Academic Program: UG

Academic Year 2024-25

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 2024-25 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 entrepreneurial 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 COLLEGEOF ENGINEERING AND TECHNOLOGY,DHARWAD
Department of Chemical Engineering
V Semester
Scheme of Teaching and Examinations 2024 – 25

Sl. No	Course	Course code	Course Title	TD/PSB	Teaching Hours/Week			Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	HSMS	22UCHC500	Engineering Economics, Management and Entrepreneurship		3	0	0	03	50	100	100	3
2	PCC	22UCHC501	Chemical Reaction Engineering-II		4	0	0	03	50	100	100	4
3	PCC	22UCHC502	Mass Transfer-I		4	0	0	03	50	100	100	4
4	PEC	22UCHE5XX	Program Elective Course-I		4	0	0	03	50	100	100	4
5	PCCL	22UCHL503	Computational Methods in Chemical Engineering Laboratory		0	0	2	03	50	50	100	1
6	PCCL	22UCHL504	Chemical Reaction Engineering Laboratory		0	0	2	03	50	50	100	1
7	PROJ	22UCHL505	Minor Project-I		0	0	4	03	50	50	100	2
8	MC	22URMK506	Research Methodology and IPR		2	0	0	02	50	50	100	2
9	MC	22UESK507	Environmental studies		1	0	0	01	50	50	100	1
10	HSMS	22USSK508	Soft Skills-I		0	0	2	-	50	-	50	Audit
11	MC	22UNSK509	National Service Scheme (NSS)	NSS	0	0	2	-	50	-	50	Audit
Total											**1000**	**22**
Program Elective Course –I												
	PEC-I	22UCHE521	Air Pollution Control Engineering		4	0	0	03	50	100	100	4
	PEC-I	22UCHE522	Computational Methods in Chemical Engineering		4	0	0	03	50	100	100	4

HSMS: Humanity and management Science course, PCC: Professional Core Course, PCCL: Professional Core Course laboratory, AEC: Ability Enhancement course, MC: Mandatory Course, L: Lecture, T: Tutorial, P: Practical, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation. K: This letter in the course code indicates common to all the stream of engineering. PEC: Program elective course, PROJ: Project. TD: Teaching department, PSB: Paper setting Board.

Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses are added supplement the latest trend and advanced

technology in the selected stream of engineering. Each group will provide an option to select one course.
Minor-Project-I: The students are expected to identify 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 2-4 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 constituted by HOD consisting of minimum 2 faculty members shall evaluate 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 recommended by the HoD.
Soft Skills-I: Training on communication skills, proficiency in English language and aptitude ability is arranged involving external resource. The external resource person 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 50 marks. The arrangement for CIE evaluation is to be done by the department and maintain the relevant documents.
National Service Scheme: All students have to register for the courses namely National Service Scheme (NSS) with the concerned course coordinator during the first week of respective semester. Activities shall be carried out between III semester to the VI semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS activities. This course shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of degree.
AICTE activity point: Every regular student, who is admitted to the 4-year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students VIII semester grade card. The activities to earn the points can be spread over the duration of the program. However, minimum prescribed duration should be fulfilled. Activity points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression. In case student fails to earn the prescribed activity points; VIII semester grade card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the VIII semester grade card.

SDM COLLEGEOF ENGINEERING AND TECHNOLOGY, DHARWAD
Department of Chemical Engineering
VI Semester
Scheme of Teaching and Examinations 2024 – 25

Sl. No	Course	Course code	Course Title	TD/PSB	Teaching Hours/Week			Examination				Credits
					Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	22UCHC600	Mass Transfer-II		4	0	0	03	50	100	100	4
2	PCC	22UCHC601	Process Equipment Design		4	0	0	03	50	100	100	4
3	PCC	22UCHC602	Chemical Technology		3	0	0	03	50	100	100	3
4	PEC	22UCHE6XX	Program Elective Course-II		3	0	0	03	50	100	100	3
5	PEC	22UCHE6XX	Program Elective Course-III		3	0	0	03	50	100	100	3
6	OEC	22UCHO6XX	Open Elective Course-I		3	0	0	03	50	100	100	3
7	PCCL	22UCHL603	Mass Transfer Laboratory		0	0	2	03	50	50	100	1
8	PCCL	22UCHL604	Simulation Laboratory		0	0	2	03	50	50	100	1
9	PROJ	22UCHL605	Minor Project-II		0	0	4	03	50	50	100	2
10	HSMS	22USSK606	Soft Skills-II		0	0	2	-	50	-	50	Audit
11	MC	22UNSK607	National Service Scheme (NSS)	NSS	0	0	2	-	50	-	50	Audit
								Total			**1000**	**24**
Program Elective Course -II												
	PEC-II	22UCHE621	Chemical Process Integration		3	0	0	03	50	100	100	3
	PEC-II	22UCHE622	Novel Separation Techniques		3	0	0	03	50	100	100	3
Program Elective Course – III												
	PEC-III	22UCHE631	Petroleum and Petrochemicals		3	0	0	03	50	100	100	3
	PEC-III	22UCHE632	Catalyst Technology		3	0	0	03	50	100	100	3
Open Elective Course-I												
	OEC-I	22UCHO641	Advanced waste water treatment		3	0	0	03	50	100	100	3
	OEC-I	22UCHO642	Solid Waste Management		3	0	0	03	50	100	100	3

