0	3	50	100	3	-	-
Open Elective (Open for all Branches)									
21UCHO613	OE	Sugar Technology	3 - 0 – 0	3	50	100	3		
21UCHO614	OE	Energy Technology and Management	3 - 0 – 0	3	50	100	3	-	-
21UCHO615	OE	Instrumental Method of Analysis	3 - 0 – 0	3	50	100	3	-	-

Total credits offered for the third year: 43

V Semester

21UHUC530 Management, Entrepreneurship and IPR (3–0–0) 3

Contact Hours: 39

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. **08Hrs.**

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. **08Hrs.**

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. **08Hrs.**

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. **08Hrs.**

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. **07Hrs.**

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.

21UCHC500	Mass Transfer- I	(3-0-0) 3

Contact Hours: 39

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 and applied to industrial diffusion separations, obtain transfer coefficients to propose and evaluate 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. **08Hrs**

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 **08Hrs.**

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. **08Hrs.**

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. **07Hrs.**

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. **08 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.

21UCHC501	Chemical Reaction Engineering-II	(2-2-0) 3

Contact Hours: 39

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. **08L+2THrs.**

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. **07L+2THrs.**

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. **08L+2THrs.**

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. **08L+2THrs.**

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. **08L+2THrs.**

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

21UCHC502 Computational Methods in Chemical Engineering (3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

1. Develop proficiency in using software applications essential for chemical engineers, enabling effective process simulation, data analysis, and process design.

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 importance of modeling, simulation, and optimization in the field of chemical engineering.	1, 2	3	14
CO-2	Apply linear algebraic equations and nonlinear algebraic equations to model chemical engineering systems.	2,5	1,4	13
CO-3	Demonstrate proficiency in EXCEL basics, including implementing basic functions, fitting, and plotting data, and utilizing built-in functions for chemical engineering applications.	5	1,3	-

CO-4	Developed a strong proficiency in utilizing MATLAB for various tasks in the field of chemical engineering.	5	4	14
CO-5	Develop MATLAB code to solve problems related to fluid dynamics, such as unsteady flow in a pipe, considering the conservation equations for mass, momentum, and energy	1,4	5	-

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	2	2.3	2.8			-	-	-	-	-	1	1	-

Course content:

Unit-I

Mathematical Modeling and Simulation: Introduction to modeling, Industrial production system landscape, Optimization problems in industry, General Process Analysis Principles. MODEL AND MODEL BUILDING. Basic Models: Flow Processes, Open Systems, Close Systems. Simulation. **07Hrs**.

Unit-II

Fundamentals of Functional Analysis: Introduction, Process Design problem: Dynamic behavior and operability analysis. Mechanistic Models and Abstract Equation Forms: Linear Algebraic Equations, Nonlinear Algebraic Equations, Optimization Based Formulations Introduction to numerical methods for solving ordinary differential equations (ODEs), Euler's method and higher-order ODE solvers, Runge-Kutta methods for ODE integration, Stability and accuracy considerations Application of numerical methods to chemical engineering problems involving ODEs. **08Hrs.**

Unit-III

Excel for Chemical Engineering: EXCEL basics: built-in functions, operations with columns and rows, plotting, solver, building functions in VBA. Examples: fitting, plotting, and solving, fluid mechanics. Unit operations,mass and energy balances, link EXCEL with other software. **08Hrs.**

Unit-IV

MATLAB for Chemical Engineering: MATLAB basics: basic functions, fitting and plotting, using built-in functions, programming language. Examples: momentum, mass and energy transfer, Heat and Mass Transfer in 2D, Unsteady flow in a pipe. SIMULINK. **08Hrs.**

Unit-V

MATLAB Code development: Unsteady flow in a pipe, Compute the missing quantity among P, V, T for an ideal gas, Newton's Law of Cooling, Calculation of Residence Time in a Reactor, Mass and Energy Balances, Chemical Reaction Kinetics. Steady-State Material Balances. Thermodynamics: Calculate the vapor-liquid equilibrium using the Antoine equation. **08 Hrs**

Reference Books:

1) Introduction to Software for Chemical Engineers, Mariano Martin, CRC Press Taylor & Francis Group, Second Edition, 2020.
2) Computational and Statistical methods for chemical Engineers, (1/e) Taylor & Francis Ltd;, Emst C. Wit and Wim P. Krijnen, 2022.
3) Pushpavanam S., Mathematical methods in Chemical engineering, (1/e), PH Learning Pvt.Ltd.,2004.
4) Excel 2019 Bible, Michael Alexander, 1/e, Wiley.
5) INTRODUCTION TO MATLAB PROGRAMMING, TOOLBOX & Paperback, Jaydeep Chakravorty, The Orient Blackswan

