BIRLA INSTITUTE OF TECHNOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS) CURRICULUM

(Effective from Academic Session: Monsoon 2020)

NAME OF THE PROGRAMME

B.TECH. (CHEMICAL ENGINEERING)

NAME OF THE DEPARTMENT

CHEMICAL ENGINEERING

Institute Vision

To become a Globally Recognised Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research, and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Postgraduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education, and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision:

To be a center of excellence for the provision of effective teaching/learning, skill development and research in the areas of chemical engineering and allied areas through the application of chemical engineering principles.

Department Mission

1) To educate and prepare graduate engineers with critical thinking skills in the areas of chemical engineering & polymer science and engineering, who will be the leaders in industry, academia and administrative services both at national and international levels.

2) To inculcate a fundamental knowledge base in undergraduate students which enable them to carry out post-graduate study, do innovative interdisciplinary doctoral research and to be engaged in long-life learning.

3) To train students in addressing the challenges in chemical, petrochemical, polymer and allied industries by developing sustainable and eco-friendly technologies.

Graduate Attributes

1. **Engineering Knowledge**: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

2. **Problem Analysis**: Identify, formulate, 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 specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

4. **Conduct investigations of complex problems** using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of 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 modelling to complex engineering activities with an understanding of the limitations.

6. **The Engineer and Society**: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

7. **Environment and Sustainability**: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

9. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary 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 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.

Programme Educational Objectives (PEOs)

1. To understand and apply working knowledge of chemical engineering principles in independent research and development.
2. To implement the inter-perceptional skills of individuals in technical profession.
3. To prepare students for the employment in such industries as chemical, petroleum, and allied chemical industries.
4. To update technical know-how by self- learning besides learning a great deal by associating with professional bodies and alumni.
5. To develop an ability to succeed in the graduate competitive examinations and pursue higher studies in chemical engineering or lateral disciplines.

(A)Programme Outcomes (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and teamwork:** 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.

(B) Programme Specific Outcomes (PSOs)

1. To develop students' understanding of the core scientific, mathematical and engineering principles conceive and design processes to produce, transform and transport materials (chemical products) - beginning with experimentation in the laboratory and followed by implementation of technologies in full-scale production.

2. To prepare students for professional work in development, design, modelling, simulation, optimization and operation of chemical products and processes.

3. To prepare students with high scholastic attainment to enter graduate programs leading to advanced degrees in chemical engineering or in related professional, scientific, and engineering fields.

PROGRAMME COURSE STRUCTURE (ALL SEMESTERS)

Semester/ Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits *L-Lecture; T-Tutorial; P-Practical*			Total Credits *C-Credits*
					L *(Periods/week)*	**T** *(Periods/week)*	**P** *(Periods/week)*	**C**
FIRST (Monsoon)	**THEORY**							
	FIRST	**FS** ***(Foundation Sciences)***	**MA 103**	Mathematics - I	3	1	0	4
			PH 113	Physics	3	1	0	4
		GE ***(General Engineering)***	**EE 101**	Basics of Electrical Engineering	3	1	0	4
			CS 101	Programming for Problem Solving	3	1	0	4
	LABORATORIES							
	FIRST	**FS**	**PH 114**	Physics Lab	0	0	3	1.5
		GE	**CS 102**	Programming for Problem Solving Lab	0	0	3	1.5
		GE	**PE 101**	Workshop Practice	0	0	3	1.5
		MC (Mandatory Course)	**MC 101/102/ 103/104**	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL								**21.5**

SECOND (Spring)	**THEORY**							
	FIRST	**FS**	**MA107**	Mathematics - II	3	1	0	4
			CH101	Chemistry	3	1	0	4
		GE	**ME101**	Basics of Mechanical Engineering	3	1	0	4
			EC101	Basics of Electronics & Communication Engineering	3	1	0	4
	LABORATORIES							
	FIRST	**FS**	**CH102**	Chemistry Lab	0	0	3	1.5
		GE	**EC102**	Electronics & Communication Lab	0	0	3	1.5
			ME102	Engineering Graphics	0	0	4	2
		MC	**MC105/ 106/107/ 108**	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL								**22**
GRAND TOTAL FOR FIRST YEAR								**43.5**
THIRD (Monsoon)	**THEORY**							
	SECOND	**FS**	**MA203**	Numerical Methods	2	0	0	2
	FIRST		**CE101**	Environmental Sciences	2	0	0	2
	SECOND	**PC**	**CL201**	Thermodynamics	3	1	0	4

			CL203	Fluid Mechanics	3	0	0	3
			CL204	Chemical Process Calculations	2	1	0	3
			CL205	Mechanical Operations	3	0	0	3
			CL211	Chemical Principles for Chemical Engineers	3	0	0	3
	LABORATORIES							
	SECOND	**GE**	**IT202**	Basic IT Workshop	0	0	2	1
		FS	**MA204**	Numerical Methods Lab	0	0	2	1
		MC	**MC201/ 202/203/ 204**	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL								**23**
FOURTH (Spring)	**THEORY**							
	SECOND	**GE**	**IT201**	Basics of Intelligent Computing	3	0	0	3
	FIRST	**FS**	**BE101**	Biological Science for Engineers	2	0	0	2
	SECOND	**PC**	**CL208**	Heat Transfer Operations	3	1	0	4
			CL215	Mass Transfer Operation - I	3	1	0	4
		HSS	**UHV2**	Understanding Harmony	2	1	0	3
		PE		Program Elective (PE-I)	3	0	0	3

		OE		Open Elective (OE-I)/MOOC	3	0	0	3
	LABORATORIES							
	FIRST	**GE**	**EE102**	Electrical Engineering Lab	0	0	3	1.5
	SECOND	**MC**	**MC205/ 206/207/ 208**	Choice of : NCC/NSS/PT & Games/ Creative Arts (CA)	0	0	2	1
		PC	**CL213**	Chemical Engineering Lab -I	0	0	3	1.5
TOTAL								**26**
FIFTH (Monsoon)	**THEORY**							
	FIRST	**HSS**	**MT123**	Business Communications	3	0	0	3
	THIRD	**PC**	**CL319**	Mass Transfer Operation - II	3	0	0	3
			CL302	Chemical Reaction Engineering-I	3	1	0	4
			CL309	Material Science & Engineering	3	0	0	3
		PE		Program Elective (PE-II)	3	0	0	3
		OE		Open Elective (OE-II)/MOOC	3	0	0	3

	LABORATORIES							
	THIRD	PC	CL304	Computer Aided Process Engineering Lab.	0	0	4	2
			CL305	Chemical Engineering Lab -II	0	0	4	2
TOTAL								23
SIXTH (Spring)	THEORY							
	THIRD	PC	CL320	Chemical Reaction Engineering - II	3	1	0	4
			CL 335	Chemical Process Technology	3	0	0	3
			CL 318	Transport Phenomena	3	0	0	3
		PE		Program Elective (PE-III)	3	0	0	3
		OE		Open Elective (OE-III)/MOOC	3	0	0	3
		MC	MC300	Summer Training - Mandatory	N/A			2
	LABORATORIES							
	THIRD	PC	CL 310	Design Lab	0	0	3	1.5
			CL 317	Chemical Engineering Lab - III	0	0	3	1.5
TOTAL								21

	THEORY							
SEVENTH (Monsoon)	**FOURTH**	**PC**	**CL 404**	Project Engineering and Economics	3	0	0	3
			CL 405	Process Control & Instrumentation	3	0	0	3
			CL 406	Process Modelling, Simulation & Optimization	3	0	0	3
		PE		Program Elective (PE-IV)	3	0	0	3
		OE		Open Elective (OE-IV)/MOOC	3	0	0	3
		MC	**MT 204**	Constitution of India	2	0	0	NC
		PROJ	**CL 400M**	Minor Project	0	0	3	3
	LABORATORIES							
	FOURTH	**PC**	**CL 401**	Process Control & Instrumentation Lab	0	0	3	1.5
			CL 403	Plant Design	0	0	4	2
TOTAL								**21.5**
EIGTH (Spring)	**FOURTH**	**PC**	**CL 400**	Research Project / Industry Internship	**Total**			**10**
GRAND TOTAL *(Minimum requirement for Degree award)*								**168**

PROGRAMME ELECTIVES (PE)*
(OFFERED FOR LEVEL 1-4)

PE / LEVEL		Code no.	Name of the PE courses	Prerequisites courses with code	L	T	P	C
3	PE 1	CL221	Energy Engineering	CL201, CL311	3	0	0	3
3		CL222	Pollution Control Equipment Design	CL209, CL208, CL203	3	0	0	3
3		CL223	Colloid and Interfacial Science	CH101, PH101, CL209	3	0	0	3
3		CL224	Analytical Instrumental Methods	CH101, PH101	3	0	0	3
3		CL225	Fluid-Solid Operation	CH101, PH101, CL205, CL203	3	0	0	3
3	PE 2	CL321	Petroleum Refinery Engineering & Petrochemicals	CH101, PH101, CL209	3	0	0	3
3		CL322	Macromolecular Science	CH 101, PH101	3	0	0	3
3		CL323	Safety & Hazards in Process Industries	PH101, CH101, PH101	3	0	0	3
3		CL324	Computational Fluid Dynamics	CH101, PH101, CL205, CL203	3	0	0	3
3		CL325	Biomaterials	CH101, PH101	3	0	0	3
4	PE 3	CL326	Reservoir Engineering	CL203	3	0	0	3
4		CL327	Polymer Processing	CH101, PH101	3	0	0	3
4		CL328	Paints and Surface Coating Technology	CH101,PH101	3	0	0	3
4		CL329	Elastomer Technology	CH101, PH101	3	0	0	3
4		CL330	Natural Gas Engineering	CH101, PH101	3	0	0	3
4		CL333	Polymer Technology	CH101, PH101	3	0	0	3
4		CL332	Membrane Science & Technology	CH101, PH101	3	0	0	3
4	PE 4	CL421	Fibre Science & Technology	CH101, PH101	3	0	0	3
4		CL422	Polymer Composite	CH101, PH101	3	0	0	3

4		CL423	Introduction to Microelectronics Fabrication	CH101, PH101	3	0	0	3
4		CL424	Microfluidics	CL203	3	0	0	3
4		CL425	Plastic Packaging Technology	CH101, PH101	3	0	0	3
4		CL426	Chemical Process Intensification	CL208, CL209, CL301, CL302, CL306	3	0	0	3
4		CL427	Computer Aided Process Engineering	CL208, CL209, CL301, CL302, CL306, CL307	3	0	0	3

*** PROGRAMME ELECTIVES TO BE OPTED ONLY BY THE DEPARTMENT STUDENTS**

OPEN ELECTIVES (OE)**
(OFFERED FOR LEVEL 1-4)

OE / LEVEL	Code no.	Name of the PE courses	Pre-requisites	L	T	P	C
OE/1	CL224	Analytical Instrumental Methods	NIL	3	0	0	3
OE/1	CL221	Energy Engineering	NIL	3	0	0	3
OE/2	CL323	Safety & Hazards In Process Industries	NIL	3	0	0	3
OE/2	CL322	Macromolecular Science	NIL	3	0	0	3
OE/2	CL325	Biomaterials	NIL	3	0	0	3
OE/3	CL330	Natural Gas Engineering	NIL	3	0	0	3
OE/3	CL328	Paints and Surface Coating Technology	NIL	3	0	0	3
OE/4	CL422	Polymer Composites	NIL	3	0	0	3
OE/4	CL423	Introduction to Microelectronics Fabrication	NIL	3	0	0	3

**** OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS**

In-depth Specialization in Chemical Process Engineering

Students who have registered for ***B. Tech in Chemical Engineering*** should complete 20 credits opting courses listed below. The credits shall be over and above minimum requirement for degree award. Courses shall be selected from single specialization area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits L-Lecture; T-Tutorial; P-Practical			Total Credits *C - Credits*
					L	**T**	**P**	**C**
FIFTH (Monsoon)		**THEORY**						
	Third	**DS**	**CL375**	Multiphase flow	3	1	0	4
			CL377	Advanced Computational Fluid Dynamics	3	1	0	4
TOTAL								**8**
SIXTH (Spring)		**THEORY**						
	Third	**DS**	**CL379**	Molecular Simulation	3	1	0	4
			CL381	Process Integration	3	1	0	4
TOTAL								**8**
SEVENTH (Monsoon)		**THEORY**						
	Fourth	**DS**	**CL450**	Project & Viva	0	0	8	4
TOTAL								**4**
GRAND TOTAL *(Minimum requirement for in-depth specialization award)*								**20**

In-depth Specialization in Polymer Technology

Students who have registered for ***B. Tech in Chemical Engineering*** should complete 20 credits opting courses listed below. The credits shall be over and above minimum requirement for degree award. Courses shall be selected from single specialization area only.

Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits L-Lecture; T-Tutorial; P-Practical			Total Credits
					L	**T**	**P**	**C**
FIFTH (Monsoon)		**THEORY**						
	Third	**DS**	**CL383**	Introduction to Polymer Science	4	0	0	4
			CL385	Polymer Technology - 1	4	0	0	4
TOTAL								**8**
SIXTH (Spring)		**THEORY**						
	Third	**DS**	**CL387**	Polymer Processing Technology	3	1	0	4
		DS	**CL389**	Polymer Technology - II	4	0	0	4
TOTAL								**8**
SEVENTH (Monsoon)								
	Fourth	**DS**	**CL452**	Project & Viva	0	0	8	4
TOTAL								**4**
GRAND TOTAL *(Minimum requirement for in-depth specialization award)*								**20**

Minor in Chemical Engineering
(Offered ONLY to OTHER department students)

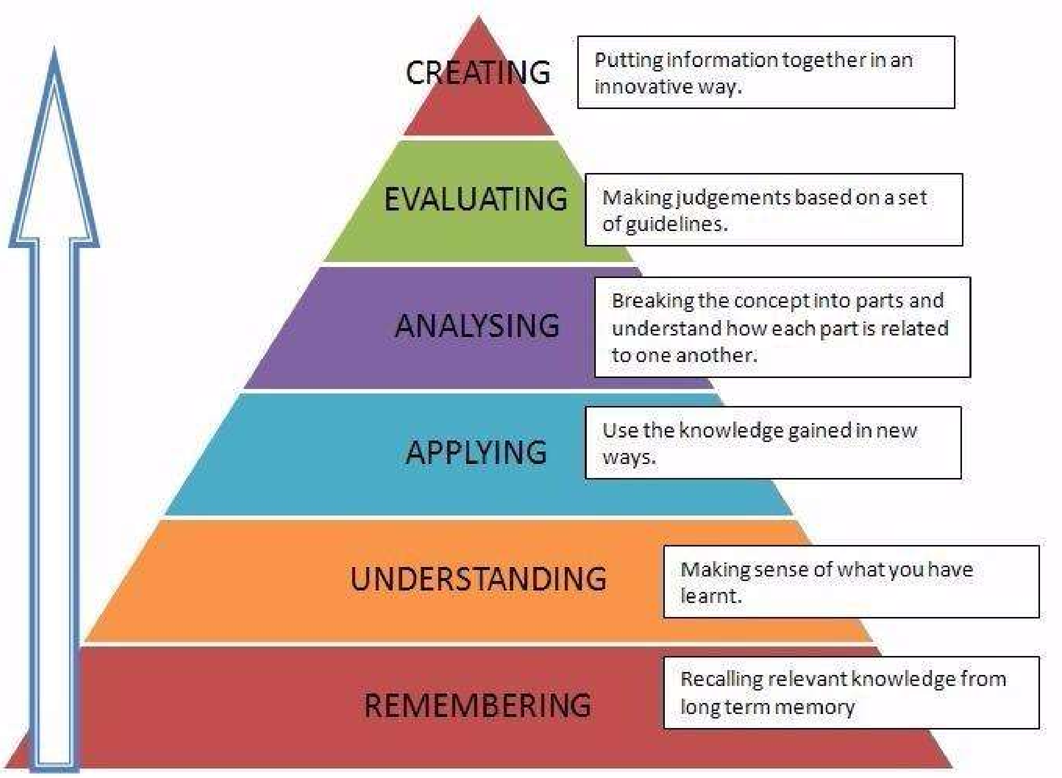
Students who have registered for ***B. Tech Minor in Chemical Engineering*** should complete 20 credits and shall opt for courses listed below. Courses shall be selected from single specialisation area only.

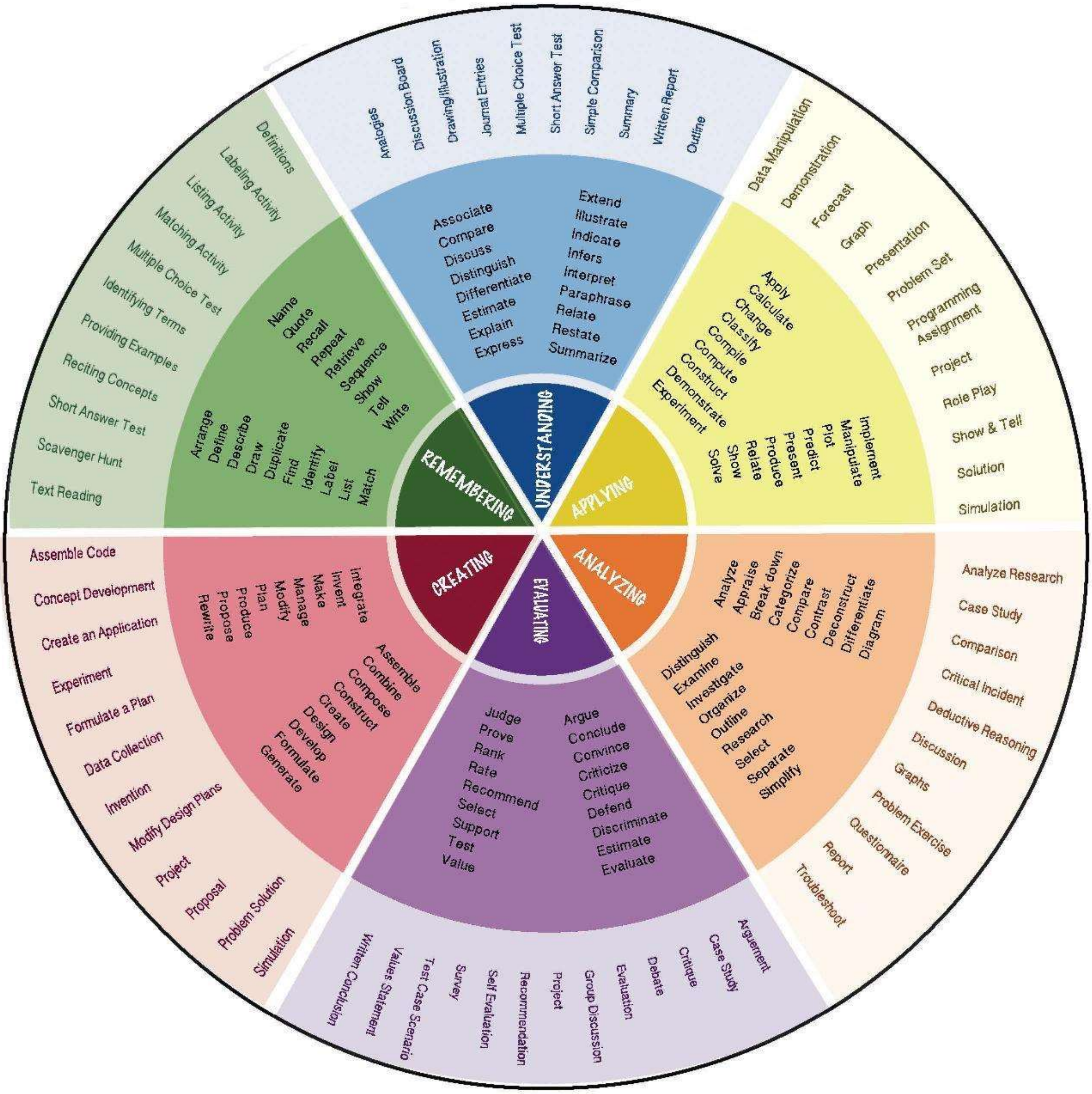
Semester/Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits L-Lecture; T-Tutorial; P-Practical			Total Credits
					L	T	P	C
FIFTH (Monsoon)		**THEORY**						
	Second	**PC**	**CL241**	Unit Operation-I	3	1	0	4
	Second		**CL243**	Unit Operation-II	3	1	0	4
TOTAL								**8**
SIXTH (Spring)		**THEORY**						
	Second	**PC**	**CL245**	Fundamentals of Chemical Reaction Engineering	3	1	0	4
TOTAL								**4**
SEVENTH (Monsoon)		**THEORY**						
	Third	**PC**	**CL391**	Unit Operation-III	3	1	0	4
	Fourth		**CL454**	Project & Viva	0	0	8	4
TOTAL								**8**
GRAND TOTAL *(Minimum requirement for minor degree award)*								**20**

BLOOM'S TAXONOMY FOR CURRICULUM DESIGN AND ASSESSMENT:

Preamble

The design of curriculum and assessment is based on Bloom's Taxonomy. A comprehensive guideline for using Bloom's Taxonomy is given below for reference.