HSMS: Humanity and management Science course, PCC: Professional Core Course, PCCL: Professional Core Course laboratory, AEC: Ability Enhancement course, MC: Mandatory Course, L: Lecture, T: Tutorial, P: Practical S= SDA: Skill Development Activity, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation. K: This letter in the course code indicates common to all the stream of engineering. PEC: Program elective course, OEC: Open elective course, PROJ: Projects. TD: Teaching department, PSB: Paper setting Board.
Professional Elective Courses (PEC): A professional elective (PEC) course is intended to enhance the depth and breadth of educational experience in the Engineering and Technology curriculum. Multidisciplinary courses are added supplement the latest trend and advanced technology in the selected stream of engineering. Each group will provide an option to select one course. The minimum numbers of students' strength for offering Open Elective Course are as prescribed by the DAP.
Open Elective Courses (OEC): Students belonging to a particular stream of Engineering and Technology are entitled to opt for the open electives offered by their parent Department and other departments provided that they satisfy the prerequisite condition if any. Registration to open electives shall be documented under the guidance of the Program Coordinator/ Advisor/Mentor. The minimum numbers of students' strength for offering Open Elective Course are as prescribed by the DAP.
Minor-project-II: It is either a continuation of Mini-Project-I or a new project. The students are expected to identify 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 2-4 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 constituted by HOD consisting of minimum 2 faculty members shall evaluate 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 recommended by the HoD.
Soft Skills-II: Training on communication skills, proficiency in English language and aptitude ability is arranged involving external resource. The external resource person 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 50 marks. The arrangement for CIE evaluation is to be done by the department and maintain the relevant documents.
National Service Scheme: All students have to register for the courses namely National Service Scheme (NSS) with the concerned course coordinator during the first week of respective semester. Activities shall be carried out between III semester to the VI semester (for 4 semesters). Successful completion of the registered course and requisite CIE score is mandatory for the award of the degree. The events shall be appropriately scheduled by the colleges and the same shall be reflected in the calendar prepared for the NSS activities. This course shall not be considered for vertical progression as well as for the calculation of SGPA and CGPA, but completion of the course is mandatory for the award of degree.

AICTE activity point: Every regular student, who is admitted to the 4-year degree program, is required to earn 100 activity points in addition to the total credits earned for the program. The activity points earned by the student shall be reflected on the students VIII semester grade card. The activities to earn the points can be spread over the duration of the program. However, minimum prescribed duration should be fulfilled. Activity points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression. In case student fails to earn the prescribed activity points; VIII semester grade card shall be issued only after earning the required activity Points. Students shall be eligible for the award of degree only after the release of the VIII semester grade card.

Total credits offered for the Second year: 46

V Semester

22UCHC500 Engineering Economics, Management and Entrepreneurship (3-0-0)3

Contact Hours: 39

Course Learning Objective (CLO):

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

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1,12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Comprehend the concepts of plant location, layout, and feasibility survey and perform cost estimation.	11	8, 9,14	10, 12
CO-2	Apply economic concepts viz. depreciation, cash flow, profitability, replacement, breakeven analysis etc. in solving chemical engineering problems.	11	8, 9,14	10, 12
CO-3	Explain planning, organizing, staffing, directing and controlling in modern organization structures.	11	8,9,10	12, 14
CO-4	Interpret production material and marketing management with its virtues inclusive of value engineering applied to a chemical industry.	11	8, 9,10	12, 14
CO-5	Summarize the role of entrepreneurs in economic development and asses impact of liberalization and globalization on SSI.	11	8, 9, 10	12, 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	2	1.6	3	1	-	1.4	-

Course content:

Unit-I

Introduction: Importance of economics and management, plant location and plant layout, feasibility survey.

Cost Estimation Factors involved in project cost estimation, methods employed for the total cost estimation, Cost Index. **08 Hrs.**

Unit-II

Depreciation: Different methods of Depreciation. Time value of money and its equivalence. Cash flow diagrams. Taxes and Insurance.

Profitability and Methods of Evaluation: Replacement and alternative investments. Break even analysis. Financial statements. **08 Hrs.**

Unit-III

Management: Characteristics and levels of management. Functions of management, planning, organizing, staffing, directing, and controlling. **07 Hrs.**

Unit-IV

Production, Material and Marketing Management: Types of production, production planning, schedule, work study, method study, automation. Functions of purchasing, Quality standards and Inspection, Inventory management, ABC and EOQ Model, Value analysis. Functions of marketing, marketing and sales, market research, product life cycle, pricing methods and advertisements. **08 Hrs.**

Unit-V

Entrepreneurship: Characteristics of entrepreneur. Functions and types of entrepreneurs, role of entrepreneurship in economic development and barriers of entrepreneurship. Role of small-scale industry (SSI) development**,** advantages, and steps to start SSI. Institutions assisting SSI, objectives, and functions of SSIDC, SSIB, DICs, TCOs, NSIC, SIDO, IDBI and SIDBI. Preparation of the project report. **08 Hrs.**

Reference Books:

1) Peters and Timmerhaus, “Plant design and Economics for Chemical Engineers”, McGraw Hill, 1991.
2) Banga and Sharma, “Industrial Organization and Engineering Economics”, Khanna Publications, 1999.
3) Tripathi and Reddy, “Principles of Management”,5/e, Tata McGraw-Hill Education, 2004.
4) Veerabhadrappa Havinal, “Management and Entrepreneurship”, 1/e, ISBN (13): 978-81-224-2659-5, New Age International, 2009.
5) Thomas W. Zimmerer, “Essentials of Entrepreneurship”, PHI, 2005.

22UCHC501	Chemical Reaction Engineering-II	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand non-Ideal flow behavior in chemical reactors.
2. To provide the forum to understand the principles and concepts involved in catalytic reactions.
3. To understand kinetics of heterogeneous reactions (non-catalytic) and apply the same for reactor design.

Course Outcomes (COs):

Description of the course outcome: At the end of the course, student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Define residence time distribution and determine conversion using single parameter models for real reactors.	2	-	1
CO-2	Apply various models for fluid-particle reactions and design reactors for ideal flow patterns.	3, 13	2	4
CO-3	Develop rate equations for fluid-fluid reactions and design reactors for ideal flow patterns.	3, 13	2	4
CO-4	Select various methods to estimate properties of solid catalyst, controlling mechanisms and reactor design.	3, 4, 13	1	-
CO-5	Develop deactivation kinetics and design catalytic reactor with regeneration.	3	4	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.5	2.3	3.0	1.75	-	-	-	-	-	-	-	-	3.0	-	-

Prerequisite: Chemical Reaction Engineering-I

Course content:

Unit-I

Non-ideal Flow: Causes for non-ideal flow, the residence time distribution (RTD), E, C

and F Curves, Experimental methods for finding extent of non-ideal behavior, Micro and macro mixing, conversion in non-ideal flow reactors from tracer information, dispersion model and tanks-in-series model. **11 Hrs.**

Unit-II

Fluid-Particle Reactions: Introduction to heterogeneous non-catalytic reactions, industrial examples, overall rate expression, Ideal contacting patterns, progressive conversion and shrinking core model, overall rate expression for various controlling mechanisms from shrinking core model, conversion – time expressions, Design of reactors for particles of single size and different sizes under ideal flow patterns.