21UCHL503 Computational Methods in Chemical Engineering Laboratory (0-0-2)1

Contact Hours: 30

Course Learning Objective (CLOs):

1. Understand the importance and relevance of software applications in the field of chemical engineering.
2. Demonstrate proficiency in using essential software applications for process simulation, data analysis, and process design

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	Develop a comprehensive understanding of Excel's built-in functions relevant to chemical engineering calculations.	4, 5, 15	8, 10	9
CO-2	Gain Proficiency in MATLAB Basics for Chemical Engineering Applications.	4, 5, 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	3.0			2.0	1.0	2.0	-	-	-	-	3.0

List of Experiment:

Solve the problem using MATLAB/EXCEL.

1. Solving equation of state, regression of parameters.
2. Calculation of Reynolds number, friction factor and pressure drop.
3. Calculation of heat transfer coefficient in a Heat Exchanger.
4. Calculation of Bubble and due point calculation.
5. Calculation of HTU and NTU in an Absorber.
6. Calculation of Antoines coefficient.
7. Estimation of settling velocity of solids in liquids using Stokes law.
8. Calculation of minimum number of stages in a distillation column.
9. Solving mass and energy balance problems.
10. Calculation of Power in Reciprocating compressor.

Reference Books:

1) Introduction to Software Chemical Engineering Mariano Martin, CRC Press Taylor & Francis Group, Second Edition, 2020.
2) Excel 2019 Bible, Michael Alexander, 1/e, Wiley.
3) INTRODUCTION TO MATLAB PROGRAMMING, TOOLBOX & Paperback, Jaydeep Chakravorty, The Orient Blackswan

21UCHL504 Chemical Reaction Engineering Laboratory (0-0-2) 1

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To study the reaction kinetics for lab scale reactors by applying the knowledge of chemical kinetics.
2. To analyze and interpret the experimental data to find the rate law to design reactors for large scale production and to submit in the form of a 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	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.
3) Chemical Reaction Engineering Laboratory Manual

21UAEE530 Principles in Chemical Engineering- II (2-0-0) 2

Contact Hours: 26

Course Learning Objective (CLO): To provide knowledge to learn, understand and inculcate the principles and practices adopted in a chemical process industry.

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 chemical process industry with roles and responsibilities of various designates	13, 6	8, 9	1
CO-2	Prioritize process selection, conversions, vessels and columns used in unit operations and specific utilities in a chemical plant	13	8	1
CO-3	Outline the fundamentals of process control and instrumentation and AIML in a chemical process industry	5, 13	8	2
CO-4	Outline the basics of pilot plant and scale up along with the technology towards process sustainability	7, 8	6	3
CO-5	Outline the basic principles of plant economics and overall quality of the process	8, 14	6	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	1.0	-	3.0	1.66	3.0	2.4	2.0	-	-	-	3.0	3.0	-

Course Content:

Unit-I

Chemical Industry and Engineering: Chemical Industry an overview, chemical processing, job description and role of a research and development engineer, production engineer, piping and layout engineer, environment engineer, materials engineer, project engineer. **05Hrs.**

Unit-II

Equipments and Process plant: Process selection, chemical and biochemical conversions, outline of unit processes and unit operations, vessels and columns; types and configurations, thermic fluids, air conditioning. **06Hrs.**

Unit- III

Introduction to control and measurements: Importance and applications of process control and instrumentation; temperature, pressure, flow, level measurements. Modeling and simulation and AIML in chemical engineering. **05Hrs.**

Unit-IV

Process sustainability: Pilot plant and scale up, carbon capture and carbon sequestration, bio remediation, environment and sustainability in chemical engineering, Life cycle assessment and circular economy. **05Hrs.**

Unit-V

Plant economics principles: Process economics, Competing processes, materials, energy, labour and evaluation of a typical chemical plant, quality control and quality assurance, total quality management. **05 Hrs.**

Reference Books:

1) Max Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers, 5/e 2004; Mc Graw Hill.
2) M Gopala Rao and Marshall Sittig, Dryden's Outlines of Chemical Technology, 3/e. East West Press.
3) Perry's Chemical Engineers Hand book, 7th edition, Mc Graw Hill
4) M.A. Chaudhari, "Industrial Measurements" Nirali Publications, 2018.
5) Uche Nnaji, Introduction to Chemical Engineering, Scrivener Publishing, 2019, Wiley.

21UCHL505	Minor Project -1	(0-0-2) 1

Contact Hours: 20

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.