REMEMBERING
Name
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Draw
Duplicate
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Identify
Label
List
Match
Definitions
Labeling Activity
Listing Activity
Matching Activity
Multiple Choice Test
Identifying Terms
Providing Examples
Reciting Concepts
Short Answer Test
Scavenger Hunt
Text Reading
UNDERSTANDING
Associate
Compare
Discuss
Distinguish
Differentiate
Estimate
Explain
Express
Extend
Illustrate
Indicate
Infers
Interpret
Paraphrase
Relate
Restate
Summarize
Analogies
Discussion Board
Drawing/Illustration
Journal Entries
Multiple Choice Test
Short Answer Test
Simple Comparison
Summary
Written Report
Outline
APPLYING
Apply
Calculate
Change
Classify
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Demonstrate
Experiment
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Manipulate
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Predict
Present
Produce
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Data Manipulation
Demonstration
Forecast
Graph
Presentation
Problem Set
Programming Assignment
Project
Role Play
Show & Tell
Solution
Simulation
ANALYZING
Analyze
Appraise
Break down
Categorize
Compare
Contrast
Deconstruct
Differentiate
Diagram
Distinguish
Examine
Investigate
Organize
Outline
Research
Select
Separate
Simplify
Analyze Research
Case Study
Comparison
Critical Incident
Deductive Reasoning
Discussion
Graphs
Problem Exercise
Questionnaire
Report
Troubleshoot
EVALUATING
Judge
Prove
Rank
Rate
Recommend
Select
Support
Test
Value
Argue
Conclude
Convince
Criticize
Critique
Defend
Discriminate
Estimate
Evaluate
Arguement
Case Study
Critique
Debate
Evaluation
Group Discussion
Project
Recommendation
Self Evaluation
Survey
Test Case Scenario
Values Statement
Written Conclusion
CREATING
Integrate
Invent
Make
Manage
Modify
Plan
Produce
Propose
Rewrite
Assemble
Combine
Compose
Construct
Create
Design
Develop
Formulate
Generate
Assemble Code
Concept Development
Create an Application
Experiment
Formulate a Plan
Data Collection
Invention
Modify Design Plans
Project
Proposal
Problem Solution
Simulation

<u>**SYLLABUS (ALL SEMESTERS)**</u>

<u>**COURSE INFORMATION SHEET**</u>

Course code	CL201
Course title	Thermodynamics
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	4
Class	B. Tech.
Semester / Level	III / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students to:

1.	Apply the concept of thermodynamics to solve physical and chemical problems encountered in chemical and biochemical industries.
2.	Apply knowledge of thermodynamics principles in heat transfer, mass transfer and chemical reaction engineering.
3.	Analyze and interpret data, to identify, formulate, and solve engineering problems.
4.	Solve real world engineering problems using thermodynamic principles.
5.	Apply the knowledge of thermodynamics to design chemical engineering equipments.

Course Outcomes

After the completion of this course, students will be able to:

CO201.1	Apply the laws of thermodynamics on closed and open systems.
CO201.2	Evaluate the properties of real gases.
CO201.3	Solve problems involving various thermodynamic cycles.
CO201.4	Evaluate the thermodynamic properties (Such as Partial molar properties, Fugacity coefficients, activity coefficients) of pure fluid and mixtures.
C0201.5	Predict equilibrium composition of mixtures under phase and chemical-reaction equilibria.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction and Basic Concepts First law of thermodynamics, Energy balance for closed systems, Mass and Energy balances for open systems, Volumetric properties of pure fluids, Virial	8

equations of state, Cubic equations of state, Theorem of corresponding states, Acentric factor, generalized correlations for gases and liquids, Statements of the second law, Heat engines, Carnot cycle, Refrigerator and Heat pump, Third law of thermodynamics, Microscopic interpretation of entropy.	
Module 2: Thermodynamic Relations and Thermodynamic Properties of Fluids Euler relation, Gibbs-Duhem relation, Helmholtz free energy, Gibbs free energy, Maxwell relations, Gibbs energy as a generating function, Joule-Kelvin Effect, Clausius/Clapeyron equation, Antoine equation, Residual properties, Thermodynamic properties of real gases.	8
Module 3: Vapor-Liquid Equilibrium in Mixtures Introduction to Vapor-Liquid Equilibrium, Vapor-Liquid Equilibrium in ideal mixtures, Dew point and bubble point temperatures/Pressures, VLE from K-value correlations (Flash calculations), Low-Pressure Vapor-Liquid equilibrium in non-ideal mixtures.	8
Module 4: Thermodynamics of Multicomponent Mixtures Fundamental Property Relation, The Chemical Potential and Phase Equilibria, Partial Properties, The Ideal-Gas Mixture Model, Fugacity and Fugacity Coefficient (Pure Species and Species in Solution), The Ideal-Solution Model, Excess Properties, The Excess Gibbs Energy and the Activity Coefficient, Models for the Excess Gibbs Energy (Margules equation, Redlich-Kister equation, van Laar equation, Wilson equation, NRTL model and UNIQUAC equation) SRK, PR.	8
Module 5: Chemical Reaction Equilibria The reaction coordinate, Application of Equilibrium Criteria to Chemical Reactions, The standard Gibbs Energy Change and the Equilibrium Constant, Effect of Temperature on the Equilibrium Constant, Evaluation of Equilibrium Constants, Relation of equilibrium constants to composition, Equilibrium Conversions for single Reactions, Phase Rule and Duhem's Theorem for Reacting Systems, Multi-reaction equilibria.	8

Text books:

1. Introduction to Chemical Engineering Thermodynamics: J.M. Smith, H.C. Van ness, and M.M. Abbot. 7th Edition, McGraw-Hill's Chemical Engineering Series.

2. Chemical, Biochemical and Engineering Thermodynamics: Stanley I. Sandler. Fourth Edition, John Wiley & Sons, Inc.

3. Chemical Engineering Thermodynamics: Y V C Rao, University Press.

Reference books:

1. Molecular Thermodynamics of Fluid-Phase Equilibria: J.M. Prausnitz, R.N. Lichtenthaler, E G de Azevedo. 3rd Edition, Prentice Hall International Series in the Physical and Chemical Engineering Sciences.

2. Engineering and Chemical Thermodynamics: Milo D. Koretsky. 2nd Edition, John Wiley & Sons, Inc.

3. Using Aspen Plus in Thermodynamics Instruction: Stanley I. Sandler, John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)

Use of process simulator such as ASPEN to study phase equilibria/reaction equilibria.

POs met through Gaps in the Syllabus
PO3, PO4, PO5

Topics beyond syllabus/Advanced topics/Design
Introduction to molecular/statistical thermodynamics.

POs met through Topics beyond syllabus/Advanced topics/Design
PO3, PO4, PO5

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO 1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO 2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO 3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO 4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO 5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8

CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD 3	Seminars	CO3	CD1, CD2, CD4, CD8
CD 4	Mini projects/Projects	CO4	CD1, CD2, CD4, CD8
CD 5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD4, CD8
CD 6	Industrial/guest lectures		
CD 7	Industrial visits/in-plant training		
CD 8	Self- learning such as use of NPTEL materials and internets		
CD 9	Simulation		

COURSE INFORMATION SHEET

Course code	CL203
Course title	Fluid Mechanics
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech
Semester / Level	III / Second
Branch	Chemical

Course Objectives

This course enables the students to:

1.	Develop an appreciation for the properties of Newtonian fluids.
2.	Understand the working principle of pressure measuring and flow measuring devices.
3.	Apply concepts of mass and momentum conservation to fluid flows and analytically solve a variety of simplified problems.
4.	Understand the dynamics of fluid flows and the governing non-dimensional parameters.
5.	Understand the working principle of fluid moving machines.

Course Outcomes

After the completion of this course, students will be able to:

CO203.1	Describe fluid pressure, its measurement and calculate forces on submerged bodies.
CO203.2	Explain the flow visualization, boundary layer and momentum correction factor, state the Newton's law of viscosity andReynolds number. Analyze fluid flow problems with the application of the continuity and momentum equation.
CO203.3	Examine energy losses in pipe transitions and evaluate pressure drop in pipe flow using Hagen-Poiseuille's equation and Bernoulli's principle for laminar flow.
CO203.4	Explain the basics of drag, lift, streamlining, equivalent diameter, sphericity, determine minimum fluidization velocity in fluidized bed and Compute pressure drop in fixed bed, packed bed and fluidized system.
CO203.5	Analyze the general equation for internal flow meters and determine the performance aspects of fluid machinery.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Fluid Statics: Basic equation of fluid statics; pressure variation in a static field; pressure measuring devices–manometer, U-tube, inclined tube, well, diaphragm, hydraulic systems – force on submerged bodies (straight, inclined), pressure centre.	8
Module 2: Fluid flow phenomena: Fluid as a continuum, Terminologies of fluid flow, velocity – local, average, maximum, flow rate – mass, volumetric, velocity field; dimensionality of flow; flow visualization – streamline, path line, streak line, stress field; viscosity; Newtonian fluid; Non-Newtonian fluid; dimensional analysis and similitude criterion, Buckingham's Pi theorem. Reynolds number-its significance, laminar, transition and turbulent flows: Prandtl boundary layer, compressible and incompressible. Momentum equation for integral control volume, momentum correction factor.	8
Module 3: Internal incompressible viscous flow: Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseuille equation; flow of Non-Newtonian fluid, introduction to turbulent flow in a pipe; energy consideration in pipe flow, relation between average and maximum velocity, Bernoulli's equation–kinetic energy correction factor; head loss; friction factor; major and minor losses, Pipe fittings and valves.	8
Module 4: Flow past of immersed bodies: Introduction; concept of drag and lift; variation of drag coefficient with Reynolds number; streamlining; packed bed; concept of equivalent diameter and sphericity; Ergun equation, Fluidization: Introduction; different types of fluidization; fluidized bed assembly; governing equation; industrial use. Agitation and mixing of liquids: agitated vessel, blending & mixing, suspension of solid particles. Dispersion operation. Turbine Design/scale up, Flow number, Power Requirement.	8
Module 5: Flow measurement: Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; concept of area meters: rotameter; Local velocity measurement: Pitot tube. Fluid moving machines: Introduction; Basic classification of pumps, Mechanical pump: Centrifugal and Positive	8

displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor.	

Text books:

1. Fox and McDonald's Introduction to Fluid Mechanics by Philip J. Pritchard, Wiley; 8th Edition, 2010.

2. Frank M. White, Fluid Mechanics, Sixth Edition, Tata McGraw-Hill, New Delhi, 2008.

3. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.

Reference books:

1. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall Inc.

2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, Volume I", Pergamon Press.

Gaps in the syllabus (to meet Industry/Profession requirements)

Solution of industrial problems.

POs met through Gaps in the Syllabus

PO2, PO3, PO4, PO5

Topics beyond syllabus/Advanced topics/Design

Numerical solution of fluid related industrial problems.

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3, PO4, PO5

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO 1	3	3	2	2	2	2	2	2	3	3	1	2	3	3	2
CO 2	3	3	2	2	2	2	2	2	3	3	1	2	3	3	2
CO 3	3	3	2	2	2	2	2	2	3	3	1	2	3	3	2
CO 4	3	3	3	2	2	2	2	2	3	3	1	2	3	3	2
CO 5	3	3	3	2	2	2	2	2	3	3	1	2	3	3	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD7, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD7, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL204
Course title: Chemical Process Calculations
Pre-requisite(s):
Co- requisite(s):
Credits: L: 2 T: 1 P: 0
Class schedule per week: 3 hrs
Class: B. Tech.
Semester / Level: III / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Understand the fundamental concepts and calculations of process calculation.
2.	Use basic, applied chemistry/ thermodynamics for material balance calculations for different unit operations and unit processes.
3.	Use basic, applied chemistry/ thermodynamics for energy balance calculations for different unit operations and unit processes.
4.	Understand the various heats and their calculations related to chemical reactions.
5.	Develop understanding about humidity and usage of psychrometric chart.

Course Outcomes
After the completion of this course, students will be able to:

CO204.1	Apply the concept of dimension and unit conversion to check dimensional consistency of balanced equation and understand the specific terms used in process calculation.
CO204.2	Solve problems related to ideal and real gas and solution.
CO204.3	Solve material balance problems without chemical reactions.
CO204.4	Solve material balance problems with chemical reactions.
CO204.5	Solve energy balance problems of various unit processes.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module I: Introduction to Stoichiometry: Units and Dimensions: Conversion of Equations, Systems of Units, Dimensional Homogeneity and Dimensionless Quantities, Buckingham Pi-theorem for Dimensional Analysis, Introduction to Chemical Engineering Calculations: Basis,	8

Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration of different forms, Conversion from one form to another, Stoichiometric and composition relations, Excess & Limiting reactants, Degree of completion, Conversion, Selectivity and Yield.	
Module II: Gas Calculations, Humidity & Saturation: Gas laws-Ideal gas law, Dalton's Law, Amagat's Law, and Average molecular weight of gaseous mixtures. Vapour pressure, partial pressure, Vapour pressures of miscible, immiscible liquids and solutions. Real-gas relationships, Raoult's Law, Henry's law, Antoine's Equation, Clausius Clapeyron Equation. PVT calculations using ideal and real gas relationships, Relative Humidity and percent saturation; Dew point, Dry and Wet bulb temperatures; Use of humidity charts for engineering calculations.	8
Module III: Material Balance without Chemical Reaction: Unit Operations & Process Variables, Degree of Freedom Analysis, Application of material balances to single and multiple unit operations without chemical reactions involving distillation column, absorption column, evaporators, driers, crystallizer, liquid-liquid and liquid-solid extraction units, Unsteady state material balances.	8
Module IV: Material Balance with Chemical Reaction: Material balances with Single Reaction & Multiple Reactions applicable to single and multiple unit operations, Recycle, purge, bypass in batch, stage wise and continuous operations in systems with or without chemical reaction. Material balances in combustion, gas-synthesis, acid-alkali production reactions.	8
Module V: Energy Balance: Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible and latent heats, Evaluation of enthalpy, Standard heat of reaction, heat of formation, combustion, solution mixing etc., Calculation of standard heat of reaction, Hess Law, Energy balance for systems with and without chemical reaction, Unsteady state energy balances.	8

Text books:

1. Haugen, P.A. Watson, K.M., Ragatz R.A Chemical Process Principles Part - I
2. Himmelblau, D.M Basic Principles and Calculation in chemical engineering, Prentice Hall
3. Bhatt B.L.Vora, S.M Stoichiometry, Tata McGraw Hill Publishing Co. Ltd., New Delhi

Reference books:

1. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000
2. Venkataramani, V., Anantharaman, N., Begum, K. M. MeeraSheriffa, "Process Calculations", Second Edition, Prentice Hall of India.
3. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India

Gaps in the syllabus (to meet Industry/Profession requirements)

Material and energy balance of industrial processes.

POs met through Gaps in the Syllabus

PO2, PO3, PO4, PO5

Topics beyond syllabus/Advanced topics/Design

Use of process simulator to study industrial processes.

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3, PO4, PO5

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO 1	3	3	0	0	2	0	0	0	1	0	0	3	3	0	2
CO 2	3	3	2	1	1	1	0	0	1	1	0	3	3	0	2
CO 3	3	3	0	1	1	2	2	2	2	2	2	3	3	3	2
CO 4	3	3	2	0	1	2	2	2	2	2	2	3	3	3	2
CO 5	3	3	2	0	1	2	2	2	2	2	2	3	3	3	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD 1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD 2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD 3	Seminars	CO3	CD1, CD2, CD8
CD 4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD 5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD 6	Industrial/guest lectures		
CD 7	Industrial visits/in-plant training		
CD 8	Self- learning such as use of NPTEL materials and internets		
CD 9	Simulation		

COURSE INFORMATION SHEET

Course code	CL 205
Course title	Mechanical Operations
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
ClassB. Tech.	
Semester / Level	III / Second
Branch	Chemical Engineering
Name of Teacher	

Course Objectives
This course enables the students to:

1.	Develop an understanding of basics of mechanical operations.
2.	Understand storage and transportation of solids.
3.	Understand size analysis, size reduction and working principle of associated equipment used for size reduction.
4.	Understand solid-liquid and liquid-liquid mechanical separation.
5.	Understand gas-solid and solid-solid mechanical separation.

Course Outcomes
After the completion of this course, students will be able to:

CO 205.1	Remembering the fundamental laws of particulate separation and basic mathematical formulae.
CO 205.1	Understanding the need of mechanical operations in chemical engineering industries.
CO 205.1	Analysis of size reduction machineries for various industries and solid-fluid separation units .
CO 205.1	Concept of size reduction machineries for various industries, solid-fluid separation units.
CO 205.1	Compare among different mechanical separation units for solid-fluid separation.

SYLLABUS:

MODULE	NO. OF LECTURE HOURS
Module 1: **Characterization of solid particles:** Particle Shape. Particle size analysis Differential and cumulative analysis. **Properties of particulate masses:** Bulk density, coefficient of Internal Friction, Storage of solids, Pressure distribution in hopper. Janssen Equation. **Transportation of Solids**: Studies on performance and operation of different conveyors eg. Belt, Screw, Apron, Flight etc. and elevators.	8
Module 2: Size Reduction: Rittinger's law, Kick's law, Bond's law, Work index, Types of comminuting equipment - Jaw Crushers, Gyratory Crusher, Roll crushers; Grinders-hammer Mill, Ball Mill, Rod Mill etc. Dry and wet grinding, open and closed circuit. Simulation of Milling operation grinding rate function, breakage function.	8
Module 3: Solid Liquid separation : Gravity Settling process – Clarifiers and Thickeners, Flocculation Design of Gravity Thickner,**. Centrifugal Settling:** principle, Centrifuges for solid liquid and liquid-liquid separation.	8
Module 4:Filtration: Theory of solid-liquid filtration, principle of filtration, constant pressure and constant rate filtration, compressible and incompressible cakes, Filter aids, Equipment of liquid solid filtration, Batch and continuous pressure filters. Theory of centrifugal filtration, Equipment for centrifugal filtration.	8
Module 5:Solid Solid Separation : Industrial Screening equipment :Screen effectiveness and Capacity.**Wet Classification:** Differential settling, Liquid cyclones,Drag, Rake and Spiral, Bowl, Hydroseparator, Hydaulic classifiers, Tabling, Jigging, Froth floatation, Dense media separation etc.Magnetic separation, Electrostating Separation. **Gas-solid separation:** Settling chambers, centrifugal settling, Cyclones, ESP, Scrubbers, Filters.	8

Text books:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations Chemical Engineering", McGraw-Hill, Inc.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, VolumeI", Pergamon Press.

Reference books:
1. Geankoplis, C.J., "Transport Processes and Unit Operations", Prentice-Hall Inc.

Gaps in the syllabus (to meet Industry/Profession requirements) :

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design :

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
2	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
3	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
4	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
5	3	3	3	2	3	1	1	1	1	1	1	1	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD 1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD 2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD 3	Seminars	CO3	CD1, CD2, CD8
CD 4	Mini projects/Projects	CO4	CD1, CD2, CD8

CD 5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD 6	Industrial/guest lectures		
CD 7	Industrial visits/in-plant training		
CD 8	Self- learning such as use of NPTEL materials and internets		
CD 9	Simulation		

COURSE INFORMATION SHEET

Course code: CL211
Course title: Chemical Principles for Chemical Engineers
Pre-requisite(s):
Co- requisite(s):
Credits: L: 03 T: 00 P: 00
Class schedule per week: 03
Class: B. Tech.
Semester / Level: III / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Describe the reaction mechanism of common organic transformations
2.	Illustrate Schrödinger wave equation and partition functions
3.	Describe the relation between entropy and probability
4.	Apply the knowledge to biochemical reaction mechanism
5.	Understand the polymerization reaction mechanism and its kinetics

Course Outcomes
After the completion of this course, students will be to:

CO206.1	Define: Describe the reaction mechanism of common organic transformations.
CO206.2	Illustrate: Explain collision state theory and transition state theory.
CO206.3	Application: Apply transition state theory for common organic reactions.
CO206.4	Synthesize: Develop suitable model for microbial growth kinetics.
CO206.5	Evaluate: Compare the properties of polymer synthesized by different techniques.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
MODULE– I Introduction to organic reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of commonly used industrial chemicals.	9
MODULE- II	8

Fundamentals of Statistical Thermodynamics, Wave Mechanics, Schrodinger wave equation, Models in Statistical Thermodynamics, F-D Statistics, Partition function and application to monoatomic gas, Principles of equipartition of energy and statistics of a photon gas, Application of partition function and relation between entropy and probability.	
MODULE- III Integrated rate laws. Experimental methods in chemical kinetics. Elementary reactions and reaction mechanism. Temperature dependence of reaction rates. Complex reactions. Theories of reaction rates- Collision theory. Transition state theory. Potential energy surfaces (PES). Free energy and EMF.	9
MODULE– IV Introduction to biotechnology. Prokaryotic and Eukaryotic cells. Metabolism I Kinetics. Mechanism II Kerb cycle. Anaerobic oxidation and fermentation. Growth kinetics for different biological systems. Microbial growth kinetics. Product recovery from over expressed cells.	7
MODULE– V Principles of condensation polymerization, kinetics, chain length regulation and control of molecular weight, Principles of addition polymerization. Principles of ionic polymerization. Principles co-ordination polymerization. Polymer supported catalyst.	7

Text Books:

1. M. B. Smith, Organic Synthesis. F. A. Carey and R. J Sundberg, Advanced Organic Chemistry,
2. Introduction to Polymer Science and Chemistry. M. Chandra. Copyright © 2006 by Taylor & Francis Group, LLC. CRC Press, New York
3. A Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and Sons, 2006.
4. Basic Biotechnology edited by Colin Ratledge, Bjorn Kristiansen, 3rd edition, Cambridge University Press,2006

Reference books:

1. Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.
2. The Element of Polymer Science & Engineering: Rudin.
3. I.K. Puri and K. Annamalai, Advanced Engineering Thermodynamics, CRC Press, 2001.
4. Biological science fundamentals and systematics - Volume II edited by Alessandro Minelli , Eloss Publishers, UK, 2009.