11 Hrs.

Unit-III

Fluid – Fluid Reactions: Industrial examples, Rate equations for straight mass transfer and mass transfer with chemical reaction, various kinetic regimes, liquid film enhancement factor, Role of Hatta number, Design of reactors for fluid-fluid reactions under co-current and counter-current operations based on ideal flow patterns.

10 Hrs.

Unit-IV

Solid Catalyzed Reactions: The nature and mechanism of catalytic reactions, Adsorption isotherms, physical, chemical dynamic and mechanical properties of solid catalyst and their determination, catalyst preparation, overall rate expressions for various controlling mechanisms. Experimental methods to determine rate equation.

10 Hrs.

Unit-V

Catalyst Deactivation: Causes for deactivation, mechanisms of deactivation, Experimental methods to find deactivation kinetics using Batch- solids and Batch-fluids, Batch solids and Mixed constant and variable flow of fluid, Batch solids and plug constant and variable flow of fluid. Deactivation with regeneration.

10 Hrs.

Reference Books:

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

22UCHC502	Mass Transfer- I	(4-0-0) 4

Contact Hours: 52

Course Learning Objectives (CLOs):

1. To understand the fundamentals and principles of diffusion mechanism in all the phases of matter along with equilibrium diffusion between the phases with an insight of interphase mass transfer.
2. To understand and apply analogy between transport processes 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. **12 Hrs**

Unit-II

Interphase Mass Transfer: Introduction, concentration profile. Use of Film Transfer Coefficients in unicomponent diffusion and equimolal counter diffusion. Use of Overall Transfer Coefficients. Graphical approach, equilibrium diffusion between the phases, types of operations. Material balance in each process. Stages, efficiencies **10 Hrs.**

Unit-III

Crystallization: Introduction, importance with examples, solubility concept, equilibrium solubility etc. Saturation/equilibrium, super saturation, mechanism of crystallization etc. Myer's theory of super saturation, Methods of generating super saturation. Nucleation types, crystal breeding, growth regimes. Ostwald's ripening, crystal growth and coefficients, crystal size and shape factors. Material balance calculations, ΔL law of crystal growth, caking of crystals. **10 Hrs.**

Unit-IV

Humidification: Importance and terminology, Psychrometric chart for air-water system. Measurement of Wet Bulb Temperature, Adiabatic Saturation Temperature, Lewis relation. Cooling towers, Theory of cooling towers. Types, construction and working. **10 Hrs.**

Unit-V

Drying: Importance with examples. Terminology in drying. Graphical representations of various terms. Typical rate of drying curve. Drying time calculations. Mechanism of drying, use of heat transfer and mass transfer coefficients. Theories of moisture movement. Industrial Dryers.

Adsorption: Introduction, importance with examples, applications. Types of adsorption; nature of adsorbents, Adsorption equilibria; isotherms, isobars and isosteres. Adsorption calculations, Stage wise calculations and graphical representation. Adsorption equipments. **10 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.

22UCHL503 Computational Methods in Chemical Engineering Laboratory (0-0-2)1

Contact Hours: 26

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) IntroductiontoSoftware Chemical Engineering Mariano Martin, CRCPress Taylor&FrancisGroup, Second Edition, 2020.
2) Excel 2019 Bible, Michael Alexander, 1/e, Wiley.
3) Introduction to Matlab Programming, Toolbox & Paperback, Jaydeep Chakravorty, The Orient Blackswan

22UCHL504 Chemical Reaction Engineering Laboratory (0-0-2) 1

Contact Hours: 26

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, 2004.
2) J. M. Smith, “Chemical Engg Kinetics”, 3/e, Mc Graw Hill, 1984.

22UCHL505	Minor Project - I	(0-0-4) 2

Contact Hours: 52

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 which are social relevant under chemical engineering.	2,10	8, 12	7, 14
CO-2	Compare the literature review and select suitable materials and	3,4,5,15	8,11,12	7, 10, 14

	methodologies for selected topic.			
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 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.

22URMK506	Research Methodology and IPR	(2-0-0) 2

Contact Hours: 26

Course Learning Objectives (CLOs):

The students are expected to learn about the need and types of research, problem formulation, literature review, measurement, scaling, data collection, testing of hypothesis, result interpretation and report writing. Also expected to learn about the importance of IPR and trade mark.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Formulate the research problem, carryout literature survey and decide the methodology.	-	2	-
CO-2	Importance of Literature survey and need to identify gaps	-	2	5
CO-3	Describe measurement and scaling and data collection &report writing			3
CO-4	Basic concepts concerning IPR and copy rights	-	4	-
CO-5	Explain the need for Trademark and IT act.		5	

POs/PSOs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level		2	1	2	1.5							

Pre-requisites:

Design and Analysis of Engineering subjects related issues

Contents:

Unit-I

Research Methodology: Introduction, meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, research methods versus methodology.

Defining the Research Problem: Research problem, selecting the problem, necessity of defining the problem, technique involved in defining a problem, an illustration. **05 Hrs.**

Unit-II

Reviewing the literature: Importance of the literature review in research, how to review the literature, searching the existing literature, reviewing the selected literature and writing about the literature reviewed.

Research Design: Meaning of research design, need for research design, features of a good design, important concepts relating to research design. **05 Hrs.**

Unit-III

Data Collection: Collection of primary data, observation method, interview method, collection of data through questionnaires.