21UCHL506 Internship-I (2 Weeks) 1

Contact Hours: 13

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
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	-	-	-	1	-	2	2	3	3	3	2	-	3	-	3

Internship: The students are required to undergo internship in any of the relevant department including centre of excellences & incubation centres in the college for a period of minimum two weeks in vacation between IV and V semesters to get an exposure to the Engineering establishment and activities of the other departments. The students are required to prepare a report on the internship-I undergone. The internal faculty shall monitor the student and award CIE marks based on the assessment conducted. The performance shall be communicated to the CoE office and the same shall reflect in the V semester grade card.

21UCHE507 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. **07Hrs.**

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. **08Hrs.**

Unit-III

Processing Technology: Extrusion, Injection moulding, blow moulding Compression moulding, rotational moulding, thermoforming, Calendering, Compounding. **09Hrs.**

Unit-IV

Polymer Manufacturing: Industrial production methods of PE, PP, PS, PVC, UF, PF, PU, Poly butadiene, Nylon 6 and Nylon 66. **08Hrs.**

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. **07Hrs.**

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.

21UCHE508 Chemical Equipment Design (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.
2. To study the detailed design considerations of different types of equipment 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	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.

21UCHE509 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: Sources and classification of air pollutants. Effects of air pollutants on human health, vegetation and animals, Materials. 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. **07Hrs.**

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. Introduction to meteorology and transport of air pollution. 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 with different Modeling Techniques

08Hrs.

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. **08Hrs.**

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. **08Hrs.**

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. **08Hrs.**

Reference Books:

1) M.N. Rao and H. V. Rao, Air Pollution, McGrew Hill Publications, 2007. ISBN-13- 9780074518717.
2) Anjaneyulu. Y, Air Pollution & Control Technologies, BS Publication, 2/e. 2000. ISBN: 9789387593053.
3) 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.
4) David H.F. Liu, Bela G. Liptak, Air Pollution, CRC Press. 1/e. 2000. ISBN-10: 1566705134.

VI Semester

21UCHC600	Mass Transfer - II	(3-0-0)3

Contact Hours: 39

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. **09Hrs.**

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. **08Hrs.**

Unit-III

Multistage Distillation: Multi-stage rectification column. Design using McCabe Thiele method for binary mixtures. Efficiencies–overall, local, and Murphree plate efficiencies. Multicomponent distillation. Vacuum, molecular, extractive and azeotropic distillations **08Hrs.**

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. **07Hrs.**

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. **07Hrs.**

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).

21UCHC601	Process Equipment Design	(2-2-0)3

Contact Hours: 39

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 and mass transfer equipments	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.
- Use of standard code books to be taught.

1. Shell and Tube Heat Exchanger.
2. Condenser
3. Distillation Column.
4. Evaporator
5. Absorption Column.
6. 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.

21UCHC602	Chemical Technology	(3-0-0) 3

Contact Hours: 39

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. **08Hrs.**

Unit-II

Chlor-Alkali Industry: Sodium chloride, Soda ash, Caustic soda, Chlorine, Bleaching powder

Acids: Sulfuric, Nitric, Hydrochloric and Phosphoric acids. **09Hrs.**

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. **07Hrs**.

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.

08Hrs.

Unit-V

Oils and Fats Industry: Manufacture of oils (vegetable and industrial) processing and refining, essential oils and uses,

Soaps and detergent Industry: Types of soaps and detergents, manufacturing process and uses. **07Hrs.**

Reference Books:

1) George T Austin: Shreves and Brink “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

21UCHL603	Mass Transfer Laboratory	(0-0-2)1

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	8, 10	9
CO-2	Estimate the percentage recovery for types of Extraction equipments.	4, 15	8, 10	9
CO-3	Calculate the Diffusion coefficient for Diffusion of organic vapour experiment, and height of cooling tower	4, 15	8, 10	9
CO-4	Interpret the temperature dependency on ternary phase diagram.	4, 15	8, 10	9
CO-5	Evaluate Freundlich equation using adsorption principles	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. 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
5) Mass Transfer Laboratory Manual

21UCHL604 Simulation Laboratory (0-0-2)1

Contact Hours: 30

Course Learning Objectives (CLOs):

1. To make the students understand physical systems in chemical engineering and using UniSim to develop models and solutions for these models.
2. The students will also learn to use 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 UniSim simulation software.	4, 5,15	8, 10	9
CO-2	Compute the chemical engineering problems with Numerical Integration	4, 5,15	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	3.0	-	-	2.0	1.0	2.0	-	-	-	-	3.0

List of Experiments:

1. Introduction to UniSim.
2. Modeling of Mixer.
3. Modeling of Mixer in series with Heater.
4. Modeling of Mixer in series with Flash separator
5. Flash Separation operation
6. Simulation of Distillation column
7. Simulation of Refrigeration Cycle including compressor
8. Simulation of Multi-component Absorption Column
9. Model of the heater and reactor system
10. Simulation of Conversion reactor
11. Modelling and simulation of CSTR

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.