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO206.1	3	3	3	1	2	2	2	3	2	2	0	1	3	2	1
CO206.2	3	3	3	1	2	2	2	3	2	2	0	1	3	2	1
CO206.3	3	3	3	1	1	2	2	3	2	2	0	1	3	2	1
CO206.4	3	3	3	2	1	2	2	3	2	2	0	1	3	2	1
CO206.5	3	3	3	2	1	2	2	3	2	2	0	1	3	2	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD 1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD 2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD 3	Seminars	CO3	CD1, CD2, CD8
CD 4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD 5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD 6	Industrial/guest lectures		
CD 7	Industrial visits/in-plant training		
CD 8	Self- learning such as use of NPTEL materials and internets		
CD 9	Simulation		

COURSE INFORMATION SHEET

Course code: CL208
Course title: Heat Transfer Operations
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 1 P: 0
Class schedule per week: 4 hrs
Class: B. Tech
Semester / Level: IV / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Understand the basic laws of heat transfer.
2.	Develop methodologies for solving various practical engineering problems.
3.	Understand working principles of heat transfer equipments.
4.	Design heat exchangers and evaporators and analyze their performance.
5.	Develop basic competence related to other courses involving thermal energy systems and processes.

Course Outcomes
After the completion of this course, students will be able to:

CO208.1	Understand mechanism of heat transfer and heat transfer related dimensionless numbers.
CO208.2	Determine heat transfer co-efficient using empirical correlations and apply to various heat transfer related problems.
CO208.3	Analyze the effect of boundary condition on heat transfer process.
CO208.4	Explain and apply concept of phase change.
CO208.5	Design heat exchangers.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module I **Basic Concepts:** Modes of heat transfer, conduction, convection and radiation, analogy between heat flow and electrical flow. **Conduction:** One dimensional steady state heat conduction, the Fourier heat conduction equation, conduction through plane wall, conduction through cylindrical wall, spherical wall, conduction through composite slab, cylinder and sphere, critical radius of	8

insulation, **Extended surfaces:** heat transfer from a fin, fin effectiveness and efficiency, Introduction to unsteady state heat conduction.	
Module II **Convection:** Natural and forced convection, the convective heat transfer coefficient. **Forced Convection:** Correlation equations for heat transfer in laminar and turbulent flows in a Circular tube and duct, Reynolds and Colburn analogies between momentum and heat transfer, heat transfer to liquid metals and heat transfer to tubes in cross flow. **Natural Convection:** Natural convection from vertical and horizontal surfaces, Grashof and Rayleigh numbers.	8
Module III **Heat transfer by radiation:** Basic Concepts of radiation from surface: black body radiation, Planks law, Wien's displacement law , Stefan Boltzmann's law, Kirchhoff's law, grey body, Radiation intensity of black body, View factor , emissivity, radiation between black surfaces and grey surfaces. Solar radiations, combined heat transfer coefficients by convection and radiation.	8
Module IV **Boiling and Condensation:** Pool boiling, pool boiling curve for water, maximum and minimum heat fluxes, correlations for nucleate and film pool boiling, drop wise and film wise condensation, Nusselt analysis for laminar film wise condensation on a vertical plate, film wise condensation on a horizontal tube, effect of non-condensable gases on rate of condensation. **Evaporation:** Types of evaporators, boiling point elevation and Duhring's rule, material and energy balances for single effect evaporator, multiple effect evaporators: forward, mixed and backward feeds, capacity and economy of evaporators.	8
Module V **Heat Exchangers:** Introduction, Industrial use, Types of heat exchangers, Co-current, Counter-current & Cross-current, Principal Components of a Concentric tube & Shell-and Tube Heat Exchanger, Baffles, Tubes and Tube Distribution, Tubes to Tube sheets Joint, Heat Exchangers with Multiple Shell & tube Passes, Fixed-Tube sheet and Removable-Bundle Heat Exchangers, log-mean temperature difference, overall heat transfer coefficient, fouling factors, Design of double pipe and shell and tube heat exchangers.	8

Text books:

1. Holman, J. P., 'Heat Transfer ', 9th Edn., McGraw Hill, 2004.
2. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.
3. Cengel, Y.A., Heat Transfer - A Practical Approach, McGraw-Hill, 1998.

Reference books:

1. Incropera, F.P. and Dewitt, D.P., Fundamentals of Heat and Mass Transfer, 5th ed., John Wiley, 2002.
2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 6th Edn., McGraw-Hill, 2001.

3. Coulson, J.M. and Richardson, J.F., “Chemical Engineering “ Vol. I, 4th Edn., Asian Books Pvt. Ltd., India, 1998.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher’s Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO208.1	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO208.2	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO208.3	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO208.4	3	3	3	3	2	2	2	1	2	3	1	2	3	2	2
CO208.5	3	3	3	3	2	2	2	1	2	3	1	2	3	2	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD7, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD7, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL215
Course title: Mass transfer operations I
Pre-requisite(s): CL 201, CL 204
Co- requisite(s): Transport Phenomena
Credits: L: 3 T: 1 P: 0
Class schedule per week: 04
Class: B. Tech.
Semester / Level: IV / Second
Branch: Chemical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Understand the basic knowledge of mass transfer operation and its application.
2.	Describe the processes diffusion, convective mass transfer and interphase mass transfer.
3.	Understand gas-liquid contact process and design absorption column.
4.	Describe the distillation process and its applications.
5.	Determine design parameters of distillation column.

Course Outcomes
After the completion of this course, students will be to:

CO215.1	Explain the basic mechanism of mass transfer including diffusion and convective mass transfer.
CO215.2	Determine the mass transfer coefficient and solve problems related to interphase mass transfer.
CO215.3	Explain the gas-liquid contacting process and solve problems related to design calculation.
CO215.4	Solve problems on design calculation of distillation column.
CO215.5	Explain enhanced distillation and solve related problems.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Introduction to mass transfer and applications, Principles of molecular diffusion, Fick's Law, Diffusivity, Equation of continuity and unsteady state	8

diffusion, Diffusion in solids. Convective mass transfer and Mass transfer coefficient, Correlation of mass transfer coefficients.	
Module 2 Interphase mass transfer, Theories of Mass Transfer, individual gas and liquid phase mass transfer coefficient, overall mass transfer coefficient, Analogy between momentum, heat and mass transfer, Concept of stage wise contact processes.	8
Module-3 The mechanism of absorption, Equipment for Gas Liquid contact, Kremser equation, plate and packed tower internals, Packed tower design, H. E. T. P., H. T. U., and N. T. U. concepts, height of column based on conditions in the gas film, height of column based on conditions in the liquid film, height of column based on overall coefficients, plate type towers, number of plates, plate efficiency, absorption factor.	8
Module-4 Relative Volatility, calculation of number of plates by McCabe-Thiele method, Total and minimum reflux ratio, distillation with side streams, Enthalpy concentration diagram, calculation of number of plates by and Ponchon and Savarit method, Steam distillation, Azeotropic & Extractive Distillations, batch distillation with reflux, Introduction to multicomponent distillation.	8
Module-5 Shortcut method on multi component distillation, MESH equations (HK, LK component), Fenske-Underwood- Gilliland method.	8

Text books:

1.Mass Transfer Operations: R.E. Treybal Mc Graw Hill, 1981
2.Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
3.Principles of Mass Transfer and Separation Processes, Binay K. Dutta, 2nd edition,Prentice Hall of India,2007.
4.Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Reference books:
1.Separation Process Principles-Chemical and Biochemical Operations, J. D. Seader, Ernest J. Henley, D. Keith Roper, 3rd Ed., John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)
Solve MESH equations using computer simulations for multicomponent distillation.

POs met through Gaps in the Syllabus
PO2, PO3, PO4, PO5

Topics beyond syllabus/Advanced topics/Design
Multicomponent separation
POs met through Topics beyond syllabus/Advanced topics/Design
PO1, PO2, PO3, PO4

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO209.1	3	3	0	2	2	0	0	0	1	0	0	3	3	0	2
CO209.2	3	3	0	0	2	0	0	0	1	0	0	3	3	0	2
CO209.3	3	3	3	3	2	2	2	2	2	3	1	3	3	2	2
CO209.4	3	3	3	3	2	2	2	2	2	2	2	3	3	3	2
CO209.5	3	3	3	3	2	2	2	2	2	2	2	3	3	3	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD7, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD7, CD8
CD3	Seminars	CO3	CD1, CD2, CD7, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD7, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD7, CD8

CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

LABORATORY

COURSE INFORMATION SHEET

Course code:	CL213
Course title:	Chemical Engineering Lab I
Pre-requisite(s):	
Co- requisite(s):	
Credits:	1.5 (L: 0 T: 0 P: 3)
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	IV / Second
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students to:

1.	Plan experiments, make appropriate measurements, analyze the data and report the results.
2.	Apply theoretical concepts for data analysis and interpretation.
3.	Learn to operate equipments/instruments.
4.	Develop experimental skills.
5.	Examine the theory through experiments

Course Outcomes

After the completion of this course, students will be able to:

CO212.1	Demonstrate various fluid flow measuring devices and examine the performance of a centrifugal pump.
CO212.2	Operate mechanical separation equipments and analyse the results.
CO212.3	Evaluate heat transfer in composite wall and shell and tube heat exchanger.
CO212.4	Analyse the experimentally derived quantities with estimates from correlations/models discussed in the related theory courses.
CO212.5	Evaluate errors in measurements and assess the result.

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Studies on Venturimeter, Orificemeter and Rotameter.
2	Studies on flow over notches.
3	Studies on friction in pipes and pipe fittings.
4	Centrifugal Pump test rig.
5	Studies on Ball Mill.
6	Studies on Cyclone Separator.
7	Studies on Plate and Frame Filter Press.
8	Particle size analysis & Characterization of particulate solids.
9	Heat Transfer by Conduction Lagged pipe and composite wall.
10	Shell and tube heat exchanger.
11	Studies on Fluidization.
12	Studies on solid conveyor (bucket conveyor).

Text books:

1. Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, VolumeI", Pergamon Press.
3. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.

Reference books:

1. Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
(1) Progressive Evaluation	60
(2) End Semester	40

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO212.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3	3
CO212.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3
CO212.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3	3
CO212.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3	3
CO212.5	1	1	1	1	1	3	1	1	1	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD4, CD5, CD7, CD8
CD2	Tutorials/Assignments	CO2	CD4, CD5, CD7, CD8
CD3	Seminars	CO3	CD4, CD5, CD7, CD8
CD4	Mini projects/Projects	CO4	CD4, CD5, CD7, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD4, CD5, CD7, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL319
Course title: Mass transfer operations-II
Pre-requisite(s): Mass transfer operation I (CL 209)
Co- requisite(s): Transport Phenomena
Credits: 3 (L: 3 T: 0 P: 0)
Class schedule per week: 3
Class: B. Tech.
Semester / Level: V/Third
Branch: Chemical Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Explain various separation processes such as extractions, drying, and adsorption.
2.	Explain psychometric chart for calculating water vapour-air mixture properties.
3.	Solve design related problems for drying operation.
4.	Explain adsorption and crystallization techniques and solve related problems.
5.	Describe various membrane separation processes.

Course Outcomes
After the completion of this course, students will be able to:

CO319.1	Solve design calculation problems on liquid-liquid and solid-liquid extraction.
CO319.2	Solve problems related to humidification and drying.
CO319.3	Explain the various adsorption isotherms and solve problems related toadsorption.
CO319.4	Explain the mechanisms of crystallization and solve related problems.
CO319.5	Apply the knowledge of membrane-based separation processes like ultrafiltration, electrodialysis, pervaporation, reverse osmosis, and membrane distillation.

SYLLABUS

MODULE	No. of Lecture Hours
Module 1: **Liquid-liquid extraction:** Introduction to Extraction, Liquid-liquid equilibria, Ternary diagram, solvent selection, Stage wise contact: single stage and multistage cross-current & counter-current extraction, number of equilibrium stages by graphicalmethod, minimum solvent rate, extraction equipment. **Solid-liquid extraction:** Introduction to leaching, general principle, Liquid-solid equilibria, factors affecting the rate of extraction, calculation of number of stages, batch processes, counter-current washing, stage calculation methods.	8
Module 2: Humidification and dehumidification operations, properties of water vapor-air system and psychrometric chart, cooling towers (Natural draft, forced draft and induced draft cooling tower).	8
Module 3: Introduction to drying, rate of batch drying, mechanism of batch drying, cross circulation and through circulation drying, classification and design of dryers.	8
Module 4: Introduction to adsorption, nature of adsorbents, batch adsorption, Adsorption isotherms, Adsorption equipment, pressure swing, thermal- swing, breakthrough curves, design of fixed bed adsorption column. Principles of ion exchange and applications, ion exchange equilibria, rate of ion exchange.	8
Module 5: Introduction to crystallization, Industrial examples of crystallization, Different types of solubility curves, Crystal geometry and crystal size distribution, theory of Crystallization, eutectic point, Formation and growth of crystals, crystal yield, rate of crystallization, crystallization equipments. Introduction of membrane separation processes, Equipment and Design principles for various membrane separation processes.	8

Textbooks:

1. Mass Transfer Operations: R.E. Treybal Mc Graw Hill, 1981.
2. Principles of Mass Transfer and Separation Processes, Binay K. Dutta, 2nd edition,PrenticeHall of India,2007.
3. Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed.1993.

Reference books:

1. Separation Process Principles-Chemical and Biochemical Operations, J. D. Seader, Ernest

J.Henley, D. Keith Roper, 3rd Ed., John Wiley & Sons, Inc.
2. Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Gaps in the syllabus (to meet Industry/Profession requirements)
Solve problems related multi components separation processes.

POs met through Gaps in the Syllabus
PO1, PO2, PO3, PO4, PO5.

Topics beyond syllabus/Advanced topics/Design
Design cooling towers and rotary dryers.

POs met through Topics beyond syllabus/Advanced topics/Design
PO1, PO2, PO3, PO4, PO5.

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO301.1	3	3	3	0	1	1	2	2	2	0	0	2	3	1	1
CO301.2	3	3	0	0	0	2	2	0	0	2	0	0	3	0	1
CO301.3	3	2	0	2	1	2	1	1	0	2	2	2	3	3	1
CO301.4	3	2	1	0	0	0	1	0	0	0	0	2	3	0	1
CO301.5	2	0	1	1	0	3	2	3	1	2	1	2	3	2	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD7, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2,CD7, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Course Information Sheet

Course code:	CL302
Course title:	Chemical Reaction Engineering-I
Pre-requisite(s):	CL204 Chemical Process Calculations
Co- requisite(s):	
Credits:	4 (L: 3 T: 1 P: 0)
Class schedule per week:	4
Class:	B. Tech.
Semester / Level:	V/ Third
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students to:

1.	Describe basic concept of kinetics and rate laws.
2.	Explain the characteristics of ideal homogeneous reactors.
3.	Analyse kinetic data.
4.	Describe the effect of heating on performance of non-isothermal reactors.
5.	Explain RTD in reactors.

Course Outcomes

After the completion of this course, students will be able to:

CO302.1	Explain the concepts of Kinetics and Rate Laws.
CO302.2	Analyze ideal Reactors for homogeneous reactions.
CO302.3	Determine rate constant, reaction order and reactor volume using the kinetic data.
CO302.4	Analyze the performance of ideal and non-ideal reactors.
CO302.5	Design ideal reactors.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Overview of chemical reaction engineering. Classification of reactions. Rate of reaction for a homogeneous reaction. Temperature and concentration-dependent terms for a homogeneous reaction. Kinetic models for nonelementary reactions. Steady state approximation and rate limiting step theory.	8
Module 2: Interpretation of batch reactor data: data collection, plotting, and analysis. Determination of kinetics of homogeneous reactions using Integral, differential,	8

and half-life methods analysis of data. Series and parallel reactions. Autocatalytic reactions.	
Module 3: **Ideal reactors:** generalized material balance, design equations, graphical interpretation. Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors-solving design equations for constant and variable density systems, reactors in series and parallel.	8
Module 4: **Non-Isothermal Operation and Stability of Reactors:** Non-isothermal design of ideal reactors, auto-thermal process, steady state multiplicity and effect of operating variables on the stability of CSTR, optimal temperature progression for first order reversible reaction.	8
Module 5: **Non-ideal reactor:** Residence time distribution (RTD) theory, role of RTD in determining reactor behaviour, age distribution (E) of fluid, experimental methods for finding E, relationship between E and F curve; Models for nonideal flow-single parameter and multi parameter models.	8

Text books:

1.Fogler H. S., "Elements of Chemical Reaction Engineering", 4thEd., Pearson-Prentice Hall.
2. Levenspiel O., "Chemical Reaction Engineering", 3rdEd., John Wiley and Sons.

Reference books:
1. Schmidt L. D., "The Engineering of Chemical Reactions", 2nd Ed., Oxford University Press.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO302.1	3	3	3	2	2	2	1	1	1	2	1	2	3	2	2
CO302.2	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO302.3	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO302.4	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO302.5	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL 309
Course title: Material Science and Engineering
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 00 P: 00
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Knowledge: Define crystal structure, defects and microstructural change during processing
2.	Explain: Explain Iron-C phase diagram
3.	Demonstrate: Demonstrate the extraction of metal by different methods
4.	Synthesize: synthesize a polymer material based on available resources
5.	Evaluate: Evaluate the properties and functions of a given material.

Course Outcomes:
After the completion of this course, students will be able to:

CO309.1	Define: Define crystal structure, defects and microstructural change during processing
CO309.2	Demonstrate: Demonstrate the phase diagram and properties of processing on steel
CO309.3	Analyse: Given a type of microstructure analyse the basics of processing techniques for altering the microstructure and properties of metals
CO309.4	Synthesize: Given a set of specification synthesize a polymer material based on available resources
CO309.5	Evaluate: Apply the basic principles of composite materials evaluate the properties for specific functions

SYLLABUS

MODULE	NO. OF LECTURE HOURS
MODULE I Introductory concept: Crystal structures, Space lattice, Symmetry elements, Unit cells, Crystal systems, Packing factors, Miller indices, Single crystals,	8

Polycrystalline materials, X-ray diffraction & Bragg's law. Types of imperfections, Point defects. Dislocations: Edge dislocation & Screw dislocation, Burger's vector, Concepts of dislocation density, Surface defects, Volume defects, vibrational defects. Phase Equilibria, Microstructural changes during cooling, The Lever rule and its applications, Gibbs phase rule.	
MODULE II Solidification of pure metal. Plastic deformation of pure metal. Diffusion in solids. Solidification in binery alloys. Fe-C phase diagram. Ternary phase diagram. Metal working, Deformation processing. Preparation of solid solution. Heat treatment of metal. Surface hardening. Structural steel. Ultra high strength steel. Preferred orientation. Metal joining. IS coding and compositions.	8
MODULE III Principles of metal extraction. Ellingham diagram. Principles of electrochemistry. Pyrometallurgy Calcination, roasting, smelting. Hydrometallurgy leaching, solvent extraction, ion exchange, precipitation and electrometallurgy, electrolysis, electrorefining. Stress-strain behaviour of metal, Introduction to Fracture, Fatigue and Creep.	8
MODULE IV Principles of polymer. Structure property relationship of Polymer, Molecular weight and Molecular weight distribution. The glassy state and the glass transition. Rheological and Mechanical properties of polymer. Thermodynamics of Polymer solutions. Properties of common polymer (Polythene, PP, PVC, PS, PMMA, PET, Nylon, PTFE). Properties of elastomer (NR, SBR, Silicone rubber).	8
MODULE V Basic concepts of glass structure, Common Refractory Materials, Glass ceramics. Optical Fibre.Types of glazes and enamels. Sol-gel technology. Fiber reinforced composites. Sensors and actuators.	8

TEXTBOOKS:

1. V. Raghavan, Materials Science and Engineering: A first Course, PHI Learning, New Delhi 2009

2. W.D. Callister (Jr) Material Science can Engineering, An introduction, John Wiley andSons, 2003

3.Y.W.Chung, Introduction to Materials Science and Engineering, CRC Press, Boca Raton, 2006

4.W.F. Smith, Materials Science and Engineering, Tata McGraw-Hill, New Delhi 2008

5 B. Jaffe, W. R. Cook, Jr. and H. Jaffe "Piezoelectric Ceramics", Academic Press, London, 1971.

REFERENCE BOOKS:

1 A. J. Moulson and J. M.Herbert "Electroceramics: Materials, Properties andApplications", , Chapman &Hall, London, 1993.

2. G. S. Upadhyaya and A. Upadhyaya, Materials Science and Engineering, New Delhi 2005.

3. Physical Properties of Materials, M. C. Lovell, A. J. Avery, M. W. Vernon, ELBS

4. R. C. Buchanan (ed.), "Ceramic Materials for Electronics", Marcel Dekker, New York, 1986.

5 L. L. Henchand J. K. West, "Principles of Electronic Ceramics", WileyInterscience, New York, 1990.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO309.1	3	3	3	1	2	2	2	3	2	2	0	1	3	2	1
CO309.2	3	3	3	1	2	2	2	3	2	2	0	1	3	2	1
CO309.3	3	3	3	1	1	2	2	3	2	2	0	1	3	2	1
CO309.4	3	3	3	2	1	2	2	3	2	2	0	1	3	2	1
CO309.5	3	3	3	2	1	2	2	3	2	2	0	1	3	2	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

LABORATORIES

COURSE INFORMATION SHEET

Course code: CL304
Course title: Computer Aided Process Engineering Lab
Pre-requisite(s):
Co- requisite(s):
Credits: 2 (L: 0 T: 0 P: 4)
Class schedule per week: 4
Class: B. Tech.
Semester / Level: V / Third
Branch: Chemical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Improve the computing skills of the students.
2.	Solve complex engineering problems using advanced programming softwares.
3.	Develop process flow sheets.
4.	Analyze and evaluate the accuracy of different numerical methods.
5.	Analyze the data and prepare the report in a meaningful way.

Course Outcomes
After the completion of this course, students will be able to:

CO304.1	Solve mathematical models using MATLAB.
CO304.2	Solve process control problems using simulink.
CO304.3	Develop flowsheets for reactors and distillation column .
CO304.4	Evaluate techno-economic feasibility of distillation column
CO304.5	Solve fluid flow and heat transfer using CFD tools.