Testing of Hypotheses: What is a Hypothesis? Basic concepts concerning testing of hypotheses, procedure for hypothesis testing, flow diagram for hypothesis testing, measuring the power of a hypothesis test, tests of hypotheses

Interpretation and Report Writing: Meaning of interpretation, technique of interpretation, precaution in interpretation, significance of report writing. **06 Hrs.**

Unit-IV

Meaning and conception of IPR, competing, rationale for protection, international conventions, world court.

Copy right: Historical evolution of the law on copy right, meaning, content

Patents: Meaning of Patent, purpose and policy object of patent law, gains to inventor, application of patents, joint application, discovery and invention, patentable and non-patentable inventions. **05 Hrs.**

Unit-V

Trademarks: Definitions and conceptions of Trademark, advantages of registration, marks which are not registrable, known and well-known trade marks, application for registration and procedure for registration, procedure and certification of Trademarks.

The Information Technology Act:

Definitions, certifying authority, meaning of compromise of digital signature, offences and penalties, applicability of IPRs, cybercrimes, adjudicating officer, violation,

damages and penalties, Cyber regulation appellate tribunal, World Wide Web and domain names and cyber flying, Self study. **05 Hrs.**

Reference Books:

1) C.R. Kothari, Gaurav Garg, Research Methodology: Methods and Techniques, New Age International, 4th Edition, 2018.
2) Ranjit Kumar, Research Methodology a step-by-step guide for beginners, SAGE Publications, 3rd Edition, 2011.
3) Fink A, Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications, 2009.
4) N. K. Acharya, Text book on Intellectual Property Rights, 4th Edition, Asia Law House, Hyderabad.

22UESK507	Environmental Studies	(1-0-0) 1

Contact Hours: 13

Course Learning Objective (CLO):

The students are to learn in this course about the need of balanced ecosystem, effects of human activities on environment, optimized use of natural resources including energy extraction and current Environmental issues.

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	Discuss the concept of ecosystem and effects of human activities on environment.		7	
CO-2	Describe the adverse effects on health and society due to erratic exploitation of natural resources.			6
CO-3	Understand various types of energy, sources of energy.		6	
CO-4	Explain different types of Pollution and concept of Global warming, Ozone		7	

	layer depletion.			
CO-5	Discuss the current developments towards NGO to protect environment.		6	

POs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mapping Level	-	-	-	-	-	1.6	2	-	-	-	-	-	-	-	-

Course content:

Unit - I

Environment and Effects of Human activities on Environment: Introduction, Ecosystem – Types & Structure of Ecosystem, Impacts of Agriculture & Housing, Mining & Transportation. Environmental Impact Assessment, Sustainable Development. **03 Hrs**.

Unit - II

Natural Resources: Introduction Water resources – Availability & Quality aspects, Water borne diseases, Fluoride problem in drinking water. Material Cycles - Carbon cycle and Nitrogen cycle. **03 Hrs**.

Unit - III

Energy in Ecological System: Different types of energy, Conventional sources & Non-Conventional sources of energy. Solar energy, Hydro electric energy, Wind energy, Nuclear energy, Biomass & Biogas, Fossil Fuels, Hydrogen as an alternative energy. **03 Hrs.**

Unit - IV

Environmental Pollution: Water Pollution, Land Pollution, Air Pollution, Global Warming, Ozone layer depletion. **02 Hrs.**

Unit - V

Current Environmental Issues & Environmental Protection: Environmental Acts & Regulations, Role of Nongovernmental Organizations (NGOs). Introduction to GIS & Remote Sensing, Applications of GIS & Remote Sensing. **02 Hrs.**

Reference Books:

1. P. Meenakshi, “Elements of Environmental Science and Engineering”, Prentice Hall of India Private Limited, New Delhi, 2006.
2. Benny Joseph “Environmental Studies”, Tata McGraw – Hill Publishing Company Limited, 2010.
3. Raj Gopalan “Environmental Studies” Oxford University press, New Delhi, 3rd Edition, 2016.
4. Kaushik and Kaushik “Perspectives in Environmental Studies “, New Age International Private Limited, 2005.
5. D. L. Manjunath “Environmental Studies “, Pearson, Noida, 2016.

22USSK508 Soft skills - I (0-0-2) Audit

Contact Hours: 26

Course Learning Objectives (CLOs):

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 the student will be able to:		**Mapping to POs (1-12)/PSOs**		
		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	-

PO's	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.0	-	1.0

Contents:

Number System, Linear Equations + Assessment Test ▪ HCF and LCM, Ratios & Proportions + Assessment Test ▪ Percentage, Profit & Loss + Assessment Test ▪ Time, Work & Distance + Assessment Test ▪ Simple and compound Interest, Averages and

Mixtures + Assessment Test ▪ Permutations, Probability + Assessment Test ▪ Data analysis **14Hrs**

Cyptarithmetic ▪ Analytical Puzzles ▪ Classification Puzzles ▪ Mathematical Puzzles ▪ Human Relations ▪ Directional tests ▪ Coding and decoding ▪ Series completion – Verbal and Non-verbal ▪ Questions from recent recruitment tests. **10 Hrs**

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.