21UCHL605	Minor Project-2	(0-0-3) 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 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.

21UHUL606	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

21UCHE607 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. **06Hrs.**

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. **09Hrs.**

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). **09Hrs.**

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) **09Hrs.**

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. **06 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

21UCHE608	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 Whittaker'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. **08Hrs.**

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. **08Hrs.**

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. **09Hrs.**

Unit-IV

Fermentation Technology: Ideal bioreactors, medium formulation, operation and maintenance of typical aseptic aerobic fermentation processes, alternate bioreactor configurations. **07Hrs.**

Unit-V

Downstream Processing: Steps involved in product recovery, operations involved - centrifugation, chromatography and emerging technologies including membrane separation techniques. **07Hrs.**

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.

21UCHE609 Petroleum and Petrochemicals Engineering (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. **07Hrs.**

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. **09Hrs.**

Unit-III

Crude Pretreatment: Crude receiving, Storing, Pumping, dehydration, comparison, petroleum furnaces and comparison, Refining of petroleum – Atmospheric and vacuum distillation. **07Hrs.**

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.

08Hrs.

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. **08Hrs**.

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.

21UCHE610	**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. **08Hrs.**

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. **08Hrs.**

Unit-IV

Super Critical Fluid Extraction: Physicochemical principles, supercritical fluids, 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.

21UCHE611 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. **07Hrs**

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. **08Hrs**

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.**08Hrs**

Unit-IV

Pharmaceuticals, Microbiological Products: Laxatives, Radiopharmaceuticals, Cardiovascular agents, Central Nervous System stimulants, External Antiseptics, Analgesics, Antacids, Antibiotics, Antineoplastic drugs, Antidiabetic drugs, Hormones, Vitamins. **08Hrs**

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. **08Hrs**

Reference Books:

1) D. M. Brahmankar and S. B. Jaiswal. “Biopharmaceutics and Pharmacokinetics - A Treatise”, Vallabh Prakashan, New Delhi. 2015.
2) Felton, Linda A., Remington: “Essentials of Pharmaceutics”, College of Pharmacy, Philadelphia, 1/e. Pharmaceutical Press. 2013.
3) Juergen Siepmann, Ronald A. Siegel, Michael J. Rathbone, “Fundamentals and Applications of Controlled Release Drug Delivery”, Springer New York, 2011.
4) L. Lachman, Lieberman H.A. and Kanig J.L., “The Theory and Practice of Industrial Pharmacy”, 3/e. Indian Edition, Varghese Publishing House, Mumbai, 2013.

21UCHE612 Food Technology (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. **07Hrs**

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) **08Hrs**

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. **08Hrs**

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. **08Hrs**

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. **08Hrs**

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. **08Hrs**

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.

21UCHO613 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.**

Unit- III

Unit Operations: Evaporation, multiple effect evaporation, various features of evaporators 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.

21UCHO614 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 Renewable 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	Understand principles of emerging technologies in mechanical, electrochemical, and thermal storage systems. Analyze the advancements in energy efficiency for insights to shape a sustainable future.	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: Definition of energy sources, Classification of energy sources (renewable vs non-renewable), Importance of energy sources in the modern world. **Fuels**: Classification, properties and tests and analysis of

solid, liquid and gaseous fuels. Overview of coal, oil, and natural gas, Environmental impact, and sustainability issues **08 Hrs.**

Unit-II

Renewable Energy Sources: Solar Energy: Photovoltaic systems, Solar thermal technologies. Wind Energy: Wind turbine technology, Wind farm design and operation. Hydropower; Types of hydropower plants, Environmental considerations. **07 Hrs.**

Unit-III

Biomass and Bioenergy: Introduction to Biomass: Definition, Various forms, Biomass availability and geographical considerations, Biomass sources. Conversion technologies: Thermochemical Conversion, Biochemical Conversion. Biofuels and their applications. **08 Hrs.**

Unit-IV

Emerging Energy Technologies: Energy storage systems: Definition and significance of energy storage, Various types of energy storage systems. Mechanical Energy Storage, Electrochemical Energy Storage, Thermal Energy Storage. Advances in Energy Efficiency: Definition and significance of energy efficiency, Technological Advances in Energy Efficiency, Policies and Regulations for Energy Efficiency. **08 Hrs.**

Unit-V

Energy Management: Smart Grids and Energy Management Systems: Introduction to smart grids, Demand-side management. **Energy Auditing and Performance Assessment:** Basics of energy auditing, Tools and techniques for energy performance assessment, Case studies on energy auditing in industries. **08 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.