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Solving ODE, non-linear equations, linear simultaneous equations, optimization of single variable equation (interval halving & golden section search method)using MATLAB .
2	Solving VLE problems for ideal systems using MATLAB (Bubble point, dew point, flash vaporization).
3	Solving VLE problems for non-ideal systems using MATLAB (Bubble point, dew point, flash vaporization).
4	Solving process control problems using MATLAB Simulink (Isothermal CSTR).
5	Solving process control problems using MATLAB Simulink (non-isothermal CSTR).
6	Solving process control problems using MATLAB Simulink (liquid-level control).
7	Reactor modeling and design using ASPEN Plus.
8	Design, simulation and economic optimization of distillation column for binary mixtures.
9	Design and simulation of multicomponent distillation column.
10	Solving Fluid flow and heat transfer problems using CFD tools.

Text books:

Reference books:

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
(1) Progressive Evaluation	60
(2) End Semester	40

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO301.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3	3
CO301.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3
CO301.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3	3
CO301.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3	3
CO301.5	1	1	1	1	1	3	1	1	1	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD4, CD8, CD9
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD4, CD8, CD9
CD3	Seminars	CO3	CD1, CD2, CD4, CD8, CD9
CD4	Mini projects/Projects	CO4	CD1, CD2, CD4, CD8, CD9
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD4, CD8, CD9
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL305
Course title:	Chemical Engineering Lab II
Pre-requisite(s):	
Co- requisite(s):	
Credits:	2 (L: 0 T: 0 P: 4)
Class schedule per week:	4
Class:	B. Tech.
Semester / Level:	V / Third
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Plan experiments, make appropriate measurements, analyze the data and report the results.
2.	Apply theoretical concepts for data analysis and interpretation.
3.	Learn to operate equipments/instruments.
4.	Develop experimental skills.
5.	Examine the theory through experiments

Course Outcomes
After the completion of this course, students will be able to:

CO305.1	Operate mass separation equipments and analyse the results.
CO305.2	Evaluate heat transfer in various heat exchanger.
CO305.3	Estimate heat and mass transfer parameters for unit operation equipments.
CO305.4	Analyse the experimentally derived quantities with estimates from correlations/models discussed in the related theory courses.
CO305.5	Evaluate errors in measurements and assess the result.

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Diffusion of vapor in air.
2	Absorption in wetted wall tower.
3	Drying rate curve in Tray dryer.
4	Sieve Plate Distillation column (determination of overall tray efficiency).
5	Crystallizer.
6	Heat transfer in agitated vessel.
7	Spiral Heat exchanger.
8	Plate heat exchanger.
9	Membrane preparation by phase inversion and studies on cross-flow and hollow fibre membranes.
10	Studies on Heat and Mass Transfer in Cooling Tower.
11	Steam Distillation of turpentine.
12	Batch Distillation with reflux in packed column with stacked packing.
13	Liquid-Liquid extraction in York Schieble Extraction column.
14	Studies on adsorption column and Bonnotto type solid liquid extractor

Text books:

1.Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
2.Coulson, J.M. and Richardson, J.F., “Chemical Engineering, Volume I”, Pergamon Press.
3.Kern, D.Q., “Process Heat Transfer “, McGraw-Hill, 1999.

Reference books:

1.Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
(1) Progressive Evaluation	60
(2) End Semester	40

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO301.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3	3
CO301.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3
CO301.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3	3
CO301.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3	3
CO301.5	1	1	1	1	1	3	1	1	1	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD4, CD5, CD6, CD8
CD2	Tutorials/Assignments	CO2	CD4, CD5, CD6, CD8
CD3	Seminars	CO3	CD4, CD5, CD6, CD8
CD4	Mini projects/Projects	CO4	CD4, CD5, CD6, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD4, CD5, CD6, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL335
Course title	Chemical Process Technology
Pre-requisite(s)	Thermodynamics CL201, Chemical Process Calculations CL204
Co- requisite(s)	Mass Transfer Operation CL 209, Heat Transfer Operation CL208, Chemical Reaction Engineering
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	VI / Third
Branch	Chemical Engineering
Name of Teacher	

Course Objectives
This course enables the students to:

1.	Understand the processes involved in chemical industries to produce chemicals.
2.	Illustrate the different unit operations and unit processes in a given process flow diagram.
3.	Explain the effect of various process parameters on manufacturing processes.
4.	Understand major engineering problems in a process.
5.	Understand the role of process modifications for economic and environmental sustainability.

Course Outcomes
After the completion of this course, students will be able to:

CO335.1	Describe manufacturing processes involved in the productions of various chemicals such as inorganics, synthetic organics, natural products, foods etc.
CO335.2	Understand the role of different unit operations and unit processes in a process flow diagram.
CO335.3	Determine the effect of various process parameters on a chemical process for plant operation.
CO335.4	Identify major engineering problems in a chemical process
CO335.5	Modify the process for economic and environmental sustainability.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Sulfuric acid: Production of of sulfuric acid, Hydrates of sulfuric acid and uses, Contact process, Catalysts developments, DCDA process. Chlor-alkali industries: Manufacture of Soda Ash, Caustic Soda and Chlorine. Bleaching Powder, Calcium Hypochlorite, Sodium Hypochlorite.	8
Module 2: Phosphorous Industries: Phosphate rock, Superphosphates, Manufacturing of Phosphoric acid (Wet-Process and Electric-Furnace), Phosphates (Sodium phosphates, Pyrophosphates, Calcium Phosphates), manufacturing of Diammonium phosphate. Cement and lime: Properties of cement, types of Portland cement, production of cement, Lime manufacturing.	8
Module 3: Nitrogen industries: Manufacturing of Ammonia; Ammonium nitrate, Ammonium sulphate; manufacturing of Urea and Nitric acid. Fertilizer Industries: Manufacturing of Single Superphosphate (SSP) & Triple Superphosphate (TSP), Ammonium phosphate, Nitrophosphate, NPK fertilizer.	8
Module 4: Natural Product Industries: Oils & Fats: Methods of extracting vegetable oils, Hydrogenation of oils. Soaps, Detergents & Glycerin: Classification of cleansing compounds, uses, Methods of soap production, detergent manufacture and Glycerin production. Fermentation Industry: Manufacture Ethanol production through fermentation. Pulp and Paper industries: Their types, uses, and productions.	8
Module 5: Chemical from aromatics: Allied chemicals and uses. Productions of Phenol, Styrene, Cumene, Phthalic anhydride, Maleic anhydride, Terephthalic acid, etc.	8

Textbooks:

1. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.
2. Shreve's Chemical Process Industries, George T. Austin, 5th Edition, Tata McGraw Hill Edition.

Reference books:

1. Kirk & Othmer (Ed.), Encyclopedia of Chemical Technology.
2. Unit operation in organic systhesis : P.H. Groggins.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO312.1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3
CO312.2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO312.3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO312.4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	3
CO312.5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, , CD7, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD7, CD8
CD3	Seminars	CO3	CD1, CD2,, CD7, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Course Information Sheet

Course code: CL320
Course title: Chemical Reaction Engineering-II
Pre-requisite(s): Chemical Reaction Engineering-I
Co- requisite(s):
Credits: L: 3 T: 1 P: 0
Class schedule per week: 4
Class: B. Tech
Semester / Level: VI / Third
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Explain the basic concepts of heterogeneous catalysis.
2.	Calculate and explain the physical properties of the catalysts.
3.	Analyze the kinetics of heterogeneous catalytic reactions
4.	Describe the rectors for various reactions.
5.	Develop critical and creative thinking skills related to reaction engineering.

Course Outcomes:
After the completion of this course, students will be able to:

CO320.1	Describe the heterogeneous catalysis and evaluate the physical properties of the catalysts.
CO320.2	Model solid catalyzed gas phase reaction.
CO320.3	Explain the effect of heat and mass transfer on kinetics of catalytic reactions.
CO320.4	Explain the effects of reaction and mass transfer limitations in the heterogeneous catalysis.
CO320.5	Describe the kinetics of gas-liquid and biochemical reaction systems.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction to heterogeneous reactions. Classification of heterogeneous reactions. Examples of heterogeneous reactions. Introduction to heterogeneous catalysis. Nature of catalytic reactions. Components of the Catalyst formulation. Catalyst preparation. Determination of physical properties (BET surface area, pore volume, and pore size distribution) of catalysts.	8
Module 2: Concept of intrinsic and global rate of reaction. Steps in a catalytic reaction: Adsorption isotherms, Surface reaction, Desorption. Rate limiting step. Synthesizing a rate law, mechanism, and rate-limiting step.	8
Module 3: different types of non-catalytic solid-gas reactions; kinetic models for gas-solid non-catalytic reactions: Shrinking Core Model (SCM), Progressive conversion Model (PCM), design of non-catalytic gas solid reactors.	8
Module 4: Kinetics of solid catalyzed gas phase reaction; isothermal and non-isothermal inter-and-intraphase effectiveness factors, catalytic gas-solid reactor design.	8
Module 5: Gas liquid reactions, film and penetration theories, enhancement factor in gas-liquid reactions, gas-liquid reactors. Introduction to biochemical reaction systems. Enzyme and microbial fermentations.	8

Textbooks:

1. J. J. Carberry, Chemical and Catalytic Reaction Engineering, Dover Books on Chemistry, 2001.
2. Chemical Engineering Kinetics, J. M. Smith.
3. Elements of Chemical Reaction Engineering, Fogler H. S., Prentice Hall, 2001.
4. O. Levenspiel, Chemical Reaction Engineering, 3rd Edn, Wiley& Sons (1999).

Reference books:

1. Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, John Wiley & Sons, Incorporated, 2010

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods:

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		

CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL318
Course title:	Transport Phenomena
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L: 3 T: 0 P: 0
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	VI / Third
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students to:

1.	Understand the mathematical foundation required for analysis of fluid flow.
2.	Understand the mathematical foundation required for analysis of heat and mass transfer.
3.	Learn systematic analysis of fluid flow and heat transfer with emphasis on analogies and specific technique using treating such boundary value problems.
4.	Solve ODE and PDE related to heat, mass and momentum transport.
5.	Solve problems combining heat, mass and momentum transport.

Course Outcomes

After the completion of this course, students will be able to:

CO318.1	Identify and describe mechanisms of transport phenomena, present in given isothermal and non-isothermal, laminar and turbulent flow systems.
CO318.2	Classify interrelations between the molecular, microscopic and macroscopic descriptions of transport phenomena.
CO318.3	Explain similarities and differences between the descriptions of the combined fluxes and the equations of change for mass, momentum and heat transport.
CO318.4	Apply the method of dimensional analysis to reformulate and then find the form of solutions of the equations of change, to determine the dependence of the interfacial fluxes on system parameters.
CO318.5	Elaborate conceptual and mathematical models, from conservation principles, to complicated systems involving simultaneous mass, momentum, and/or heat transfer processes as well as reactions or other sources/sinks of transport for multi-component mixtures.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Law of conservation, Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity.	8
Module 2: Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces, Reynold's transport theorem, Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal).	8
Module 3: Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change (non-isothermal), equation of continuity, equation of motion for forced and free convection, equation of energy (non-isothermal).	8
Module 4: Shell mass balances, concentration profiles, average concentration, mass flux at surfaces, Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component).	8
Module 5: Introduction to the concept of heat and mass transfer coefficients. Interphase mass transfer, various coefficient of mass transfer and their determination, resistance concept, controlling phase concept, Mass transfer in turbulent flow, Analogies of mass transfer, Empirical equations. Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory.	8

Text books:

1. Bird R.B., Stewart W.E. and Lightfoot E.N., "Transport Phenomena",2nd Ed., John Wiley and Sons.
2. Geankoplis C.J., "Transport Processes and Separation Process Principles", 4th Ed., Prentice-Hall of India.

Reference books:

1.Brodkey, R.S., Hershey H.C., "Basic concepts in transport phenomena, a unified approach". Vol 1, Brodkey Publishing.
2. Fox and McDonald's, 'Introduction to fluid Mechanics'
3. Robert E. Treybal, Mass-Transfer Operation

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

1. Turbulent flow behaviour
2. Conservation law applicable in thin film.

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO313.1	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO313.2	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO313.3	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO313.4	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO313.5	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

LABORATORIES

COURSE INFORMATION SHEET

Course code: CL310
Course title: Design Lab
Pre-requisite(s):
Co- requisite(s):
Credits: 1.5 (L: 0 T: 0 P: 3)
Class schedule per week: 3
Class: B. Tech.
Semester / Level: VI / Third
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Acquire the basic knowledge of design parameter.
2.	Learn the complete knowledge of design procedure for commonly used process equipments.
3.	Estimate the physical properties for required design parameters.
4.	Evaluate the properties of air-water system for the design of rotary dryer and cooling tower.
5.	Draw the detailed schematics of various process equipments.

Course Outcomes
After the completion of this course, students will be able to:

CO310.1	Estimate physical properties of materials.
CO310.2	Design heat transfer equipments.
CO310.3	Design mass transfer equipments
CO310.4	Design mechanical parameters of a pressure vessel.
CO310.5	Feasibility analysis of designed equipments

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Prediction of physical properties.
2	Design of shell and tube heat exchangers.
3	Design of plate distillation column.
4	Design of packed absorption column.
5	Design of rotary dryer.
6	Design of pressure vessels.
7	Design of tray tower.
8	Design of cooling tower.
9	Design of crystallizer (with crystal size distribution).

Text books:

1.Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
2.Coulson, J.M. and Richardson, J.F., "Chemical Engineering, Volume I", Pergamon Press.
3.Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.

Reference books:

1.Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
(1) Progressive Evaluation	60
(2) End Semester	40

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO301.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3	3
CO301.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3
CO301.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3	3
CO301.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3	3
CO301.5	1	1	1	1	1	3	1	1	1	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD4, CD5, CD6, CD8
CD2	Tutorials/Assignments	CO2	CD4, CD5, CD6, CD8
CD3	Seminars	CO3	CD4, CD5, CD6, CD8
CD4	Mini projects/Projects	CO4	CD4, CD5, CD6, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD4, CD5, CD6, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL317
Course title: Chemical Engineering Lab III
Pre-requisite(s):
Co- requisite(s):
Credits: 1.5 (L: 0 T: 0 P: 3)
Class schedule per week: 3
Class: B. Tech.
Semester / Level: VI / Third
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Plan experiments, make appropriate measurements, analyze the data and report the results.
2.	Apply theoretical concepts for data analysis and interpretation.
3.	Learn to operate equipments/instruments.
4.	Develop experimental skills.
5.	Examine the theory through experiments

Course Outcomes
After the completion of this course, students will be able to:

CO317.1	Learn to employ various methods to dertermine the kinetics of reactions.
CO317.2	Quantify the effects of non-ideality of flow in chemical reactors.
CO317.3	Estimate physical parameters of different types of fuels.
CO317.4	Analyse the experimentally derived quantities with estimates from correlations/models discussed in the related theory courses.
CO317.5	Evaluate errors in measurements and assess the result.

LIST OF EXPERIMENTS:

Sl. No.	Description
1	To study a non-catalytic homogeneous reaction in an isothermal batch reactor.
2	To study a non-catalytic homogeneous reaction in a coil tube type plug flow reactor under isothermal conditions.
3	To study a non-catalytic homogeneous reaction in a CSTR under isothermal conditions.
4	To study the performance of a cascade of three equal volumes CSTR's in series.
5	RTD studies in a CSTR.
6	RTD studies in PFR.
7	Characterization of coal - I (Proximate Analysis&Bomb Calorimeter).
8	Commercial viscometer - Redwood I, Redwood II, Engler, Saybolt.
9	Flashpoint by Cleaveland Open Cup, Pensky Martin Closed Cup, Abel Closed cup.
10	Solar Energy – photovoltaic.
11	Solar Energy - Thermal energy.
12	Energy storage by phase change material.
13	ASTM distillation of petrol and characterization of diesel.

Text books:

1.Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
2.Coulson, J.M. and Richardson, J.F., "Chemical Engineering, Volume I", Pergamon Press.
3.Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.

Reference books:

1.Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
(1) Progressive Evaluation	60
(2) End Semester	40

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO311.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3	3
CO311.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3
CO311.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3	3
CO311.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3	3
CO311.5	1	1	1	1	1	3	1	1	1	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD4, CD5, CD6, CD8
CD2	Tutorials/Assignments	CO2	CD4, CD5, CD6, CD8
CD3	Seminars	CO3	CD4, CD5, CD6, CD8
CD4	Mini projects/Projects	CO4	CD4, CD5, CD6, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD4, CD5, CD6, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		

CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL404
Course title	PROJECT ENGINEERING & ECONOMICS
Pre-requisite(s)	Chemical Process Calculations CL204, chemical reaction engineering CL302, Industrial chemical process
Co- requisite(s)	Mass Transfer Operation CL209, Heat Transfer Operation CL208.
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	VII/ Third
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:

This course enables the students to:

1.	To develop concept of start of a plant design and find the best design method
2	Draw block diagrams/process flow diagrams and plant layout of the processes plant
3.	To understand the various components of the project cost.
4.	To understand the components of profit and loss
5.	Identify and understand various hazards and safety measures in chemical industries

Course Outcomes:

After the completion of this course, students will be able to:

CO404.1	Estimate best design method and capital cost product cost.
CO404.2	Calculate interest on loan and evaluate the breakeven point
CO404.3	Evaluate the feasibility of the project in terms of profit, payback period and other components
CO404.4	To solve optimization problems in a chemical process industries.
CO404.5	Adopt safety measures in chemical process industries through HAZOP studies and hazard analyses.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Development and implementation of the projects: Design need, Preliminary design ideas and rough evaluation of market and economics; selection of best design, flow sheet development, Cost estimation of investment and production: equipment cost and capital cost estimation, update cost data, Total product cost: Manufacturing cost; Raw material cost; Miscellaneous cost (labour cost, repair cost and maintenance cost); Depreciation. Estimation of revenue.	8
Module 2: Time value of money: Interests and Investment costs, Simple Interest, Ordinary and Exact simple Interest, Compound interest, Nominal and Effective interest rates, Continuous interest. Present worth and Discount, Annuities, Perpetuities, and Capitalized costs of investments. Break Even Analysis: Drawing of breakeven charts, effect of different variable on breakeven point.	8
Module 3: Depreciation: Reasons for replacement, book value, Present Value, Salvage Value, Market Value, Replacement Value. Straight line method, Declining-balance or Fixed percentage method, Sum -of -the-years-digits method, Sinking -fund Method, Accelerated cost recovery system, Modified accelerated cost recovery system. Profitability analysis: gross profit, income tax, net profit, Rate of return on investment, Present worth and discounted cash flow, Payback period, Capitalized Costs. Accounting of Business Transactions: Accounting principles, journal and ledger entries, balance sheet, profit and loss statement.	8
Module 4: Optimum design and design strategy: Procedure with one, two and more variables, Optimum production rates in Plant Operation, Case Studies, Linear Programming-Simplex algorithm.	8
Module 5: Safety and Loss Prevention: Hazard, Safety measures and loss prevention in chemical process industries, Hazard and operability study, Hazard analysis,	8

Text books:

1. Plant Design and Economics for Chemical Engineers, Max S. Peters, K. D. Timmerhaus, 4th Edition, McGraw-Hill Inc.13
2. Process Engineering Economics, James Riley Couper, Marcel Dekker Inc.
3. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.

Reference books:

1. Coulson & Richardson's Chemical Engineering Design, R K Sinnott, Vol. 6., Fourth Edition, Elsevier.
2. Project Planning and control with PERT & CPM, B.C. Punmia, K.K. Khandelwal

Gaps in the syllabus (to meet Industry/Profession requirements) POs

met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation

procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL405
Course title: Process Control and Instrumentation
Pre-requisite(s): Chemical process calculations CL204, Computer aided process engineering CL303
Co- requisite(s): Chemical Reaction Engineering – I CL302
Credits: L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI I/ Third
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand the key concepts of instrumentation and measurements of a chemical process plant.
2.	Understand and analyze the dynamics of different types of open loop and closed loop system.
3.	Analyze stability and tuning of a control system.
4.	Apply the concepts of control in unit operation and unit process.
5.	Apply the concepts of various types of computer-based control and advanced control strategies.

Course Outcomes:
After the completion of this course, students will be:

CO405.1	Define the operating principles of various instruments and measurements in a chemical process plant.
CO405.2	Understand Laplace transformation and the dynamics of control systems and construct the block diagram of closed-loop control system with mathematical formulations.
CO405.3	Analyze the stability of a control system.
CO405.4	Design of controller using different tuning techniques.
CO405.5	Apply computer-based advanced process control for better accuracy, economy, product quality and safety.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Process Instrumentation, measurement and its classification by physical characteristics, working principles of transducers/sensors employed for the measurement of flow, level, pressure, temperature, concentration, etc. Control valves and their characteristics. [7L]	8
Module 2: The concept of process dynamics and control, review of Laplace transform methods, Laplace transform of disturbances and building functions, dynamic response of first and second order system, interacting and noninteracting system, transportation lag, measurement lag. Linear closed-loop system, its different elements, block diagram, negative feedback and positive feedback system, servo problem and regulator problem.	8
Module 3: Controllers and final control element, PID. Stability of a linear closed-loop system, generalized stability criteria, Routh stability criteria, root locus, Frequency Response-Bode stability criteria, Bode plot.	8
Module 4: Controller tuning- Ziegler-Nichols rules, Cohen and Coon rules, criteria for good control, control system design by frequency response, use of gain and phase margins. Basic concepts of Control of Reactors, Unit operation equipment- heat exchanger, distillation column, flash chamber, mixer.	8
Module 5: Digital computer control loop and its elements, modes of computer control-direct digital control, SCADA, PLC, DCS. Advanced control strategies-feedforward, cascade, dead time compensation, ratio control, multivariable control.	8

Text books:

1. Coughanowr, Process Systen Analysis, MGH.
2. Stephenopolos, S., "Chemical process control", Prentice Hall of India, New Delhi, 1984.
3. Considine, D.M., "Process/Industrial Instruments and Controls Handbook", McGraw Hill, 1993.