22UNSK509	National Service Scheme	(0-0-2) Audit

Contact Hours: 24

Course Learning Objectives:

1. Understand the community in which they work.
2. Identify the needs and problems of the community and involve them in problem-solving.
3. Develop among themselves a sense of social & civic responsibility & utilize their knowledge in finding practical solutions to individual and community problems.
4. Develop competence required for group-living and sharing of responsibilities & gain skills in mobilizing community participation to acquire leadership qualities and democratic attitudes.
5. Develop capacity to meet emergencies and natural disasters & practice national integration and social harmony.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO1	Understand the importance of his / her responsibilities towards society.	12	6	8
CO2	Analyze the environmental and societal problems/issues and will be able to design solutions for the same.	12	6	8

CO3	Evaluate the existing system and to propose practical solutions for the same for sustainable development.	12	6	8,
CO4	Implement government or self-driven projects effectively in the field.	12	6	8

POs	1	2	3	4	5	6	7	8	9	10	11	12
Mapping Level	-	-	-	-	-	2	-	1	-	-	-	3

Activity list:

1. Waste management– Public, Private and Govt organization.
2. Setting of the information imparting club for women leading to contribution in social and economic issues.
3. Water conservation techniques – Role of different stakeholders– Implementation.
4. Preparing an actionable business proposal for enhancing the village income and approach for implementation.
5. Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.
6. Developing Sustainable Water management system for rural areas and implementation approaches.
7. Contribution to any national level initiative of Government of India. For eg. Digital India, Skill India, Swachh Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc.
8. Spreading public awareness under rural outreach programs. (minimum 2 programs).
9. Social connect and responsibilities.
10. Plantation and adoption of plants. Know your plants.
11. Organize National integration and social harmony events /workshops/ seminars. (Minimum 02 programs).
12. Govt. school Rejuvenation and helping them to achieve good infrastructure.

Students have to take up at least three activities on the above said topics and have to prepare content for awareness and technical contents for implementation of the projects and have to present strategies for implementation of the same.

Note: Activities must be unique (Not repeat) across semesters for each student.

CIE will be evaluated based on their presentation, approach and implementation strategies.

Reference Books:
NSS Course Manual, Published by NSS Cell, VTU Belagavi

ASSESSMENT AND EVALUATION PATTERN		
	Time Schedule	CIE (50)
Presentation: on Selected topic	Before the IA-3	50 Marks

Note: Implementation strategies of the project with report duly signed by the Department NSS Coordinator and HoD

22UCHE521 Air Pollution Control Engineering (4-0-0)4

Contact Hours: 52

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. **11Hrs.**

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 **10Hrs**.

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. **10Hrs.**

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. **10Hrs.**

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. **11Hrs.**

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.

22UCHE522 Computational Methods in Chemical Engineering (4-0-0) 4

Contact Hours: 52

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 Mathematical Modeling, Overview of mathematical modeling in chemical engineering, Importance and applications, Types of mathematical models: deterministic vs. stochastic, empirical vs. mechanistic. Fundamentals of Simulation, Introduction to simulation techniques Discrete-event simulation vs. continuous simulation, Differential Equations in Chemical Engineering, Basics of chemical reaction kinetics. **10 Hrs.**

Unit-II

Fundamentals of Functional Analysis: : Introduction to Functional Analysis and Process Design, Vector Spaces and Normed Spaces, Linear Operators and Functionals, Mechanistic Models and Abstract Equation Forms, Introduction to Numerical Methods for ODEs, Application of Numerical Methods to Chemical Engineering Problems, Hands-on Practice with Numerical Methods and reaction kinetics. Case Studies and Applications. **12 Hrs.**

Unit-III

Excel for Chemical Engineering: Introduction to Excel Basics for Chemical engineering , Data Analysis and Visualization in Excel, Solver and goal Seek for Chemical Engineering Problems, Building functions in VBA for Chemical Engineering, Advanced Excel Techniques for Chemical Engineering. Unit Operations and Mass/Energy Balances in Excel, Linking Excel with Other Software for Chemical Engineering Review, Practical Exercises, and Project Presentation. **10 Hrs.**

Unit-IV

MATLAB for Chemical Engineering: Introduction to MATLAB Basics, MATLAB Built-in Functions for Chemical Engineering, MATLAB Programming Language, Heat and Mass Transfer in 2D using MATLAB, Unsteady Flow in a Pipe using MATLAB, Introduction to SIMULINK, Advanced SIMULINK Applications, Review, Practical Exercises, and Project Presentation. **10 Hrs.**

Unit-V

MATLAB Code development: Unsteady Flow in a Pipe Simulation, Ideal Gas Properties and Missing Quantity Calculation, Newton's Law of Cooling Simulation, Residence Time Calculation in a Reactor, Chemical Reaction Kinetics Simulation, Steady-State Material Balances, Vapor-Liquid Equilibrium Calculation using Antoine Equation. Case study. **10 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

VI Semester

22UCHC600	Mass Transfer - II	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

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

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Describe the phenomena of vapor-liquid equilibria, principle and types of distillation process	1, 3	2	13
CO-2	Design and calculate the no. of stages for distillation process by different methods	3, 13	2	1
CO-3	Outline the principles of different mass transfer equipment and Interpret the concept and mechanism of the absorption tower and its sizing	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.

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. **08 Hrs.**

Unit-II

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 **08 Hrs.**

Unit-III

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. **09 Hrs.**

Unit-IV

Liquid-Liquid Extraction: Liquid-Liquid equilibrium, ternary diagrams, solvent characteristics, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Equipment for liquid-liquid extraction. **07 Hrs.**

Unit-V

Leaching Operation: Solid-liquid extraction (Leaching), various types with application, Stage wise contact, Single stage extraction, Multistage crosscurrent and counter current extraction, Graphical Analysis of stages, Leaching equipment: Selection, construction, and operation. **07 Hrs.**

Reference Books:

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

22UCHC601	Process Equipment Design	(4-0-0)4

Contact Hours: 52

Course Learning Objectives (CLOs):

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

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Congregate and analyze the data from the hand book, code book to design and evaluate the heat and mass transfer equipment.	3, 13	2	1

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	2.0	3.0	-	-	-	-	-	-	-	-	-	3.0	-	-

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

Course content:

- Detailed Chemical Engineering Process Design of the following equipment.
- Use of standard code books to be taught.

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

NOTE:

1. The question paper to contain two full design problems (100 Marks each) for the equipment from the above list and **student to answer any One full question.**

2. Perry's Chemical Engineer's Handbook shall be allowed in the examination as reference. IS Code 4503 for Heat Exchangers (if required) shall be permitted.
3. The answer shall include detailed process design steps using the data given in the problem, mechanical design for component dimensions.