21UCHO615	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. **08Hrs.**

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. **08Hrs.**

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. **08Hrs.**

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. **08Hrs.**

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). **07Hrs.**

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.

CIE and SEE Evaluation (from 2022-23 batch)

Courses with LTP 3-0-0 and 4-0-0 or 2-2-0/3-2-0

Continuous Internal Evaluation (CIE):

- Two Internal Assessment and one Improvement test each of 20 marks and one hour duration.
- Two higher scores from three tests are taken representing 40 marks.
- Question Paper pattern for Internal Assessment: 3 questions of 10 marks each with maximum of two sub divisions. Q.3 is compulsory and one question to be answered from Q.1 and Q.2.
- Course Teacher Assessment (CTA): Minimum two components such as quiz, seminar, written assignment, any technical activity related to course each of 5marks. Total CTA marks-10
- CIE=40 (from tests)+10(from CTA) =50 marks

Semester End Examination (SEE):

- SEE is conducted for100 marks with 3 hours duration. It is reduced to 50 marks.
- Question Paper pattern for SEE: Five units with built in choice. Each question with maximum of three sub divisions.
- Two questions are to be set from each unit with built in choice, for example Q1 or Q2 in unit –I, Q 3 or Q 4 in unit-II and so on.
- A total of 5 full questions to be answered choosing one full question from each unit. All five units are to be answered compulsorily.
- Each question is of 20 marks.
- The Question paper is to be set for duration of 3 hours both for 3 and 4 credits courses.
- The Question paper is to be set for 100 marks for 3 and 4 credits courses.

ASC(IC)/PCC with LTP 2-0-2, 3-0-2 and 2-2-2

Continuous Internal Evaluation (CIE):

Theory CIE component:

- Two Internal Assessment and one Improvement test each of 20 marks and one hour duration.
- Two higher scores from three tests are taken representing 40 marks.
- Question Paper pattern for Internal Assessment: 3 questions of 10 marks each with maximum of two sub divisions. Q.3 is compulsory and one question to be answered from Q.1 and Q.2.

Course Teacher Assessment (CTA): Totally based on conduction of experiments as set by the course teacher.

Laboratory component assessment:

- 5 marks: for conduction, regularity, involvement, journal writing, etc. Minimum 75% of attendance is compulsory. If the performance is not satisfactory in laboratory the student shall be detained and required to reregister for the course as a whole when ever offered next.
- 5 marks: Lab Test. A Lab test as per the class time table has to be conducted at the end for50 marks and scale down to 5 marks.
- CIE for integrated course =40 (from IA tests)+10 (from CTA i.e. lab component) =50 marks.
- There will not be any remuneration for Final Lab Test since it is CTA of integrated course.
- Copy of the Marks list to be sent to the concerned course instructor immediately after the completion of test for that batch. Original Marks list to be maintained in the department.
- CIE=40(from tests)+10(from CTA i.e. lab component) =50 marks

Semester End Examination (SEE):

- SEE is conducted for100 marks with 3 hours duration. It is reduced to 50 marks.
- Question Paper pattern for SEE: Five units with built in choice. Each question with maximum of three sub divisions.
- Two questions are to be set from each unit with built in choice, for example Q1 or Q2 in unit –I, Q 3 or Q 4 in unit-II and so on.
- A total of 5 full questions to be answered choosing one full question from each unit. All five units are to be answered compulsorily.
- Each question is of 20 marks.
- The Question paper is to be set for duration of 3 hours both for 3 and 4 credits courses.
- The Question paper is to be set for 100 marks for 3 and 4 credits courses.

AEC/HSMS/UHV Courses with LTP 1-0-0:

Continuous Internal Evaluation (CIE)

- Two Internal Assessment and one Improvement test each of 20 marks and one hour duration.
- Two higher scores from three tests are taken representing 40 marks.
- Question Paper pattern for Internal Assessment: MCQ 20 questions
- Course Teacher Assessment (CTA): Minimum two components such as quiz, seminar, written assignment, any technical activity related to course etc. each of 5marks. Total CTA marks-10
- CIE=40(from tests) +10(from CTA) =50 marks

Semester End Examination (SEE):

- SEE is conducted for 50 marks of 1 hour duration. There will be 50 MCQs.
- Question Paper pattern for SEE: The question paper will contain 12 MCQ questions drawn from each Unit.
- Students have to answer maximum of 10 questions from each unit.
- All five units are to be answered compulsorily.