Reference books:

1. Hughes T.A., Measurement and control basis, 3rd eds., ISA, 2002.
2. Dunn, W.C., Introduction to Instrumentation, Sensors, and Process Control, ARTECH HOUSE, INC, 2006.

3. Luyben, W.L., "Process modelling, simulation, and control for Chemical Engineers", McGrawHill, 1989
4. Oggunaika B.A. and Ray W.H., "Process Dynamics, Modeling and control". Oxford University Press, U.K. 1994.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO308.1	3	3	1	3	1	1	1	1	0	1	0	3	3	1	1
CO308.2	3	3	3	2	3	0	0	0	2	0	0	2	3	3	2
CO308.3	3	3	2	2	3	0	0	0	2	0	0	2	3	3	1
CO308.4	2	3	3	3	3	2	3	2	2	2	0	3	2	2	3
CO308.5	2	3	3	3	3	2	3	2	2	2	0	3	2	2	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL406
Course title	Process Modelling, Simulation and Optimization
Pre-requisite(s)	Mathematics, Thermodynamics, Chemical Process Calculations.
Co- requisite(s)	Mass Transfer Operation, Heat Transfer Operation, Chemical Reaction Engg.
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	VI / THIRD
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students to:

1.	Develop mathematical models for Chemical Engineering systems.
2.	Solve mathematical models using computer simulation.
3.	Solve chemical engineering optimization problems using various methods.
4.	Solve Linear Programming Problems.
5.	Understand global optimization techniques.

Course Outcomes:
After the completion of this course, students will be able to:

CO406.1	Develop mathematical models for chemical engineering systems.
CO406.2	Formulate optimization problem.
CO406.3	Solve unconstrained Single Variable Optimization problems.
CO406.4	Solve unconstrained Multivariable Optimization problems.
CO406.5	Solve Linear Programming Problems.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Mathematical Modeling and Simulation of Chemical Engineering Systems: Introduction, Uses of Mathematical Models, Principles of Formulation, Lumped and distributed parameter systems, Fundamental Laws: Continuity Equations & Energy Equations, Modeling of Separation Processes, Modeling of Reactors, Modeling of Heat Transfer Equipment such as Series of Isothermal constant-holdup CSTRs, CSTRs with variable holdups, Two heated tanks, Gas-phase Pressurized CSTR, Non-isothermal CSTR, Single Component Vaporizer, Multicomponent Flash drum, Batch Reactor, Reactor with mass transfer, Ideal binary distillation column, Multicomponent non-ideal distillation column etc. Computer Simulation of above modelled chemical engineering systems.	8
Module 2 Introduction to Optimization: Statement of optimization problems, Classification of optimization problems, Optimization problem formulation, Continuity of functions, Unimodal and Multimodal functions, concave and convex functions, Optimality criteria for unconstrained single variable and multivariable functions.	8
Module 3 Unconstrained Single Variable Optimization: Methods and Applications, Bracketing Method, Region elimination methods (Dichotomous search method, Interval Halving method, Fibonacci Search Method, Golden Section Search Method), Methods requiring derivatives: Newton-Raphson method, Bisection method, Secant method.	8
Module 4 Unconstrained Multivariable Optimization: Direct Search Methods (Simplex method, Hooke-Jeeves pattern search method, Powell's conjugate direction method), Unconstrained Multivariable Optimization: Gradient Based Methods (Cauchy's method, Newton's method, Marquardt Method).	8
Module 5 Linear Programming: Graphical Method and The Simplex Method. Basics of Global Optimization Algorithms, Introduction to Genetic Algorithm.	8

Books:

1. Process Modeling, Simulation and Control for Chemical Engineers, Willian L. Luyben, Second Edition, McGraw-Hill Chemical Engineering Series.

2. Modeling and Simulation of Chemical Process Systems, Nayef Ghasem, CRC Press, Taylor & Fraccis Group.
3. Process Modeling and Simulation for Chemical Engineers – Theory and Practice, Simant Ranjan Upreti, John Wiley & Sons Ltd.
4. Optimization of Chemical Processes, Edgar, Himmelblau and Lasdon, 2nd edition, McGraw-Hill Chemical Engineering Series.
5. Engineering Optimization: Theory and Practice, S S Rao, John Wiley & Sons.
6. Optimization for Engineering Design - Algorithms and Examples, K Deb, PHI Learning Private Limited.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

	Program Outcomes (POs)	Program Specific

Course Outcome													Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL401
Course title:	Process Control and Instrumentation Lab
Pre-requisite(s):	
Co- requisite(s):	
Credits:	1.5 (L: 0 T: 0 P: 3)
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	VII / Four
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives

This course enables the students to:

1.	Plan experiments, make appropriate measurements, analyze the data and report the results.
2.	Apply theoretical concepts for data analysis and interpretation.
3.	Learn to operate equipments/instruments.
4.	Develop experimental skills.
5.	Understand the basic principles and importance of process control in industrial process plant.

Course Outcomes

After the completion of this course, students will be able to:

CO401.1	Perform experiments on temperature, pressure, flow, and level control trainer and evaluate various related parameters.
CO401.2	Evaluate temperature of a system using various temperature measuring instruments.
CO401.3	Evaluate pressure of a system using Flapper-nozzle.
CO401.4	Analyze the characteristics of control valve in a control system.
CO401.5	Experiment on I/P and P/I convertor

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Temperature control trainer.
2	Level control trainer.
3	Pressure control trainer.
4	Flow control trainer.
5	Multi variable process control trainer.
6	Temperature measurement – RTD, Thermocouple and Bimetal Dial Thermometer.
7	Pressure measurement using Flapper-nozzle system.
8	Study of I/P and P/I convertor.
9	Control valve characteristics.
10	Dead Weight Pressure Gauge Tester.

Text books:

3. Unit Operations of Chemical Engineering: W.L. McCabe, and J.C. Smith McGraw Hill.5th Ed. 1993.
4. Coulson, J.M. and Richardson, J.F., "Chemical Engineering, VolumeI", Pergamon Press.
3.Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999.

Reference books:

1.Transport processes and Separation Process Principles, C.J. Geankoplis, Prentice Hall of India, 4th Ed. 2004

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
(1) Progressive Evaluation	60
(2) End Semester	40

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO301.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3	3
CO301.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3
CO301.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3	3
CO301.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3	3
CO301.5	1	1	1	1	1	3	1	1	1	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD4, CD5, CD7, CD8
CD2	Tutorials/Assignments	CO2	CD4, CD5, CD7, CD8
CD3	Seminars	CO3	CD4, CD5, CD7, CD8
CD4	Mini projects/Projects	CO4	CD4, CD5, CD7, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD4, CD5, CD7, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL403
Course title: Plant Design
Pre-requisite(s):
Co- requisite(s):
Credits: 2 **(**L: 0 T: 0 P: 4)
Class schedule per week: 4
Class: B. Tech.
Semester / Level: VII / Four
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand the concepts of plant design and project management.
2.	Estimate the capital cost, total product cost and profitability.
3.	Develop optimum flow-sheets.
4.	Develop processes based on economics
5.	Analyze the data and prepare the report in a meaningful way.

Course Outcomes
After the completion of this course, students will be able to:

CO403.1	Develop material and energy balance equations for a process involving several processing units
CO403.2	Explain the concept of Process Integration/ pinch technology and develop efficient processes.
CO403.3	Evaluate project cost based on economics for plant design.
CO403.4	Select suitable site for plant.
CO403.5	Develop process flow –sheets using Aspen Plus..

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Manual calculation of material and energy balance for a process involving several processing units. (Example 4.4 Coulson & Richardson'sVol. 6).
2	Process integration and pinch technology (Section 3.17 Coulson & Richardson'sVol. 6) and chapter 8 of James M. Douglas book.
3	Costing and project evaluation (Example 6.4 Coulson & Richardson'sVol. 6).
4	General site consideration (Chapter 14 Coulson & Richardson'sVol. 6).
5	Process flowsheet development and optimization using Aspen Plus.

Text books:

1. Coulson & Richardson's Chemical Engineering Design, Vol. 6.

2. Conceptual design of chemical processes, James M. Douglas, McGraw-Hill Book Company.

Reference books:

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
(1) Progressive Evaluation	60
(2) End Semester	40

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO403.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3	3
CO403.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3	3
CO403.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3	3
CO403.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3	3
CO403.5	1	1	1	1	1	3	1	1	1	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD4, CD5, CD6, CD8
CD2	Tutorials/Assignments	CO2	CD4, CD5, CD6, CD8
CD3	Seminars	CO3	CD4, CD5, CD6, CD8
CD4	Mini projects/Projects	CO4	CD4, CD5, CD6, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD4, CD5, CD6, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

In-Depth Specialization in Chemical Process Engineering

COURSE INFORMATION SHEET

Course code: CL361
Course title: Multiphase flow
Pre-requisite(s):
Co- requisite(s):
Credits: L:03 T:00 P:00
Class schedule per week: 03
Class: B. Tech.
Semester / Level:
Branch: Chemical Engineering,
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Learn the fundamentals of multiphase flow.
2.	Predict multiphase conditions to design appropriate systems/apparatus.
3.	Understand complex multiphase systems.
4.	Learn measurement techniques and instrumentation used in multiphase flows.
5.	Understand the recent advances in multiphase flow systems.

Course Outcomes:
After the completion of this course, students will be able to:

CO.361.1	Explain fundamental concepts, principles and application of multiphase flow.
CO.361.2	Describe different flow regimes of gas-liquid two phase flow.
CO.361.3	Solve analytical models to analyze the hydrodynamics of different flow regimes.
CO.361.4	Explain hydrodynamics of three phase flows.
CO.361.5	Describe various measurement techniques.

SYLLABUS

Module	No. of Lecture Hours
Module 1: Introduction to multiphase flow, types and applications, Common terminologies, flow patterns and flow pattern maps. One dimensional steady homogenous flow. Concept of choking and critical flow phenomena.	8
Module 2: One dimensional steady separated flow model: Phases are considered together but their velocities differ.Phases are considered separately, flow with phase change.	8
Module 3: Flow in which inertia effects dominate, energy equations. The separated flow model for stratified and annular flow.	8
Module 4: General theory of drift flux model. Application of drift flux model to bubbly and slug flow. Hydrodynamics of solid-liquid and gas-solid flow. Principles of hydraulic and pneumatic transportation.	8
Module 5: An introduction to three phase flow. Measurement techniques for multiphase flow: Flow regime identification, pressure drop, void fraction and flow rate measurement.	8

Text***Books:***

1. One dimensional Two Phase Flow by G. B. Wallis.
2. Measurement of Two Phase Flow Parameters by G.F.Hewitt.
3. Flow of Complex Mixtures by Govier and Aziz.
4. Two Phase Flow by Butterworth and Hewitt.
5. Handbook of Multiphase systems by Hetsroni.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8

CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL324
Course title	Computational Fluid Dynamics
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	6
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students:

1.	Learn the fundamentals of computational method for solving non-linear partial differential equations.
2.	Understand the widely used techniques in the numerical solution of fluid equations.
3.	Understand the issues that arise in the solution of fluid equations.
4.	Learn CFD techniques for solving incompressible and compressible N-S equation in primitive variables, grid generation in complex geometry, transformation of N-S equation in curvilinear coordinate system.
5.	Understand the Computational Fluid Dynamics along with chemical engineering application.

Course Outcomes:
After the completion of this course, students will be able to:

CO324.1	Solve the Navier-Stokes equations
CO324.2	Use Finite Difference and Finite Volume methods in CFD modeling.
CO324.3	Generate and optimize the numerical mesh.
CO324.4	simplify a real fluid-flow system into a simplified model problem, to select the proper governing equations for the physics involved in the system, to solve for the flow, to investigate the fluid-flow behavior, and to understand the results.
CO324.5	Simulate simple CFD models and analyze its results.

SYLLABUS

MODULE	No. of Lecture Hours
Module 1: **Introduction**: Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Initial and boundary conditions, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation.	8
Module 2: **Principles of Solution of the Governing Equations:** Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, CFD and formulation. **Mesh generation**: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation.	8
Module 3: **Discretization**: Spatial discretization of a simple flow domain, Taylor's series expansion and the basis of finite difference approximation of a derivative; Central and one-sided difference approximations; Order of accuracy of finite difference, Finite difference approximation of pth order of accuracy for qth order derivative; Examples of high order accurate formulae for several derivatives, One-sided high order accurate approximations.	8
Module 4: **Solution Methods:** Discretization schemes for pressure, momentum and energy equations – Explicit and implicit Schemes, Solution methods of discretised equations - Tridiagonal matrix algorithm (TDMA) Application of TDMA for 2D problems potential flow - Stream and vorticity function. Unsteady flows - Crank Nicholson scheme, solution of Navier-Stokes equations.	8
Module 5: **CFD Solution Procedure:** Problem setup-creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. **Case Studies**: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.	8

Text Books:

1. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill (1998).
2. Muralidhar, K., and Sundararajan, T. Computational Fluid Flow and Heat Transfer, Narosa Publishing House (1995).

Reference Books:

1. Niyogi, P. Chakrabarty, S.K.. and Laha, M.K., Introduction to computational fluid dynamics, Pearson education (2006).
2. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor and Francis (1978).
3. S.K. Gupta, Numerical Methods for Engineers, New Age Publishers, 2nd Edition (1995).

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3

CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL363
Course title	Molecular Simulation
Pre-requisite(s)	Chemistry, Physics, Calculus, Numerical Methods in Chemical Engineering
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. E.
Semester / Level	VI
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students to:

1.	Understand the basic quantum chemistry.
2.	Learn the basics of molecular simulation methods.
3.	Design and run simulation of systems of interest.
4.	Estimate thermodynamic properties using molecular simulation packages.
5.	Analyse the systems using molecular modelling packages.

Course Outcomes:
After the completion of this course, students will be able to:

CO363.1	Apply the Density Functional Theory to Optimize the Geometry of Molecules.
CO363.2	Explain the basic principles of molecular Simulation.
CO363.3	Develop Simple Monte Carlo Simulation Code.
CO363.4	Develop Simple Molecular Dynamics Code.
CO363.5	Estimate physical properties of pure components using LAMMPS molecular dynamics package.

SYLLABUS

MODULE	No. of Lecture Hours
Module 1: Ab-initio Methods Schrodinger Wave Equation for one electron system, Schrodinger Wave equation for many electron system, Slater Determinant and Basis Set, HartreeFock Theory, Semi Empirical and Density Functional Theory, Geometry Optimization, Gaussian Job and Frequencies, Benchmarking of Geometry Optimization.	8
Module 2: Monte Carlo Simulation Introduction to Monte Carlo Simulation, Monte Carlo Integration, Periodic Boundary Conditions, Equilibrations, Monte Carlo Sampling, Markov Process and its applications, Metropolis Sampling, Principles of Detailed balance.	8
Module 3: Monte Carlo Simulation in Various Ensembles Simulation Strategy, NVT Ensemble, NPT Ensemble, NVE Ensemble, Grand Canonical Ensemble, Gibbs Ensemble, MC simulation of polymers, MC moves for polymer simulations.	8
Module 4: Molecular Dynamics Simulation Basics of Molecular Dynamics Simulation, Force Field, Integrating Algorithms, Periodic Box and Minimum ImageConvention, Long Range Forces, Non-Bonded Interaction, Simple Molecular Dynamics Program, Temperature Control, Pressure Control, Radial Distribution Function, Mean-square-displacement.	8
Module 5: Molecular Dynamics Simulation A case study using Molecular Dynamics with LAMMPS, Steps involved in LAMMPS, Input files in LAMMPS, Analysis of output files.	8

Text books:

1.Daan Frenkel, Berend Smit, Understanding Molecular Simulation: From Algorithms toApplications, 2e, Academic Press, New York, 2002.
2. M.P. Allen, D.J. Tildesley, Computer Simulation of Liquids, Clarendon Press, Oxford, 1987.

Reference books:

1. Andrew R. Leach, Molecular modelling: principles and applications, 2e, Pearson, New Delhi, 2001.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL362
Course title	Process Integration
Pre-requisite(s)	Basic knowledge of material and energy balances, fluid mechanics, heat and masstransfer phenomena, thermodynamics.
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	
Class	B. TECH.
Semester / Level	VI
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students:

1.	To understand the energy and mass targets in design of processes.
2.	To learn the integration of chemical processes to form an efficient system.
3.	To find the minimum heating and cooling requirements for a process.
4.	To explain the role of thermodynamics in process design.
5.	To critically assess any design changes to process.

Course Outcomes:
After the completion of this course, students will be able to:

CO362.1	Explain the concept of Process Integration.
CO362.2	Explain fundamentals of Pinch Technology.
CO362.3	Apply Pinch Technology.
CO362.4	Analyze Heat Exchanger Network using Composite Curves.
CO362.5	Analyze Heat Integration of Distillation Column using Composite Curves.

SYLLABUS

MODULE	No. of Lecture Hours
Module 1: Introduction to process Intensification andProcess Integration(PI), Areas of application and techniquesavailable for PI, onion diagram, Process Integration in Chemical Industries,Formulation of a Design Problem, Chemical Process Design and Integration, Hierarchy of Chemical Process Designand Integration, Continuous and Batch Processes, New Design and Retrofit, Approaches to Chemical Process Designand Integration, Process Control.	8
Module 2: Pinch Technology- Introduction, Basic concepts, how it is different fromenergy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology. Key steps of PinchTechnology: Concept of ΔT_{min}, Data Extraction, Targeting, Designing, Optimization-Supertargeting.	8
Module 3: BasicElements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.	8
Module 4: Targeting of Heat Exchanger Network, Designing of Heat ExchangerNetworks, Hot Composite Curve, Cold Composite Curve, Problem Table Algorithm, Grand Composite Curve, AreaTargeting by Uniform Bath formula and Unit Targeting by Euler's formula, Heuristics for Pinch Design, MaximumEnergy Recovery Design, Evolution of Network.	8
Module 5: Distillation Integration: Distillation sequencing, Heat Integration characteristics of Distillation column,appropriate placement of distillation column, various configurations for heat integration of distillation column, Distillation Sequencing for Azeotropic Distillation.	8

Text books:

1. Heat Exchanger Network Synthesis, U. V. Shenoy, GulfPublishing company.
2.Chemical Process Design, R. Smith, McGraw-Hill.

Reference books:

1. A UserGuide on Process Integration for the Efficient Uses ofEnergy, B. Linnhoff, D.W. Townsend, D Boland, G. F.Hewitt,B. E.A.Thomas, A. R.Guy, and R. H.Marsland, Inst. Of Chemical Engineers.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/ OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, and CD2
CD4	Mini projects/Projects	CO4	CD1
CD5	Laboratory experiments/teaching aids	CO5	CD1, and CD2

CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

In-Depth Specialization in Polymer Technology

COURSE INFORMATION SHEET

Course code	**CL 322**
Course title	**Macromolecular Science**
Pre-requisite(s)	**PH113,CH101,CH102**
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	VI / Third
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students to:

1.	Define chemical structure of polymer, classification and isomerism
2.	Describe the different molecular weight measurement techniques
3.	Illustrate the method and kinetics of polymerization
4.	Distinguish the types of polymerization techniques to manufacture polymers for specific use
5.	Compare the properties of copolymers with that of homopolymers in respect of monomer ratios

Course Outcomes
After the completion of this course, students will be able to:

CO322.1	Remembering:Show chemical structure of polymers,tell correlation between structure and properties,recall polymerization steps
CO322.2	Understanding: Outline Polymerization processes and compare different steps of synthesis by various mechanisms,interpret polymer solubillity interms of thermodynamics
CO322.3	Analyze:Given a set of polymers assess their suitability for specific use and application on the basis of chemical structure,solubility,degree of crystallinity
CO322.4	Evaluate:Given a specific set of requirements of polymer application recommend and select the most cost effective polymerization technique for production
C0322.5	Apply:Given a polymer, suggest the method of finding out molecular weight disribution,average molecular weight, degree of crystallinity

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: Introduction to macromolecule concept Classification of polymer. Polymer structure property relationship, Molecular forces and chemical bonding in polymer. Glassy to rubber transition in polymer. Molecular weight and Molecular weight distribution. Molecular weight determination by colligative properties, Ultracentrifuge, Light scattering, Solution viscometry, Gel permeation chromatography.	10
Module 2:Condensation Polymerization Principles of Step-reaction (condensation) polymerization. Mechanism of stepwise polymerization. Kinetics and statistics of linear stepwise polymerization. Polyfunctional step-reaction polymerization, Real Industrial processes.	5
Module 3: Addition Polymerization Principles of radical chain (addition) polymerization. Initiators and initiator systems. Kinetics of vinyl radical polymerization. Kinetics of copolymerization. Composition of copolymers. Mechanism of Copolymerization Mechanism and kinetics of ionic chain growth polymerization. Mechanism and kinetics of co-ordination polymerization. Mechanism and kinetics of ring opening polymerization. ATRP, Electrochemical Polymerization.	10
Module 4: Polymer Solutions Criteria for polymer solubility. Conformations of dissolved polymer chains. Thermodynamics of Polymer solutions. Phase equilibrium in polymer solutions. Fractionation of polymers by solubility. Polymerization techniques:Bulk, Suspension, Emulsion, Solution polymerization.	7
Module 5: Morphology of Polymers Crystal structure of polymer. Morphology of crystalline polymer. Crystallization and melting. Strain induced morphology. Mechanical properties of crystalline polymer. Viscous flow. Kinetic theory of rubber elasticity. Viscoelasticity.	8

Text Books: 1. Text book of polymer Science: Billimeyer F.W., 3rd Edn., Wiley Interscience, 1984
2. Principles of polymerization: G. Odian, 2nd Edn. Wiley Interscience New York, 1981
3. Polymer Chemistry, Sixth edition, Charles E. Carraher Jr. Marcel Dekker Inc, 2003.
4. Principles of Polymer Systems, Rodriguez, F, Taylor& Francis, 4th Edn., 1996.