Reference Books:

1) R. H. Perry and D. W. Green "Chemical Engg Hand Book", 6/e, McGraw Hill, 1998.
2) Donald Q. Kern, "Process Heat Transfer", McGraw Hill, 1997.
3) Robert E. Treybal, "Mass Transfer Operations", 3/e, McGraw Hill, 1981.
4) J. M. Coulson & J. F. Richardson, "Chemical Engineering", Vol. 6 Pergamon Press, 1993.
5) Code for United Pressure Vessel, IS 2825, Bureau of Indian standards, New Delhi, 1969; IS Code 4503 for Heat Exchangers.

22UCHC602	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	14	3, 6, 7	--

	pulp and paper and fermentation industries.			
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

22UCHL603	Mass Transfer Laboratory	(0-0-2)1

Contact Hours: 26

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 coefficient of organic vapor 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. Verification of Himus expression using Surface evaporation
6. Freundlich expression verification using adsorption studies
7. Generation of VLE data on Liquid - Liquid / Vapor - Liquid systems
8. Extraction studies in Liquid extraction - (Cross current: single and 2 or 3 Stage)
9. Construction of Binodal solubility curve (ternary extraction system)
10. Liquid phase transfer coefficient calculation using Wetted wall column
11. Height of packing calculation by NTU and HTU concepts using Cooling tower
12. 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

22UCHL604	Simulation Laboratory	(0-0-2)1

Contact Hours: 26

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.

22UCHL605	Minor Project-II	(0-0-4) 2

Contact Hours: 52

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.

22USSK606	Soft skills-II	(0-0-2) Audit

Contact Hours: 26

Course Learning Objectives (CLOs):

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 the student will be able to:		**Mapping to POs(1-12) / PSOs**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	**Demonstrate** the skill in sentence completion and faster reading of passages	-	10	-
CO-2	**Use** the English language with proficiency	-	10	12
CO-3	**Demonstrate** the capability of interview facing ability	-	9	12
CO-4	**Demonstrate** the competency in the placement activities.	-	9	-

PO's	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12
Mapping Level	-	-	-	-	-	-	-	-	2.0	2.0	-	1.0

Contents:

Vocabulary ▪ Formatting and feeding correct structures ▪ Synonyms and Antonyms ▪ Analogies ▪ Sentence Completion ▪ Error Detection and Correction ▪ Faster reading of Passages ▪ Essays ▪ Carryover plan - Dictionary Usage. **10Hrs.**

Understanding Discussions ▪ Parameters measured in GDs ▪ Video Analysis of GDs ▪ Knowledge base and Ideas ▪ Taking the initiative ▪ Introduction and Conclusion. **4Hrs**.

Most common personal interview questions ▪ What companies expect ▪ Showing Commitment and Learning Ability ▪ Handling difficult questions ▪ Understanding interviewer psychology ▪ Situation Reaction and Presence of Mind ▪ Dressing right ▪ Interview etiquette. **10 Hrs.**

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.

22UNSK607	National Service Scheme	(0-0-2) Audit

Contact Hours: 24

Course Learning Objectives:

1. Understand the community in which they work.
2. Identify the needs and problems of the community and involve them in problem-solving.
3. Develop among themselves a sense of social & civic responsibility & utilize their knowledge in finding practical solutions to individual and community problems.
4. Develop competence required for group-living and sharing of responsibilities & gain skills in mobilizing community participation to acquire leadership qualities and democratic attitudes.
5. Develop capacity to meet emergencies and natural disasters & practice national integration and social harmony.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:	**Mapping to POs (1-12)**		
	Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**

CO1	Understand the importance of his / her responsibilities towards society.	12	6	8
CO2	Analyze the environmental and societal problems/issues and will be able to design solutions for the same.	12	6	8
CO3	Evaluate the existing system and to propose practical solutions for the same for sustainable development.	12	6	8,
CO4	Implement government or self-driven projects effectively in the field.	12	6	8

POs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mapping Level	-	-	-	-	-	2	-	1	-	-	-	3

Activity list:

1. Waste management– Public, Private and Govt organization.
2. Setting of the information imparting club for women leading to contribution in social and economic issues.
3. Water conservation techniques – Role of different stakeholders– Implementation.
4. Preparing an actionable business proposal for enhancing the village income and approach for implementation.
5. Helping local schools to achieve good results and enhance their enrolment in Higher/ technical/ vocational education.
6. Developing Sustainable Water management system for rural areas and implementation approaches.
7. Contribution to any national level initiative of Government of India. For eg. Digital India, Skill India, Swachh Bharat, Atmanirbhar Bharath, Make in India, Mudra scheme, Skill development programs etc.
8. Spreading public awareness under rural outreach programs. (minimum 2 programs).
9. Social connect and responsibilities.
10. Plantation and adoption of plants. Know your plants.
11. Organize National integration and social harmony events /workshops/ seminars. (Minimum 02 programs).
12. Govt. school Rejuvenation and helping them to achieve good infrastructure.

Students have to take up at least three activities on the above said topics and have to prepare content for awareness and technical contents for implementation of the projects and have to present strategies for implementation of the same.

Note: Activities must be unique (Not repeat) across semesters for each student.

CIE will be evaluated based on their presentation, approach and implementation strategies.

Reference Books:
NSS Course Manual, Published by NSS Cell, VTU Belagavi

ASSESSMENT AND EVALUATION PATTERN		
	Time Schedule	CIE (50)
Presentation: on Selected topic	Before the IA-3	50 Marks

Note: Implementation strategies of the project with report duly signed by the Department NSS Coordinator and HoD

22UCHE621 Chemical Process Integration (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

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

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Identify and explain the importance of process integration and its types.	6,7	3	14
CO-2	Evaluate and analyze the direct recycle strategy through material	13	2,3	1

	balance, graphical and algebraic approach.			
CO-3	Illustrate and develop heat exchange network by pinch diagram and through algebraic approach	13	2,3	1
CO-4	Predict and evaluate the visualization strategies of mass integrated system through graphical and algebraic approach	13	2,3	1
CO-5	Formulate and optimize the different process integration networks along with combined heat and power integration	5,13	-	1,2

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	1.0	1.75	2.0	-	3.0	3.0	3.0	-	-	-	-	-	3.0	1.0	-

Course content

Unit-I

Introduction to Process Integration: Importance of process integration, Process synthesis and analysis, Categories of process integration. Mass targeting for minimum discharge of waste and minimum purchase of fresh utilities. **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

22UCHE622	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 considerations with applications.	-	4,12	-
CO-3	Interpret the surfactant based micellar and foam separations with applications.	14	4, 12	-
CO-4	Comprehend Super Critical Fluid Extraction process with applications.	-	4, 12	14
CO-5	Outline the processes of gaseous diffusion, thermal diffusion, and electrophoresis.	4	-	14

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO-14	PSO -15
Mapping Level	-	-	-	2.4	-	-	-	-	-	-	-	2.0	-	2.0	-

Course content:

Unit-I

Introduction to Separations: Importance, principles and separation factors, economic significance etc.