Reference books:
1.Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. McGraw Hill, 1998.
2. The Element of Polymer Science & Engineering: Rudin.
3. Structural Investigation of Polymer: Bodor G., 1st Ed., Ellis Harwood Ltd., 1991.
4. Introduction to Polymer Science 3rd edition, L.H.Sperling, John Wiley and Sons 2001.

Gaps in the syllabus (to meet Industry/Profession requirements)

- Actual polymerization techniques used in industries may be learned by industrial visit

POs met through Gaps in the Syllabus:

PO11,PO9,PO2

Topics beyond syllabus/Advanced topics/Design

Details of manufacturing process of Polymers, Processing of polymers is presently beyond the scope of the syllabus

.

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3 and PO4

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
2	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
3	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
4	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
5	3	3	3	2	3	1	1	1	1	1	1	1	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD 1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD 2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD 3	Seminars	CO3	CD1, CD2, CD8
CD 4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD 5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD 6	Industrial/guest lectures		
CD 7	Industrial visits/in-plant training		
CD 8	Self- learning such as use of NPTEL materials and internets		
CD 9	Simulation		

<u>**COURSE INFORMATION SHEET**</u>

Course code	**CL 366**
Course title	**Polymer Technology - I**
Pre-requisite(s)	**CL213**
Co- requisite(s)	**PH113,CH101,CH102**
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	VI / Third
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students to:

1.	***Understand*** the structure property relationship of various plastics.
2.	***Explain***the importance of compounding ingredients in plastics and get detailed knowledge about the ingredients
3.	***Interpret*** the preparation, properties and application of various commodity plastics
4.	***Describe*** the preparation, properties and application of thermosets and engineering plastics and various copolymers
5.	***Apply*** the importance of structure property relationship to choose the materials for various applications

Course Outcomes

After the completion of this course, students will be able to:

CO366.1	**Remember:** Recall the preparation, properties and application of various commodity and engineering plastics
CO366.2	**Understand:**Explain preparation, properties and application of commodity and engineering plastics.
CO366.3	***Apply:*** Apply the importance of structure property relationship to choose the materials for various applications.
CO366.4	***Analyze:*** Categorize the methods of the preparation, properties and application of specific copolymers.
C0366.5	***Evaluate:*** Select additives for different plastics and formulate recipe for specific product manufacturing

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Additives for Plastics: Definition, classification, mechanism of action, method of incorporation of: fillers, coupling agents, plasticizer, cross linking agents, stabilizer, blowing agents.	8
Module 2 Additives for Plastics Definition, classification, mechanism of action of flame retardants, colorants: pigments and dyes, antistatic agents, antiblock agents, nucleating agents, toughening agent, lubricants	8
Module-3 Manufacturingprocess of Polymers: Flowsheet, processing application, major engineering problems of PE (LDPE, HDPE, LLDPE, XLPE, UHMHDEP), PTFE, PP.	8
Module-4 Manufacturing process of Polymers :Flow sheet, Properties, processing, applications, major engineering problems, economics and Indian scenario of Polyamides: nylon 6,nylon66, polyimides, Cellulosics	8
Module-5 Manufacturing process of Polymers properties, processing, applications of PS, PVC, PVOH, Acrylics, ABS, SAN, ionomers.	8

Text Books:

1. Plastics materials:BrydsonJ.A., 3rdEdn.,Butter worth, Woburn1975
2. Plastics Engineering Hand Book:FradosJ. Societyof plastic&Industruy.Inc. 4thEdn.,Van Nostrand,N.Y. 1976
3. The Roll of Additives in Plastics, Mascia, L., Edward Arnold, 1974
5. Hand Book of PlasticTestingTechnology, VishuShah, Wiley InterScience.

Reference books:

1. Functional Monomers and Polymers KiichiJakenioto, Raphael M, Ottenbrites, Mikhiarukamachi - Marcel Dekker.
2. Shreve‘s chemical processIndustries, GeorgeT. Sustin, McGrow Hill.
3. Unit process in Organicsynthesis, Groggins, P.H. McGrowHill.

Gaps in the syllabus (to meet Industry/Profession requirements)

Practical problems faced in industries during manufacturing of additive materials needs to addressed by industry personal

POs met through Gaps in the Syllabus:

PO11, PO9, PO4

Topics beyond syllabus/Advanced topics/Design

- Processing of plastics with emphasis on their flow properties in specific processing equipment under specific condition
- Analysis of flow characteristics of polymers during processing with respect to their chemical structure and properties

.

POs met through Topics beyond syllabus/Advanced topics/Design PO12,PO11,PO10

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO210.1	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO210.2	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO210.3	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO210.4	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3
CO210.5	3	3	3	3	1	1	1	1	1	2	2	2	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8

CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	**CL367**
Course title:	**Polymer Processing**
Pre-requisite:	**CL213,CL214**
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	**03**
Class:	**B.Tech.**
Semester / Level:	**06/3**
Branch:	**Chemical Engineering -Plastics & Polymer**
Name of Teacher:	

Course Objectives:

This course enables the students to:

1.	Outline the steps of specific process to manufacture a specific product, identify the various parts of the machine and explain the function of it
2.	Solve numerical problems on simple flow analysis for polymers during a specific processing,interpretation and analysis of rheological data using models for non-Newtonian fluids
3.	Predict the reasons behind specific product defect and propose probable solutions specific to processing technique
4.	Explain both practical and theoretical fundamentals of injection moulding and extrusion technology, including basic knowledge of the moulding process.
5.	Explain a wider range of polymer processes: thermoforming, compression and transfer moulding, rotational moulding, blow moulding, assembling techniques

Course Outcomes (CO)

After the completion of this course, students will be able to:

CO 367.1	Remembering: Choose the corresponding process to be used to manufacture a specific product from suitable polymers.
CO 367.2	Understanding: Compare the methods of different processing techniques for product manufacture with a given set of plastic materials for the specific use
CO 367.3	Apply: Apply most modern technology to modify the process variables on the existing machine to manufacture a specific plastic/ rubber/composite product
CO 367.4	Analyze: Inspect the defects in plastic products, examine the product quality in terms of machine parameters and list professional engineering solutions as remedies which will be sustainable and economical
CO 367.5	Evaluate: Explain processing difficulties and estimate numerical problems related to polymer processing

Syllabus

MODULE	No. of Lecture Hours
Module1 Rheology of Polymer melts, Viscosity models, Dependence of viscosity on Temperature, Pressure, molecular weight, Viscoelastic models. Extensional viscosity, Rheometers: Capillary, Rotational, cone & plate. Die swell.	8
Module2 Extrusion: Extruder Classification, Components- Drives, Bearing, Screw, Barrel, Breaker plate, Screen, hopper, Screw geometry, heating & cooling systems. Process analysis: Solids conveying, plasticating, melt conveying, Melt instabilities. Technology of product manufacturing: Pipe, Films, Wire coating, Tapes, Monofilaments.	10
Module3 Injection moulding – Moulding cycle. Machine construction – barrel, screw, nozzles, clamping system, Machine ratings, Basic mould construction – classification, sprue, runner, gate systems, mould cooling, ejection, Part cooling analysis, Effect of process variables on product quality. Special Injection Mouldings. Product defects and its remedies.	6
Module4 Classification, Machinery, process details, analysis, defects, remedies: Blow moulding, Thermoforming, Calendering..	8
Module 5 Classification, Machinery, process details, analysis, defects, remedies: Rotomoulding, Compression moulding and Transfer moulding.	8

Text Books:

1.Plastics Engineering, Crawford, R.J., Pergammon Press
2. Polymer Extrusion, Chris Rauwendaal, Hanser, 1994.
3. Plastics Product Design and Process Engineering, H. Belofsky, Hanser, 1995.
4. Blow Moulding Handbook, Rosato, D.V. and Rosato D.V., Hanser, 1989.
5. Plastic Extrusion Technology, Hensen, Hanser, 1997.
6. Polymer processing,D.H.Morton-Jones,Chapmman&Hall,New York,1989,

Reference books:

1. Principles of Polymer Processing, Tadmor, Z and Gogos, C.G., John Wiley and Sons, 1982.
2. Plastics: Product Design and Process Engineering, Belofsky, H., Hanser Pub. 1995.
3. Fundamentals of Polymer Processing, Middleman, Mc Graw Hill, 1979.
4. Rotational Moulding Technology, R.J Crawford and J.L.Throne, William Andrew publishing, 2002

5. Thermoforming, J.L.Throne, Hanser, 1987

Gaps in the syllabus (to meet Industry/Profession requirements)

- Guest lecture by Industry Personnel
- Mini project on Problems given by Industries

POs met through Gaps in the Syllabus

PO5,PO3

Topics beyond syllabus/Advanced topics/Design

Joining of Plastics Foam Processing, Metalizing, Machining Hot Stamping Adhesive Bonding, Mechanical fastening, mould design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2
CO2	1	2	3	3	3	2	2	2	1	1	2	3	2	3	3
CO3	2	1	1	1	1	3	2	3	1	2	1	2	3	2	1
CO4	1	2	3	3	3	2	2	2	1	1	2	3	2	3	3
CO5	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method Used**
CD1	Lecture by use of boards/LCD projectors/ OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, and CD2
CD4	Mini projects/Projects	CO4	CD1
CD5	Laboratory experiments/teaching aids	CO5	CD1, and CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: **CL368**

Course title: Polymer Technology-II

Pre-requisite(s): **CL213, CL214**

Co- requisite(s): **Nil**

Credits: L: 03 T: 00 P: 00

Class schedule per week: **03**

Class: **B. Tech.**

Semester / Level: **06/3**

Branch: **Chemical Engineering- Plastics and Polymer**

Name of Teacher:

Course Objectives: This course enables the students to:

1	Define the properties on thermoplastic and thermoset resins.
2	Interpret the properties of engineering polymer and functional polymer
3	Classify the polymer in different application.
4	Predict the properties of polymer for certain applications
5	Synthesize polymer for a specific applications

Course Outcomes: After completion of the course, learner will be able to:

CO 368.1	Remembering:Relate properties of given thermoplastic and thermoset resins to chemical structures, recall industrial manufacturing processes of polymers suitable for different applications.
CO 368.2	Understanding: Summerize the mechanical, thermal etc. properties of engineering polymer and functional polymers
CO 368.3	Apply:Choose specific polymer for a given product application.
CO 368.4	Analyze:Compare the polymers in a given list in terms of their structure-property relationship and classify according to specific applications and product manufacturing techniques.
CO 368.5	Evaluate:Assess the performance of given polymer product in terms of standard testing methods and decide on the suitability of it for specific application

Syllabus

MODULE	No. of Lecture Hours
MODULE- I Thermosets: Phenol-formaldehyde resins, Urea-formaldehyde, Melamine-formaldehyde, alkyl & aryl epoxies, polyurethanes, silicones, Unsaturated Polyester	**8**
MODULE- II High performance thermoplastics: thermoplastic Polyesters- PET, PBT, Polycarbonate, Polyacetal, Polyphenylene oxide, sulfone polymers, Polyphenylene sulfide, Polyether Ketones, liquid crystal polymers, polybenzimidazole.	**10**
MODULE- III Plastics in automobile industries, home appliances, building construction, film packaging, biomedical application, electronic application, cable application, agriculture application, space and defence application.	**8**
Module-IV: Polymer Blends: Definition, difference between polymer blends and alloys, classification of polymer blends and alloys, principle of polymer compatibility, miscibility effect of molecular structure on polymer-polymer interaction, thermodynamics of polymer-polymer mixing, Rheology of Polymer Blends, Blend morphology & characterization**.**	**7**
Module-V: Polymer composite systems: Types of composites, reinforced thermoplastic, thermoset, elastomerProcessing techniques - open mould, hand layup, spray up, vacuum bag moulding, pressure bag moulding, autoclave moulding, closed mould, SMC, DMC, RTM. Continuous manufacturing process - pultrusion, filament winding, centrifugal casting.	**7**

Text Books:

1. Plastic Materials: Brydson J.A. 3rd Edn. Butterworth Woburn, 1975
2. The Roll of Additives in Plastics, Mascia,L., Edward Arnold, 1974
3. Functional Monomers and Polymers KiichiJakenioto, Raphael M, Ottenbrites, Mikhiarukamachi - Marcel Dekker.

ReferenceBooks:

1. Plastics Engineering Hand Book:FradosJ. Societyof plastic&Industruy.Inc. 4^{th}Edn., Van Nostrand,N.Y. 1976
2. Shreve‘s chemical processIndustries, GeorgeT. Sustin, McGrow Hill.
3. Unit process in Organicsynthesis, Groggins, P.H. McGrowHill.
4. Hand Bookof PlasticTestingTechnology, VishuShah, Wiley InterScience.

Gaps in the syllabus (to meet Industry/Profession requirements)

- Guest lecture by Industry personnel
- Industry visit

- Project work on problems/topics given by industries

POs met through Gaps in the Syllabus
PO5, PO3,PO10

Topics beyond syllabus/Advanced topics/Design
Photo responsive polymers, Ion conducting polymers, bio polymers (proteins, nucleic acids, polysaccharides), Piezoelectric polymers, Inorganic polymers, biodegradable polymers, Magnetic polymers

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1,CO4,CO3,CO5,CO2	CD1
CD2	Tutorials/Assignments	CO2,CO5,CO4,CO3	CD1
CD3	Seminars	CO3,CO4,CO5,CO2	CD1 and CD2
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Minor in Chemical Engineering

COURSE INFORMATION SHEET

Course code	CL216
Course title	Unit Operation-I
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	V
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students to:

1.	Calculate Mass and Energy Balances over various chemical engineering Equipments.
2.	Learn numerous industrial operations dealing with the particulate solids along with fluids.
3.	Develop an understanding of basics of mechanical operations.
4.	Understand size analysis, size reduction and working principle of associated equipment used for size reduction.
5.	Understand solid-liquid and liquid-liquid mechanical separation.

Course Outcomes:
After the completion of this course, students will be able to:

CO216.1	Estimate mass balance over various unit processes.
CO216.2	Estimate energy balance over various unit processes.
CO216.3	Explain/Estimate various characterisation of solid particles.
CO216.4	Explain various solid handling Equipments.
CO216.5	Classify various solid-solid/solid-fluid separation processes.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module-1: Introductory concepts of units, Mole Concept, Basisof calculations, Introduction to Material Balance, Material Balance problems without chemical reaction.Material Balance with chemical reaction, Material Balances with recycle, bypass and purge. Energy balance: open and closed system, heat capacity, calculation of enthalpy changes, Energy balances with chemical reaction: Heat of reaction, Heat of combustion.	8
Module 2: Characterization of solid particle:Particle Shape, Particle size,Mixed Particle sizes and Size analysis, Specific Surface of mixture, Average Particle Size, Number of Particles in Mixture, Screen Analysis, Screening: Stationary screens and Grizzlies, Gyrating Screens, Vibrating Screens, Comparison of Ideal and Actual Screens, Material Balance over Screen, Screen Capacity and Effectiveness.	8
Module 3: Size Reduction: Principles of Comminution, Crushing efficiency, Rittinger's law, Kick's law, Bond's law, Work index, Size-Reduction Equipment: Jaw Crushers, Gyratory Crusher, Roll crushers; Grinders-hammer Mill, Ball Mill, Rod Mill, Fluid Energy Mill, DryandWetGriding, Open-circuit and closed-circuit operation.	8
Module 4: Filtration: Theory of solid-liquid filtration, principle of filtration, constant pressure and constant ratefiltration, compressible and incompressible cakes, Filter aids, Equipment of liquid-solid filtration, Batchand continuous pressure filters. Theory of centrifugal filtration, Equipment for centrifugal filtration.	8
Module 5: Gravity Settling process- Gravity Classifiers, Sorting Classifiers, Clarifiers and Thickeners, Flocculation, Batch Sedimentation, Clarifier and Thickener design, Centrifugal Settling Processes: Cyclones, Hydro-cyclones, Centrifugal Decanters: Centrifuges for solid-liquid and liquid-liquidSeparation, Principles of Centrifugal Sedimentation.	8

Text books:

1. D. M. Himmelblau, J. B. Riggs, Basic Principles and Calculations in Chemical Engineering, Eighth Ed., Pearson India Education Services, 2015.

2. Unit Operations of Chemical Engineering, McCabe Smith, Julian C. Smith, P. Harriot TMH, 5th Edn.

3.Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.

Reference books:

1. Introduction to chemical engineering. Walter L. Badger and Julius T. Banchero. McGraw-Hill book company, Inc., New York (1955).

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3

CO2	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3
CO3	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3
CO4	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3
CO5	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD7, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD7, CD8
CD3	Seminars	CO3	CD1, CD2, CD7, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD7, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD7, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

Course Information Sheet

Course code: CL341

Course title: Fundamentals of Chemical Reaction Engineering

Pre-requisite(s): CL204 Chemical Process Calculations

Co- requisite(s):

Credits: 3 (L: 3 T: 0 P: 0)

Class schedule per week: 3

Class: B. Tech.

Semester / Level: V/ Third

Branch: Chemical Engineering

Name of Teacher:

Course Objectives

This course enables the students to:

1.	Describe basic concept of kinetics and rate laws.
2.	Explain the characteristics of homogeneous and heterogeneous reactions.
3.	Analyse kinetic data.
4.	Describe the effect of heating on performance of non-isothermal reactors.
5.	Explain RTD in reactors.

Course Outcomes

After the completion of this course, students will be able to:

CO341.1	Explain the concepts of Kinetics and Rate Laws.
CO341.2	Analyze ideal Reactors for homogeneous reactions.
CO341.3	Determine rate constant, reaction order and reactor volume using the kinetic data.
CO341.4	Analyze the characteristics of non-isothermal and heterogeneous reactions
CO341.5	Analyze the non-ideality of real reactors.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module-1: Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity. Elementary and non-elementary reactions, molecularity and order of reaction, effect of process variables on rate of reaction, reaction rate fundamentals – elementary reaction sequences, steady state approximation and rate limiting step theory.	8
Module 2: Ideal reactors - generalized material balance, design equations, graphical interpretation. Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors – solving design equations for constant and variable density systems, reactors in series and parallel.	8
Module 3: Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis. Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions. Non-isothermal reactions: steady and unsteady state tubular reactor with heat exchange, CSTR with heat effects, multiple steady states.	8
Module 4: Introduction to homogeneous and heterogeneous catalysis; Reaction mechanisms, Rate equation; Factors affecting heterogeneous catalytic reaction; Physical and chemical adsorption, Adsorption isotherms, Types of catalytic Reactor and their performance equations; Related Problems. Determination of Catalyst surface area and particle size; Pore volume Distribution;	8
Module 5: Non-ideal reactor**:** Residence time distribution **(**RTD) theory, role of RTD in determining reactor behaviour, age distribution (E) of fluid, experimental methods for finding E, relationship between E and F curve; Models for non- ideal flow – single parameter and multi parameter models.	8

Text books:

1. Fogler H. S., "Elements of Chemical Reaction Engineering", 4thEd., Pearson-Prentice Hall.

2. Levenspiel O., "Chemical Reaction Engineering", 3rdEd., John Wiley and Sons.

3. Chemical Engineering Kinetics, J. M. Smith

4. Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.

Reference books:

1. Schmidt L. D., "The Engineering of Chemical Reactions", 2nd Ed., Oxford University Press.

Gaps in the syllabus (to meet Industry/Profession requirements) POs

met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO302.1	3	3	3	2	2	2	1	1	1	2	1	2	3	2	2
CO302.2	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO302.3	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO302.4	3	3	3	2	2	2	2	1	2	2	1	2	3	2	2
CO302.5	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL217
Course title: Unit Operation II
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech.
Semester / Level:
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

A.	Understand the basic principles of fluid mechanics.
B	Describe mass and momentum balance equations.
C	Learn basic principles of fluidization engineering and its application in chemical engineering.
D.	Acquire knowledge on basic principles of Heat transfer.
E.	Design heat transfer equipments.

Course Outcomes:
After the completion of this course, students will be able to:

CO217.1	Identify and describe the fluid static mechanisms, concept of pressure, pressure measuring device, flow rate measuring device.
CO217.2	Apply mass and momentum balance equation to solve various engineering problems.
CO217.3	Describe fluidization and its applications.
CO217.4	Explain the basic principles of heat transfer: Conduction, Convection and Radiation.
CO217.5	Design different types of heat transfer equipments.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction to fluids, Continuum hypothesis, Forces on fluids, Normal and shear stresses, Fluid statics - pressure distribution, Manometer, Kinematics of fluid flow- Eulerian and Lagrangian descriptions, Flow visualization, Stream function.	5
Module 2:	12

Reynolds transport theorem, Integral balances - mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Differential analysis: mass and momentum balances, Navier-Stokes equation, Unidirectional flow, Viscous flow, Transportation of fluids - pumps, selection and design of pumps	
Module 3: Solid particle characterization: Particle size, shape and their distribution; Relationship among shape factors and particle dimensions; Specific surface area; Measurement of surface area, Fluidization: Fluidized bed, minimum fluidization velocity, pressure drop, Geldart plot etc. Types of fluidization: Particulate fluidization, Bubbling fluidization, Classical models of fluidization, Circulating fluidized beds, Applications of fluidization	7
Module 4: Basic Principles of heat transfer: Conduction, Convection and Radiation, Finding the heat transfer coefficients, concept of overall heat transfer coefficient.	5
Module 5: Basic Principle of heat exchanger, Design of heat exchanger, Basic Principle of evaporator, Different types of evaporator.	11

Text books:

1 McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill.
2 Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.
3 Fox and McDonald's, Introduction to fluid Mechanics,8th edition.
4 Coulson and Richardson's Chemical Engineering, Vol. 6, Butterworth-Heinemann, Fifth edition 2002.

Reference Books:

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL343
Course title: Unit Operation III
Pre-requisite(s):
Co- requisite(s): NIL
Credits: L: 3 T: 1 P: 0
Class schedule per week: 04
Class: B. TECH.
Semester / Level: VII
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand the basic principle of mass transfer operation and its application.
2.	Explain various separation processes.
3	Understand gas-liquid contact process and design absorption column.
4.	Describe the distillation process and its applications.
5.	Describe various membrane separation processes.

Course Outcomes:
After the completion of this course, students will be able to:

CO343.1	Understand the basic principles of mass transfer operation.
CO343.2	Design separation unit for the gas-liquid and gas-solid operations.
CO343.3	Solve engineering problems related to distillation, drying and humidification.
CO343.4	Identify suitable solvent/sorbent for particular liquid-liquid or solid-liquid extraction operation and solve related problems.
CO343.5	Theoretical and analytical knowledge on crystallization and membrane separation processes and their engineering applications.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: **Basic Principles:** Principles of molecular diffusion and diffusion between phases, Fick's Law, Diffusivity, equation ofcontinuity, Diffusion in solids. Concept of Mass transfer coefficient, correlation of mass transfer coefficients, Theories of Mass Transfer, mass transfer acrossinterfaces, Analogy between momentum, heat and mass transfer.	8
Module 2: **(A)Absorption:** Introduction, The mechanism of absorption, equipment for Gas Liquid contact. Concept of HTU, NTU, HETP. Tray efficiency. Gas-liquid absorption calculation. **(B)Adsorption:** Introduction, nature of adsorbents, batch adsorption, Adsorption isotherms. Adsorption equipment,pressure swing, thermal-swing, breakthrough curves. gas-solid adsorption calculation.	8
Module 3: **(A) Distillation** Introduction, Vapor -liquid equilibria, Relative volatility, Ideal and non -ideal solutions. Batch, differential and equilibrium distillation, Design calculation of distillation column with special emphasis on McCabe-Thielemethod, importance of reflux ratio. **(B) Humidification** Humidification and dehumidification operations, Psychometricchart, Adiabatic saturation curves etc. Cooling towers and their classification. **(C) Drying** Introduction to drying, Batch drying mechanism, Drying rate curve. Drying time calculation, different types of drying equipment and their classification.	8
Module 4: **(A) Liquid-Liquid Extraction** Introduction to liquid-liquid extraction, liquid- liquid equilibria, triangular diagram, selectivity and choice ofsolvents, stage wise contact, co-current & counter-current extractor, design calculation for stage wise liquid-liquid extraction, extraction efficiency. **(B) Solid-Liquid Extraction** Introduction to solid-liquid extraction, general principle, factors affecting the rateof extraction, liquid -solid equilibria, solid-liquid extraction calculation.	8
Module 5: **(A) Crystallization** Introduction to crystallization, Theory of Crystallization, Formation and growth of crystals, crystal yield,Rate of crystallization.	8

(B)Membrane Separation Introduction to membrane separation, classification of membrane, characterization of membrane. Mambrane modules, pressure-driven and concentration driven membrane separation processes.	

Text books:

1. Mass Transfer Operations: Treybal R.E., Mc Graw Hill, 1981
2. Unit Operations of Chemical Engineering: Mc Cabe W.L.and Smith J.C., Mc Graw Hill.5th Ed. 1993.
3. Principles of Mass Transfer and Separation Processes,BinayK.Dutta, 2nd edition, Prentice Hall of India,2007.
4. Transport proceses and Separation Process Principles, C.J.Geankoplis, Prentice Hall of India, 4th Ed. 2004

Reference books:
1. Separation Process Principles-Chemical and Biochemical Operations, J. D. Seader, Ernest J. Henley, D. Keith Roper, 3rd Ed., John Wiley & Sons, Inc.

Gaps in the syllabus (to meet Industry/Profession requirements)
Design of mass transfer operation equipments

POs met through Gaps in the Syllabus
PO4, PO9 and PO12

Topics beyond syllabus/Advanced topics/Design
Design of mass transfer equipment, recent advances and design for special cases

POs met through Topics beyond syllabus/Advanced topics/Design
PO2, PO3, PO4, PO5, PO9 and PO12

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2
CO2	1	2	3	3	3	2	2	2	1	1	2	3	2	3	3
CO3	2	1	1	1	1	3	2	3	1	2	1	2	3	2	1
CO4	1	2	3	3	3	2	2	2	1	1	2	3	2	3	3
CO5	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/ OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, and CD2
CD4	Mini projects/Projects	CO4	CD1
CD5	Laboratory experiments/teaching aids	CO5	CD1, and CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

PROGRAMME ELECTIVE 1 (PE-1)

COURSE INFORMATION SHEET

Course code	CL221
Course title	Energy Engineering
Pre-requisite(s)	Basic Chemistry and Physics
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	IV
Branch	Chemical Engineering/OPEN Elective
Name of Teacher	

Course Objectives:
This course enables the students to:

1.	Understand global energy resources, demand and basic principles of waste heat recovery.
2.	Learn the principles and technologies of conversion of conventional energy resources to useful energy forms and products.
3.	Learn principles and technologies of conversion of non-conventional renewable energy resources to devices and various energy forms.
4.	Understand various renewable energy technologies and systems.
5.	Equip the students with knowledge and understanding of various possible mechanism about renewable energy projects.

Course Outcomes:
After the completion of this course, students will be able to:

CO 221.1	Explain various energy sources, their availability, importance of energy conservation & audit and available energy conservation technologies.
CO 221.2	Describe fundamental concepts of conversion technologies of conventional energy resources such as coal, petroleum and gaseous fuels and their utilization.
CO 221.3	Explain principles and technologies of conversion of renewable energy resources to various other energy forms.
CO 221.4	Acquire the knowledge of modern energy conversion technologies.
CO 221.5	Assess major energy issues and challenges of the 21^{st} century.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Introduction to Energy Science and Energy Technology; Global Energy sources and their availability. Prospects of Renewable energy sources; Energy conservation: Principle of energy conservation and Energy audit. Energy conservation Technologies – Co generation, waste heat utilization, Heat recuperates, Heat regenerators, Heat pipes, Heat pumps Energy storage.	8
Module 2 **Solid Fuels**: Introduction of solid fuels. COAL: Origin, reserves, classification & ranking, analysis, testing, storage; Coal carbonization: LTC, HTC, Ovens and Retorts; By-products recovery; Burning of coal and firing mechanism; fluidization combustion boilers **Liquid Fuels:** Constitution of petroleum, theory of formation of crude, characterization of crude oil & petroleum fuels, operation and flow-sheet of crude distillation, catalytic cracking, coking, vis-breaking and reforming processes, Process of a typical Indian refinery.	8
Module 3 **Gaseous Fuels:** Physico-chemical principles, Calorific Value, Wobbe index, flow-sheet and burners and furnace operation of: Producer gas, Water gas, Carbureted water gas, oil gas, coke-oven gas, blast furnace gas, Natural Gas and LPG. Mechanism and principle of combustion. Laminar flame propagation, theory & structure of flame. Burning velocity & its determination. Diffusion of flame & Flame stabilization. **Nuclear energy**: Nuclear reactions, Nuclear Fuels and reactors, power generation. Global, Indian Scenario.	8
Module 4 **Alternate Energy-I** **Geothermal energy:** Introduction, Resources and Utilization of Geothermal energy, Different types of Geothermal Electric power plant and their operations for Geothermal Energy systems in India. **Wind Energy:** Fundamentals and application, Wind Energy conversion system, Performance of wind machines, Electricity generation for wind. **Hydrothermal Energy:** Types, principle of operation **Bio Energy:** Biomass conversion for fuels; production methods based on thermochemical and bioconversion. Characteristics and uses; **Energy from the oceans:** Introduction Ocean Energy conversion Technologies. Types of Ocean Thermal Electric Power Generation system and their operation. Tidal power plant.	8
Module 5 **Alternate Energy-II**	8

Solar Energy: Solar radiation & its measurement, different types of solar collectors. Solar energy devices: solar photovoltaic cells, solar thermal power plants and other; storage system & application of solar energy. **Fuel cell:** Introduction, design & principle operation of fuel cell, classification of fuel cells Applications and recent advances **Hydrogen energy:** Introduction, production of hydrogen energy: electrolysis, thermo-chemical, Biotechnology methods etc. Hydrogen storage & transportations. Safety & management. Hydrogen technology development in India.	

TEXT BOOKS:

1. S. Rao and Dr. B.B. Parulekar, *Energy Technology, Non-convential, Renewable and Conventional*, Khanna Publishers.
2. G.D. Rai, *Non-conventional Energy Sources*, Khanna Publishers
3. S. Sarkar, *Fuels and Combustion*. Sangam books Ltd

Reference Books:

1. J. Brame and King, *Fuels: Solid, liquid and gaseous fuels,* Kessinger Publishing, LLC, 2007.
2. D.S. Chauhan and S.K. Srivastava, *Non- Conventional Energy Resources*, New Age International Pvt Ltd.
3. G.N. Tiwari, *Fundamentals of Renewable Energy Sources*, Narosa Publishing House.

Gaps in the syllabus (to meet Industry/Profession requirements)
Design of energy conversion devices for specific plant requirements

POs met through Gaps in the Syllabus
PO2, PO3, PO4, PO5 and PO9

Topics beyond syllabus/Advanced topics/Design
Recent advances in new energy resources, new production technologies and design of energy power plants

POs met through Topics beyond syllabus/Advanced topics/Design
PO2, PO3, PO4, PO7, PO8, PO9 and PO12

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3
CO5	3	1	3	3	3	3	3	3	3	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL222
Course title:	Pollution control and equipment design
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L:3 T:0 P:0
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Impart knowledge on different types of environmental pollution.
2.	Impart knowledge on designing of various types of equipments to control different types of pollution
3.	Learn the concepts behind industrial waste characterization, treatment and disposal.
4.	Understand the science and technology associated with pollution control and monitoring.
5.	Describe methods of advanced effluent treatment.

Course Outcomes:
After the completion of this course, students will be able to:

CO 222.1	Explain legislative aspects including water act, Air Act and effluent standards.
CO 222.2	Explain air pollution sources, air pollutants & their effects, working principle of Air pollution control equipments and their design.
CO 222.3	Describe water pollution sources, water pollutants & their effect, terms related with water pollution and working principle of primary equipments and their design.
CO 222.4	Explain conventional and advanced methods for waste water treatment.
CO 222.5	Explain solid waste collection, disposal and treatment methods.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Types of environments and their pollutants. Classification of pollutants, Legislative aspects including water act. 1974, Air Act 1981 and effluent standards. Air pollution: Sources and effects of different air pollutants, Sampling and analysis of air pollutants.	5
Module 2: Design and working principle of Air pollution control equipments: gravitational settling chambers, Cyclone Separator, ESP. Selection criteria of particulate collector. Dispersion of air pollutants and solutions to the atmospheric dispersion equation. Control of gaseous emission with special reference to Sulphur dioxide, Nitrogen oxide, carbon monoxide and hydrocarbons. Design of gaseous emission controlling equipments: Gas absorption, Adsorption, burners etc.	12
Module 3: Water pollution: Sources, sampling. Classification of water pollutants & their effect. BOD, COD, SS, TS, TDS etc. Primary Treatment- Design of Sedimentation tank, Floatation.	5
Module 4: Biological Treatment of wastewater: Design of activated sludge treatment system, trickling filter. Facultative ponds, aerobic and anaerobic ponds, etc. Advanced Treatment: microstraining, coagulation and filtration, sonoluminiscence, adsorption, Ion exchange, solvent extraction, stripping, Membrane Separation techniques – ultrfiltration, Reverse osmosis, electrodialysis etc.	8
Module 5: Solid waste management, Sources and classification, public health aspects, Methods of collection and disposal methods: open dumping, landfill, incineration, composting, vermiculture; Solid waste management using bioremediation for specific pollutants like chromium. Mercury, ammonia / urea, phenolic sludge. Incinerator Design.	10

Text books:

1 Environmental Pollution Control Engineering – C S Rao, New age
2 Pollution Control in process industries – S.P.Mahajan
3 Introduction to Environmental Engineering – Connwell&Devis. TMH.

Reference books:

1 Wastewater treatment for pollution control – S.J.Arceivala, TMH

2 Air Pollution – Rao,
3 Wastewater Engg. – Metcalf & Eddy, TMH
4 Standard Methods APHA /AWWA

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	0	0	1	1	3	3	3	3	3	1	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	1	2	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	1	2	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	1	2	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	1	2	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL223
Course title:	COLLOID AND INTERFACIAL ENGINEERING
Pre-requisite(s):	Elective Course after VIth semester. To have undertaken a course In chemical thermodynamics and a basic physical chemistry.
Credits:	L:03 T:00 P:00
Class schedule per week:	03
Class:	B. TECH.
Semester / Level:	07/04
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Remember: Define the chemical structure of different surfactants
2.	Understand: Describe the different intermolecular forces in colloidal system
3.	Apply: Illustrate the method of measurement of surface and interfacial tension
4.	Analyse: Analyse the intermolecular forces for a given system
5.	Evaluate: Given a set o specification formulate the system

Course Outcomes:
After the completion of this course, students will be able to:

CL223.1	Remember: Define the preparation and properties of colloidal system
CL223.2	Understanding: Illustrate the different intermolecular forces in colloidal system.
CL223.3	Applying: Identify the method of measurement for given colloidal system.
CL223.4	Analyzing: Illustrate the stability of the given colloidal system.
CL223.5	Evaluating: Recommend a suitable compositions for specific application.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction to colloidal material, surface properties, origin of charge on colloidal particles, preparation & characterization of colloidal particles. Measurement of Zeta potential.	5
Module 2: Theory of surfactants. Surfactants type (Anionic, cationic, Zwitterionic, Gemini and non-ionic). CMC. Kraft temperature. Surfactant geometry and packing. Phase behavior of concentrated surfactant systems. Emulsions, Microemulsions & Gels. Foams and Flotation.	7
Module 3:	8

Intermolecular Forces, Van-der-waals forces (Kessorn, Debye, and London Interactions). Potential energy curve, Brownian motion and Brownian Flocculation. Electrical phenomena at interfaces (Electronic kinetic phenomena, Electric double layer, short range forces). DLVO theory, capillary hydrostatics . thin film. Electro osmosis phenomena, Streaming potential, Electro viscous flows.	
Module 4: Measurements of Surface tension and Interfacial Tension. Surface tension for curved interfaces. Surface potential between two flat surfaces. Surface potential between one flat and one curve surfaces, Surface excess and Gibbs equation,	6
Module 5: Contact angle and its measurement, Wetting, Young-Laplace equation, Dynamic properties of interfaces. Surface viscosity, Kelvin equation. Adhesion, wetting, nucleation, flotation, patterning of soft material by self – organization and other techniques	9

TEXT BOOKS:

1. A.W. Adamson and A.P Gast, Physical Chemistry of surfaces, Wiley Interscience , NY 1997 and surface.
2. P.C Hiemenz and R.Rajgopalam, Principle of colloid and surface Chemistry 3rd edition Marcel Dekker Inc, 1997.
3. D.J.Shaw, Colloid and surface chemistry, Butterworth Heineman, Oxford,1992.
4. Jacob N. Israelachvili, Intermolecular and Surface Forces, Academic Press, 1992 or later editions

REFERENCE BOOKS:

1.Foundations of Colloid Science, Robert J. Hunter, Clarendon, Oxford, Volumes 1 & 2, 1989.
2.Colloidal Dispersions, W. B. Russel, D. A. Saville and W. R. Schowalter, Cambridge University Press, 1989.
3.Interfacial Forces in Aaqueous Media, Carel J. van Oss, Marcel Dekker or Taylor & Francis, 1994.
4. Drew Myers, Interfaces, and Colloids: Principles and Applications, Wiley, Second Edition, 2002.

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL224
Course title:	Analytical Instrumental Methods
Pre-requisite(s):	Core Course after IIIrd semester
Co- requisite(s):	
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	03
Class:	B. TECH.
Semester / Level:	04
Branch:	Chemical Engineering
Name of Teacher:	Dr Akhil Kumar Sen

Course Objectives:
This course enables the students to:

1.	Remember: Recite the different interactions of light with matter for chemical structure determination
2.	Understand: Summarize the different chromatographic techniques for separations of organic compounds
3.	Apply: Illustrate the microscopic techniques for materials characterization
4.	Analyze: Classify different spectroscopic techniques for structural determination
5.	Evaluation: Given a sample identify the structure and properties of the materials

Course Outcomes:
After the completion of this course, students will be able to:

CO 224.1	Remember: Describe the different spectroscopic techniques for chemical structure determination
CO 224.2	Understand: Discuss the different chromatographic techniques for organic compounds
CO 224.3	Apply: Given a sample assess the physical and chemical characteristics.
CO 224.4	Analyze: Outline the working principles of various microscopy.
CO 224.5	Evaluation: Applying different instrumental techniques evaluate its properties

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1:-Spectroscopic methods (Absorption UV-VIS, NIR, IR, Raman, AAS), Emission Spectroscopy (fluorescence, phosphorescence), $_1H^1$, C^{13} NMR basic principles, Electron spin resonance spectroscopy, Mass spectroscopy.	8
Module 2:-Chromatography: Principles and Applications of High Performance Liquid Chromatograpy and High Performance Thin Layer Chromatography, Gas Chromatography, Affinity Chromatography, Pyrolysis Gas Chromatograph. Electrochemical analysis.	8
Module 3: Opticalmicroscopy, Electron microscopy – TEM, SEM, Principle, Instrument, Specimen preparations, applications. Energy Dispersive Spectroscopy (EDS), Auger Electron spectroscopy(AES). Electron scanning chemical analysis (ESCA).	8
Module 4: Light Scattering,Principle of X Ray Scattering, Application of WAXS and SAXS, Degree of Crystallinity (Ruland's method), Crystallite size analysis.	8
Module 5:- Principle, Instrument, and application - Differential Scanning Calorimetry(DSC), Differential thermal analysis (DTA), Thermogravimetric analysis (TGA), Dynamic mechanical thermal analysis (DMTA).BET surface area, Physisorption and Chemisorption.	8

TEXT BOOKS:

1SKOOG, D. A., HOLLER, F. J., CROUCH, S. R. (2007). Principles of instrumental Analysis, 6. ed., Belmont: Thomson Brooks/Cole. ISBN-10: 0495012017
2. David Harvey, Modern Analytical Chemistry, McGraw Hill Co. 2000

3. Helmut Gunzlar and Alex Williams (Edited), Hand book of Analytical Techniques, Wiley VCH 2001.
4 https://en.wikipedia.org/wiki/List_of_chemical_analysis_methods

5 https://en.wikipedia.org/wiki/List_of_materials_analysis_methods

REFERENCE BOOKS:

1. Text book of polymer Science: Billimeyer F.W., 3rd Edn., Wiley Interscience, 1984
2. Principles of Polymer Systems, Rodriguez, F, Taylor& Francis, 4th Edn., 1996.
3. Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.

4. Structural Investigation of Polymer: Bodor G., 1st Ed., Ellis Harwood Ltd., 1991.
5. Introduction to Polymer Science 3rd edition, L.H.Sperling, John Wiley and Sons 2001

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	2	2	3	2	1	1	3	3	1	3	3	3	3
CO2	3	3	2	2	3	2	1	1	3	3	1	3	3	3	3
CO3	3	3	2	2	3	2	1	1	3	3	1	3	3	3	3
CO4	3	3	1	1	3	1	1	1	3	3	1	3	3	1	3
CO5	3	3	1	1	3	1	1	1	3	3	1	3	3	1	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD5, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD5, CD8
CD3	Seminars	CO3	CD1, CD2, CD5, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD5, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD5, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL225
Course title	Fluid-Solid Operation
Pre-requisite(s)	Fluid Mechanics, Mechanical Operation
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	IV
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students to:

1.	Understand the basic principles of fluid-particle operations.
2.	Learn the concepts of the various industrial operations involving particulate solids.
3.	Describe the fundamentals of fluid-particle mechanics.
4.	Understand practical aspects for industrial application.
5.	Explain the handling of particles along with fluids in various unit operations.

Course Outcomes:
After the completion of this course, students will be able to:

CO.225.1	Explain the Flow around immersed bodies.
CO.225.2	Estimate drag force and terminal settling velocity for single particles.
CO.225.3	Estimate Pressure drop in fixed and fluidized beds.
CO.225.4	Classify various solid-solid/solid-fluid separation processes.
CO.225.5	Describe the mechanical separation process of fine particles from fluid.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction: Solid particle characterization, Flow around immersed bodies: Concept of drag, boundary layer separation, skin and form drag, drag coefficients, Streamlining, Stagnation point, Stagnation Pressure.	8
Module 2: Motion of particles through fluids: Mechanics of Particle Motion, Equations for 1-D motion of particle through fluid, Motion from gravitational force, Motion in a centrifugal field, Terminal Velocity, Drag Coefficient, Motion of spherical particles, Criterion for settling regime, Hindered Settling. Packed bed: Void fraction, superficial velocity, channeling, Ergun equation and its derivation, Kozeny Carman equation, Darcy's law and permeability.	8
Module 3: Fluidization: Introduction, Advantages and Disadvantages of Fluidized Beds for Industrial Operations, Conditions for Fluidization, Minimum Fluidization velocity, Pressure Drop, Pressure drop-versus-velocity diagram, Effect of Pressure and Temperature on Fluidized Behaviour, Sintering and Agglomeration of Particles at High Temperature, Types of Fluidization, Particulate Fluidization, Bubbling Fluidization, Geldart Classification of Particles, Fast Fluidization, Circulating fluidized beds. Entrainment and Elutriation from Fluidized Beds.	8
Module 4: Industrial Applications of Fluidized Beds: Fluidized Combustion of Coal, Fluid Catalytic Cracking, Fluid Coking, Flexi Coking, Thermal Cracking, Incineration of Solid Waste, Gasification of Coal and Coke, Bio-fluidization.	8
Module 5: Tabling, jigging, magnetic and electrostatic separation.Surfacebehavior and floatation principles. Floatation machines, differential floatation and floatation circuit design. Important beneficiation circuits of coal and minerals like chalcopyrite, sphalerite, galena, magnetite and Hematite, bauxite, Steel alloying ore.	8

Text books:

1. Unit Operations of Chemical Engineering, McCabe Smith, Julian C. Smith, P. Harriot TMH, 5th Edn.
2. Fluidization Engineering, Daizo Kunii and Octave Levenspiel, Butterworth-Heinemann, 2^{nd} Edition.
3.Coulson and Richardson's Chemical Engineering, Vol. 2, Butterworth-Heinemann, Fifth edition 2002.
4. Introduction to chemical engineering. Walter L. Badger and Julius T. Banchero. McGraw-Hill book company, Inc., New York (1955).