Adsorptive Separations: Thermal swing adsorption, gradient chromatography, Ligand chromatography and unsteady state fixed bed adsorption etc. **08 Hrs.**

Unit-II

Membrane Separation Processes: Classification, structure and characteristics of membranes, membrane modules, concentration polarization and fouling of membranes, R.O; Electro dialysis, 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 and micellar separations. **08 Hrs.**

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, zone refining, 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.

22UCHE631	Petroleum and Petrochemicals	(3-0-0) 3

Contact Hours: 39

Course Learning Objective (CLO):

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

Course Outcomes:

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline the Indian petroleum industry and world scenario, and characterize the crude.	6	2	1
CO-2	Identify and characterize the different products of hydrocarbon.	2	14	3
CO-3	Apply the basic procedure and role of all fundamental system used in petroleum industry.	1,2	3	13
CO-4	Analyze the measuring parameters to be measured according to the operational conditions	13	1	4
CO-5	Describe basic principle, operation and analyze the key issues and optimization of petrochemical production system.	1	2, 13	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	2.25	2.5	1.3	1.0	-	3.0	-	-	-	-	-	-	2.0	2.0	-

Course Content:

Unit-I

Indian Petroleum Industry: prospects & future, major companies, world production, markets, offshore and onshore, oil well technology.

Petroleum Crude Characterization: Composition and classification, UOP K factor, TBP analysis, EFV Analysis, Average Boiling points, ASTM Curves, Thermal properties, Pour Point. **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.

22UCHE632	Catalyst Technology	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To understand controlling mechanisms in solid catalyzed reactions, characterization of catalyst properties and is preparation.

2. To provide catalytic reactor design concepts involving solid catalyzed reaction and catalyst deactivation.

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Outline catalyst technology development, economic importance and develop overall rate expressions.	1,2	-	-
CO-2	Classify makeup of solid catalyst and its various properties.	1,2	-	-
CO-3	Outline catalyst preparation and its characterization.	1,2	-	-
CO-4	Formulate performance equation for ideal flow patterns and apply the same for reactor design.	1,2,3	13, 14	-
CO-5	Analyze causes and mechanisms of catalyst deactivation and determine deactivation kinetics.	1,2,3	13	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	3.0	3.0	3.0	-	-	-	-	-	-	-	-	-	2.0	2.0	-

Course content:

Unit-I

Fundamentals of Catalytic Phenomena: Brief history of catalyst technology development and its economic importance. Various controlling mechanisms involved in solid catalyzed reactions, overall rate expressions. **07 Hrs.**

Unit-II

Catalyst Materials and Properties: Makeup of a typical heterogeneous catalyst and their functions. Molecular sieves and zeolites. Physical, Chemical, Dynamic and Mechanical properties of solid catalyst and adsorption isotherms. **07 Hrs.**

Unit-III

Catalyst Preparation and Characterization: Various catalyst preparation methods and equipments used, catalyst activation and forming**.** Catalyst characterization. **08 Hrs.**

Unit-IV

Reactor Design: Basic approaches to reactor design, performance equations, collection of data from laboratory reactors, experimental methods to find rate equations and reactor design. **08 Hrs.**

Unit-V

Catalyst Deactivation: Causes and mechanisms of catalyst deactivation, prevention and regeneration. Experimental methods to find rate of deactivation, design and operation strategies with deactivating catalysts. **09 Hrs.**

Reference Books:

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

22UCHO641 Advanced Waste Water Treatment (3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

1. To create awareness on the water pollution aspects and understand the kinetics and the designing system of the plant.
2. To understand the different parameters, treatment methods and control techniques of water pollution.

Course Outcomes (COs):

Description of the Course Outcome: At the end of the course the student will be able to:		**Mapping to POs (1,12)/ PSO (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Cognize the different characteristics of waste water and regulatory standards with basic design criteria for waste water treatment	-	14	3, 6, 7
CO-2	Comprehend the reaction kinetics, reactor selection and its process analysis.	13, 14	3, 6, 7	5
CO-3	Design and operational concepts of secondary treatment systems	13, 14	3, 6, 7	-

CO-4	Design and operational concepts of tertiary treatment systems	13, 14	3, 6, 7	-
CO-5	Learn the wastewater treatment criteria based on the regional requirement to understand the sewage management of the city.	3, 6, 7	14, 15	-

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	2.0	-	-	2.0	2.0	-	-	-	-	-	3.0	2.6	2.0

Course content:

Unit-I

Introduction of Wastewater Treatment: Flow measurements and Composition. Characterization -properties and analysis of wastewater. Rural wastewater systems: waste treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications- state and central. Theoretical principles and design considerations - screens, equalization basin, grit chamber, primary and secondary settling tanks. **07 Hrs.**

Unit-II

Microbiology of Waste Treatment: Growth and inhibition of bacteria. Kinetics of Biological growth Batch culture substrate limited growth, Cell growth and substrate utilization. Effects of endogenous metabolism and kinetics Monod's and Michaclis menton kinetics and their applications. Determination of biokinetic constants in batch and continuous system. **08 Hrs.**

Unit-III

Secondary Waste Water Treatment: Aerobic, anaerobic, suspended and attached growth systems. Activated sludge process standard type and modifications. Aerators. Trickling filter, Aerated lagoon, Stabilization ponds, bio-towers, RBC. Treatment disposal of sludge- Sludge characteristics, Concentration. Anaerobic sludge digestion. Aerobic Sludge digestion, Sludge conditioning, Dewatering and drying. Incineration and wet oxidation. Reactor configurations. Case studies. **08 Hrs.**

Unit-IV

Tertiary Waste Water Treatment: Introduction, Need of Tertiary Waste Water Treatment, Purpose of Advanced Waste Water Treatment. Nitrogen and Phosphorus Nitrogen Removal: Nitrification, Denitrification Simultaneous nitrification and denitrification Phosphorus Removal. Membrane Bioreactor with Membrane Module Submerged in the Bioreactor. Electro-coagulation, Electro dialysis, Reverse osmosis, Ion exchange, Adsorption, absorption, Evaporators. Case studies. **08 Hrs.**

Unit-V

Sewage Treatment and Disposal: Introduction, importance of sewage, Characteristics of sewage, Sampling and analysis of sewage, Sewage treatment and disposal: Skimming, Grit chamber, Sedimentation tanks, Septic tank, Secondary treatment-types of filters, rate of filter loading, Activated sludge process, sludge digestion, Sludge disposal. **08 Hrs.**

Reference Books:

1) Metcalf and Eddy. "Waste water Engineering: Treatment and Reuse". McGrew Hill Publication. ISBN-10: 9780070495395. 4/e. 2017
2) A. F. Gaudy and E. T. Gaudy. "Microbiological for environmental Scientist and engineers" McGraw Hill 1/e. 1980.
3) T. McGhee. "Water Supply and Sewerage", McGraw Hill. 6/e. 1991. ISBN-10: 0070609381
4) G. S. Bridie and J.S. Brides. "Water Supply and Sanitary Engineering". Dhanpat Rai & Sons 2010. ISBN-10: 8187433795.

22UCHO642	Solid Waste Management	(3-0-0) 3

Contact Hours: 39

Course Learning Objectives (CLOs):

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

Course Outcomes (COs):

Description of the course outcome: At the end of the course student will be able to		**Mapping to POs (1-12)/ PSOs (13-15)**		
		Substantial Level (3)	**Moderate Level (2)**	**Slight Level (1)**
CO-1	Review the components and characteristics of a solid waste management system.	6	7	3
CO-2	Identify the various collection, transfer and transport mechanisms of municipal solid waste management.	6	3,7	-
CO-3	Explain various processing, material and energy recovery facilities.	14	3	
CO-4	Describe different methods and safety precautions used in disposal	6,7	14	

	of MSW.			
CO-5	Explain types of hazardous solid waste and Discuss safe methods of disposal of hazardous waste & their management principles.	6,7	14	3

POs/PSOs	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -13	PSO -14	PSO -15
Mapping Level	-	-	1.5	-	-	3.0	2.5	-	-	-	-	-	-	2.3	-

Course content:

Unit I

Introduction to Solid Wastes: Definition, Characteristics, Types of solid waste, Physical, Chemical and Biological properties of Municipal Solid Waste, Overview of materials flow in society and 4R concept of solid waste management. Evolution of SWM, Effect on health and environment. Legislation and government agencies.

08 Hrs.

Unit II

Engineered Systems for Solid Waste Management: Generation of solid waste, Quantities of solid Waste, Methods to measure solid waste quantities, Solid waste generation and collection, Factors affecting solid waste generation rate, Onsite handling, Storage and Processing, Transfer and transport, Collection system and devices. **08 Hrs.**

Unit III

Processing Techniques and Recovery of Energy: Objectives of waste processing, component separation and volume reduction, various processing technologies — biological and chemical conversion methods, Composting, Factors affecting composting, Aerobic composting and anaerobic Digestion, Details of energy recovery system, heat recovery, gasification, pyrolysis and refuse derived fuels (RDFs). Municipal incinerators, Grates and Furnances, Material and Energy recovery operations. **08 Hrs.**

Unit IV

Disposal of Solid Wastes: Various disposal methods, landfills — site selection, site infrastructure, essential components of landfill; types of landfilling methods, landfill planning –leachate management and gas control; Environmental monitoring systems

for landfill sites, closure and post-closure plans for landfills, landfill site rehabilitation, reclamation and remediation. **08 Hrs.**

Unit V

Hazardous Wastes: Definition, identification and classification of hazardous solid waste, Origin and reduction at source, Collection and handling, Management issues and planning methods, Environmental Act, E-waste handling and disposal, Biomedical waste.

Industrial Solid Waste Management: Major industries and management methods used in typical industries – Coal fired power stations, textile industry, oil refinery, distillery, sugar industry, and radioactive waste generation units. **07 Hrs.**

Reference Books:

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

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.

Laboratorycomponent assessment:

- 5 marks: forconduction, regularity, involvement, journal writing, etc. Minimum 75% of attendance is compulsory.Iftheperformanceis not satisfactoryinlaboratorythe student shall bedetainedand required to reregister forthecourseasawholeheneverofferednext.
- 5 marks: LabTest. A Lab testasperthe class time table has to be conducted at theend 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.

For NSS/Physical Education&Yoga Audit Courses with LTP 0-0-2
Continuous Internal Evaluation (CIE)

- All students have to register for any one course in each semester of III to IV with concerned course instructor.
- The department must make a faculty coordinator for the above audit courses and the details of the students must be maintained.
- The concerned course instructor must define the set of activities and its schedule of the conduction in NSS, PE and Yoga by taking approval from Dean Academic Program.
- The course instructor has to conduct the events as per the schedule and maintain the attendance for the same. 75% attendance is mandatory.
- The course instructor must assess the students by conducting the MCQ test for 50 marks to be conducted during the improvement test for other courses.
- The course instructor must send the marks and attendance register to the respective departments.
- The faculty coordinator of the department must maintain the same and arrange for sending the marks to CoE.