Reference books:

1. Introduction to Particle Technology, M.J. Rhodes, 2nd edition, John Wiley, Chichester; New York, 2008.
2. Powder Sampling and Particle Size Determination, T. Allen, Elsevier, 2003

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

PROGRAMME ELECTIVE 2 (PE-2)

COURSE INFORMATION SHEET

Course code	CL321
Course title	Petroleum Refinery Engineering & Petrochemicals
Pre-requisite(s)	Reaction Engg., Heat & Mass Transfer operations
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	V
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students to:

1.	Acquire knowledge of the sources of crude petroleum, extraction of the crude petroleum, its refining to the useful petro-products and efficient transport to the end users through network
2.	Learn all the techniques/processes of petroleum refining encompassing selection of the mass/heat transfer devices, their operation and basic design.
3.	Understand feed stocks of petrochemical industries and manufacture of important petrochemicals and their end uses.
4.	Examine how each refinery process works.
5.	Draw a flow diagram that integrates all refinery processes and resulting refinery products.

Course Outcomes:
After the completion of this course, students will be able to:

CO 321.1	Describe importance of refinery industries, methods for evaluation of crude & fractions, their inter-convertibility and the principles of operation of atmospheric and vacuum distillation processes.
CO 321.2	Develop knowledge of different refining processes such as cracking, reforming, isomerization, Alkylation etc.
CO 321.3	Explain feed stocks for petrochemical Industries and processes for the production of methane, ethylene, acetylene, propylene and butadiene.
CO 321.4	Explain aromatics separation/recovery process, uses of important aromatics and process for the production of important products based on aromatic such as styrene, cumene, phthalic Anhydride etc.
CO 321.5	Develop process flow-sheet showing important process equipments.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Exploration and Refining of Crude Oil: Introduction, Indian and world reserve of crude oil and its processing. Capacity, Market demand & supply of petroleum Fractions. methods for evaluation of crude & fractions: TBP, ASTM, EFV, and their inter-convertibility, yield Curve. Desalting of crude, pipe still furnaces, preflashing operation, Atmospheric and vacuum distillation units, types of Reflux arrangements, Calculation of tray requirement for ADU column. Products from Crude oil and their characterizations	8
Module 2 Thermal conversion Processes: Thermal cracking processes – mechanism, applications e.g. visbreaking, thermal cracking, coking operations, Catalytic Conversion Processes : Catalytic cracking processes, Different FCC operating modes, Catalytic reforming operations, Hydro cracking, Simple process calculations.	8
Module 3 Polymerization, Isomerization processes, Alkylation, Hydrocracking, Catalytic Polymerization for gasoline stock preparation. Finishing & Treatment processes : Different Hydrotreating processes. LOBS extraction	8
Module 4 Petrochemical Industries & their feed stocks: Survey of Petrochemical industry. Resources and generation of different feedstocks – their purification, separation of individual components by adsorption, low temperature fractionation. Petrochemicals based on methane, ethylene, acetylene, propylene and butadiene	8
Module 5 Separation and Utilization of Aromatics: Catalytic Reforming operation – Separation of BTX from reformate. Isolation of Benzene, Toluene, Xylene. Aromatics derived from thermal cracking of naptha, pyrolysis gasoline hydrogenation process. Alkylation of Benzene. Production of styrene, cumene and phenol, Isomerization of xylene. Production of phthalic Anhydride	8

Text books:

1 Petroleum Refining Engineering: W.L. Nelson
2 Petrochemicals Technology: B.K.B. Rao
3 Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwork

Reference books:

1. Advanced Petroleum Refining: G. N. Sarkar
2. Petroleum Refining Technology - Ramprasad

Gaps in the syllabus (to meet Industry/Profession requirements)
Design of ADU and VDU units

POs met through Gaps in the Syllabus
PO4, PO5, PO9 and PO12

Topics beyond syllabus/Advanced topics/Design
Recent advances in petrochemical production technologies and design of refining equipment for specific requirements

POs met through Topics beyond syllabus/Advanced topics/Design
PO2, PO3, PO4, PO5, PO9 and PO12

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3
CO2	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3

CO3	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3
CO4	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3
CO5	3	2	2	3	1	3	2	3	3	2	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD7, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD7, CD8
CD3	Seminars	CO3	CD1, CD2, CD7, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD7, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD7, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	**CL 322**
Course title	**Macromolecular Science**
Pre-requisite(s)	**PH113,CH101,CH102**
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	V / Third
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students to:

1.	Define chemical structure of polymer, classification and isomerism
2.	Describe the different molecular weight measurement techniques
3.	Illustrate the method and kinetics of polymerization
4.	Distinguish the types of polymerization techniques to manufacture polymers for specific use
5.	Compare the properties of copolymers with that of homopolymers in respect of monomer ratios

Course Outcomes

After the completion of this course, students will be able to:

CO322.1	Remembering:Show chemical structure of polymers,tell correlation between structure and properties,recall polymerization steps
CO322.2	Understanding: Outline Polymerization processes and compare different steps of synthesis by various mechanisms,interpret polymer solubillity interms of thermodynamics
CO322.3	Analyze:Given a set of polymers assess their suitability for specific use and application on the basis of chemical structure,solubility,degree of crystallinity
CO322.4	Evaluate:Given a specific set of requirements of polymer application recommend and select the most cost effective polymerization technique for production
C0322.5	Apply:Given a polymer, suggest the method of finding out molecular weight disribution,average molecular weight, degree of crystallinity

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: Introduction to macromolecule concept Classification of polymer. Polymer structure property relationship, Molecular forces and chemical bonding in polymer. Glassy to rubber transition in polymer. Molecular weight and Molecular weight distribution. Molecular weight determination by colligative properties, Ultracentrifuge, Light scattering, Solution viscometry, Gel permeation chromatography.	10
Module 2:Condensation Polymerization Principles of Step-reaction (condensation) polymerization. Mechanism of stepwise polymerization. Kinetics and statistics of linear stepwise polymerization. Polyfunctional step-reaction polymerization, Real Industrial processes.	5
Module 3: Addition Polymerization Principles of radical chain (addition) polymerization. Initiators and initiator systems. Kinetics of vinyl radical polymerization. Kinetics of copolymerization. Composition of copolymers. Mechanism of Copolymerization Mechanism and kinetics of ionic chain growth polymerization. Mechanism and kinetics of co-ordination polymerization. Mechanism and kinetics of ring opening polymerization. ATRP, Electrochemical Polymerization.	10
Module 4: Polymer Solutions Criteria for polymer solubility. Conformations of dissolved polymer chains. Thermodynamics of Polymer solutions. Phase equilibrium in polymer solutions. Fractionation of polymers by solubility. Polymerization techniques:Bulk, Suspension, Emulsion, Solution polymerization.	7
Module 5: Morphology of Polymers Crystal structure of polymer. Morphology of crystalline polymer. Crystallization and melting. Strain induced morphology. Mechanical properties of crystalline polymer. Viscous flow. Kinetic theory of rubber elasticity. Viscoelasticity.	8

Text Books: 1. Text book of polymer Science: Billimeyer F.W., 3rd Edn., Wiley Interscience, 1984
2. Principles of polymerization: G. Odian, 2nd Edn. Wiley Interscience New York, 1981
3. Polymer Chemistry, Sixth edition, Charles E. Carraher Jr. Marcel Dekker Inc, 2003.
4. Principles of Polymer Systems, Rodriguez, F, Taylor& Francis, 4th Edn., 1996.

Reference books:

1.Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. McGraw Hill, 1998.
2. The Element of Polymer Science & Engineering: Rudin.
3. Structural Investigation of Polymer: Bodor G., 1st Ed., Ellis Harwood Ltd., 1991.
4. Introduction to Polymer Science 3rd edition, L.H.Sperling, John Wiley and Sons 2001.

Gaps in the syllabus (to meet Industry/Profession requirements)

- Actual polymerization techniques used in industries may be learned by industrial visit

POs met through Gaps in the Syllabus:

PO11,PO9,PO2

Topics beyond syllabus/Advanced topics/Design

Details of manufacturing process of Polymers, Processing of polymers is presently beyond the scope of the syllabus

.

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3 and PO4

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
2	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
3	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
4	3	3	3	2	3	2	2	1	1	1	1	1	3	3	3
5	3	3	3	2	3	1	1	1	1	1	1	1	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD 1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD 2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD 3	Seminars	CO3	CD1, CD2, CD8
CD 4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD 5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD 6	Industrial/guest lectures		
CD 7	Industrial visits/in-plant training		
CD 8	Self- learning such as use of NPTEL materials and internets		
CD 9	Simulation		

COURSE INFORMATION SHEET

Course code: CL323
Course title: Safety and hazards in chemical industries
Pre-requisite(s):
Co- requisite(s):
Credits: L: 03 T: 00 P: 00
Class schedule per week: 3
Class: B. Tech.
Semester / Level:
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Identify and manage various aspects of occupational hazards existing in chemical industries.
2.	Develop a safe protocol by safety audit and risk assessment and minimize potential damages to process equipment's, people and the environment.
3.	Understand fundamentals of chemical process safety and hazards management.
4.	Learn important component of the risk management plat i.e. hazards identification, hazard analysis etc.
5.	Describe the advancement in the field of the risk assessment.

Course Outcomes:
After the completion of this course, students will be able to:

CO 323.1	Understand the importance of plant safety and safety regulations, personal protective equipment's, principles and procedures of safety audit.
CO 323.2	Identify and mitigate different types of toxic chemical hazards
CO 323.3	Implement various safety aspect of fire and explosion in a chemical plant
CO 323.4	Assess and mitigate different hazards due to storage and transportation of chemicals, plant operations.
CO 323.5	Design safety protocols for chemical industry using various hazard evaluation tools.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
MODULE -1: Introduction to industrial safety and Hazards: Definition of safety, Hazard and Risk, Chemical Hazard Symbols, Personal protective equipment, Safety program, Accident and loss statistics (OSHA incident rate, fatal accident rate (FAR), and fatality rate), Engineering ethics, Industrial hygiene. Factories Act, 1948 and Environment (Protection) Act, 1986 and rules thereof, Review of industrial accidents.	8
MODULE -2: Toxic Substances and Confined Spaces: Toxic Substances Definition, Classes of Toxicity, Entry Points for Toxic Agents, Effects of Toxic Substance, Relationship of Doses and Responses, Threshold Limiting Values, Exposure Thresholds, Airborne Contaminants, Confined Spaces Hazards, Respiratory Protection, Prevention and Control	8
MODULE -3: Fire and Explosion: Work Place Hazard, Dangerous Substance Fire triangle, Effective Ignition Source, Static Electricity, Explosion: BLEVE, VCE, Detonation and Deflagration, Flammability Limits, LOC, Flash point, Flammability Diagram, Flammable and Combustible Liquids.	8
MODULE -4: Safety and Hazard in Chemical Process Plant: Decomposition & Runaway Reactions, Initiating factors Reactive Chemical Hazard, Case Studies: T2 Laboratories, Florida, Synthron, North Carolina, Phenol Formaldehyde Reaction. Assessing Reaction Hazard; Tools for evaluating thermal explosion, Steps to Reduce Reactive Hazards. Process Plant Design: Flow Diagrams; Piping and Instrumentation Diagram, Control System, Alarms. Chemical Plant Layout: Passive protection, Active Protection, Emergency Shutdown System, Safety Integrity Level, Inherent Safety Techniques	8
MODULE -5: Hazard Identification and Evaluation Technique: Quantitative, Qualitative Safety Review, Process /System Checklists, Dow Fire and Explosion Index, What-If Analysis. HAZOP Study, Reliability, Probability Distribution, Demand and Failure, Fault Tree Analysis (FTA), Minimal Cut Set Identification, Event Tree Analysis.	8

Text books:

1. ChemicalProcessSafety:FundamentalswithApplications:DanielA.CrowlandJ.F.Louvar
2. F.P.Lees,LossPrevention in ProcessIndustries,Vol. 1 and 2, Butterworth,1983.

Reference books:

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL324
Course title	Computational Fluid Dynamics
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	5
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students:

1.	Learn the fundamentals of computational method for solving non-linear partial differential equations.
2.	Understand the widely used techniques in the numerical solution of fluid equations.
3.	Understand the issues that arise in the solution of fluid equations.
4.	Learn CFD techniques for solving incompressible and compressible N-S equation in primitive variables, grid generation in complex geometry, transformation of N-S equation in curvilinear coordinate system.
5.	Understand the Computational Fluid Dynamics along with chemical engineering application.

Course Outcomes:
After the completion of this course, students will be able to:

CO324.1	Solve the Navier-Stokes equations
CO324.2	Use Finite Difference and Finite Volume methods in CFD modeling.
CO324.3	Generate and optimize the numerical mesh.
CO324.4	simplify a real fluid-flow system into a simplified model problem, to select the proper governing equations for the physics involved in the system, to solve for the flow, to investigate the fluid-flow behavior, and to understand the results.
CO324.5	Simulate simple CFD models and analyze its results.

SYLLABUS

MODULE	No. of Lecture Hours
Module 1: **Introduction**: Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Initial and boundary conditions, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation.	8
Module 2: **Principles of Solution of the Governing Equations:** Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, CFD and formulation. **Mesh generation**: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation.	8
Module 3: **Discretization**: Spatial discretization of a simple flow domain, Taylor's series expansion and the basis of finite difference approximation of a derivative; Central and one-sided difference approximations; Order of accuracy of finite difference, Finite difference approximation of pth order of accuracy for qth order derivative; Examples of high order accurate formulae for several derivatives, One-sided high order accurate approximations.	8
Module 4: **Solution Methods:** Discretization schemes for pressure, momentum and energy equations – Explicit and implicit Schemes, Solution methods of discretised equations - Tridiagonal matrix algorithm (TDMA) Application of TDMA for 2D problems potential flow - Stream and vorticity function. Unsteady flows - Crank Nicholson scheme, solution of Navier-Stokes equations.	8
Module 5: **CFD Solution Procedure:** Problem setup-creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization. **Case Studies**: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.	8

Text Books:

3. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill (1998).
4. Muralidhar, K., and Sundararajan, T. Computational Fluid Flow and Heat Transfer, Narosa Publishing House (1995).

Reference Books:

4. Niyogi, P. Chakrabarty, S.K.. and Laha, M.K., Introduction to computational fluid dynamics, Pearson education (2006).
5. Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor and Francis (1978).
6. S.K. Gupta, Numerical Methods for Engineers, New Age Publishers, 2nd Edition (1995).

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3

CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
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CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL325
Course title:	Biomaterials
Pre-requisite:	PH113, CH101, CH102, CL213
Co- requisite(s):	The course is to be floated as Programme elective -II
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	03
Class:	B. Tech
Semester / Level:	05/03
Branch:	Chemical Engineering (Plastics & Polymer)
Name of Teacher:	Prof. S. Goswami

Course Objectives:
This course enables the students to:

1.	Remembering: To distinguish the various materials for biomedical application
2.	Understanding: to define biocompatibility of various materials and classify them according to their suitability for the specific biomedical application
3.	Analyzing : to distinguish the advantages and limitations of specific biomaterials for a specific biomedical application
4.	Applying: to identify the specific biomaterial to be used for a specific tissue or organ replacement
5.	Evaluating: to compare the durability, cost and properties of various biomaterials for specific use

Course Outcomes:
After the completion of this course, students will be able to:

CO.325.1	Analyze : Justify the selection of a specific biomaterial for a specific biomedical application on the basis of specific characteristic features
CO.325.2	Apply: Explain the suitability of polymeric biomaterials over the others on the basis of experimental evidences
CO.325.3	Evaluate: Given a set of known polymers select the most suitable one for a specific biomedical application on the basis of biocompatibility cytotoxicity performance
CO.325.4	Remember: Different types of materials used in biomedical applicatoin, classify these and compare properties
CO.325.5	Understand: Biocompatibility, bio-absorbability and limitations of various materials for specific application

SYLLABUS

MODULE	NO. OF LECTURE HOURS
MODULE- I Biomaterials-definition-classification-metal-ceramic-polymers, composites- Source, application, advantage and limitations	6
MODULE II: Metals and alloys-Stainless Steels, CO-based alloys, Ti and Ti based alloys and dental metals corrosion and remedy, Ceramics-Aluminum oxides, calcium phosphate, glass-Ceramics, carbon manufacturing and physical properties, deterioration of ceramics	10
MODULE-III Polymeric implant materials-polyamides, PE, PP, Polyacrylates, Structure, properties and application of biological materials-proteins, polysaccharides, Structure and property relation of Tissues-Mineralized tissues, collagen rich tissues and elastic tissues	8
MODULE - IV Soft tissue replacements-Skin implants-sutures, tissue adhesives, percutaneous devices, artificial skins, maxillofacial implants, ear and eye implants, vascular implants, heart and lung assist devices, artificial kidney dialysis membranes	8
MODULE V Hard tissue replacements-long bone repair-wires, pins, screws, fracture plates, tooth implants, joint replacement-knee and hip joint-materials of construction, limitations	8

Text Books:

1.Biomaterials-An Introduction-J.B. Park & Roderic S. lakes,Springer Science and Business Media, LLC, New york,1992

2. Plastic Materials, J, A.Brydson, ISBN-13: 978-0750641326, ISBN-10: 0750641320, Butterworth Heinemann,7th Edition, Oxford

Reference books:

1.Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.

2. The Element of Polymer Science & Engineering: Rudin.

3. Introduction to Polymer Science 3rd edition, L.H.Sperling, John Wiley and Sons 2001.

Gaps in the syllabus (to meet Industry/Profession requirements)

- Testing procedure of biocompatibility, tissue compatibility and cytotoxicity of biomaterials are not included in the syllabus

POs met through Gaps in the Syllabus:

PO11, PO9, PO2

Topics beyond syllabus/Advanced topics/Design

- Testing procedure of biocompatibility, tissue compatibility and cytotoxicity of biomaterials may be included in the syllabus

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3 and PO4

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

PROGRAMME ELECTIVES 3 (PE-3)

COURSE INFORMATION SHEET

Course code: CL326
Course title: Reservoir Engineering
Pre-requisite(s): calculus, basic chemistry, thermodynamics
Co- requisite(s): transport phenomena
Credits: L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. TECH.
Semester / Level: VI
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Learn about basic rock and fluid properties relevant to petroleum reservoir.
2.	Emphasize the impact of reservoir fluid behaviour on reservoir exploitation
3.	Understand the drive mechanisms of a reservoir
4.	Apply a critical thinking and problem solving approach towards the principles of reservoir engineering.
5.	Describe production mechanism in reservoir and related expected performance.

Course Outcomes:
After the completion of this course, students will be able to:

CO326.1	Understand basic characteristics of various reservoir and reservoir fluids
CO326.2	Analyze the multiphase flow behaviour through porous media
CO326.3	Understand mechanics of oil production (natural reservoir energies & expulsion of fluids)
CO326.4	Learn basic concepts of reservoir engineering and technologies for oil recovery.
CO326.5	Describe the advanced techniques of oil and gas recovery.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Petrophysical properties of Reservoir Rock Properties: sedimentary rocks, anticline, Porosity, permeability, fluid saturation, effective and relative permeability, wettability and capillary pressure.	8
Module 2 Reservoir Fluids: Reservoir fluid characteristics, reservoir fluid sampling,PVT properties determination, different correlations and laboratorymeasurements. Phase behaviour of hydrocarbon system.	8
Module-3 Flow of Fluids through Porous Media: Darcy's law, single and multiphase flow, linear, radial & spherical flow, steady state & unsteady state flow, flow through fractures, GOR, WOR equations, tortuosity.	8
Module-4 Reservoir Pressure Measurements and Significance: Techniques of Pressure measurement. Reservoir Drives: Reservoir drive mechanics, Drive indices and recovery factors. Reserve estimation: Estimation of petroleum reserve, resource & reserve concept, volumetric material balance.	8
Module-5 Production behaviour of gas, gas condensate and oil reservoirs. Rock and fluid compressibility effect. Water influx in reservoir, Performance prediction of depletion, gas cap, water and combination drive, reservoir pressure maintenance, Displacement process, Water flood performance, enhanced oil recovery processes.	8

Text books:

1. Reservoir Engineering Handbook – Tarek Ahmed

2. Petroleum reservoir engineering: Petrophysical properties: J. W. Amyx; D. M. bass, Jr, R. L. Whiting-TEX

3. Fundamentals of Reservoir Engineering: J. C. Calhoun Jr.T

4. Oil reservoir Engineering: S. J. Pirson

5. Reservoir engineering Mannual: F. W. Cole

6. Basics of Reservoir Engineering: R. Cosse

Reference books:

Applied petroleum reservoir engineering, Ronald E. Terry and J. Brandon Rogers, Third edition, Prentice Hall.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	**CL327**
Course title:	**Polymer Processing**
Pre-requisite:	**CL213,CL214**
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	**03**
Class:	**B.Tech.**
Semester / Level:	**06/3**
Branch:	**Chemical Engineering -Plastics & Polymer**
Name of Teacher:	

Course Objectives:

This course enables the students to:

1.	Outline the steps of specific process to manufacture a specific product, identify the various parts of the machine and explain the function of it
2.	Solve numerical problems on simple flow analysis for polymers during a specific processing,interpretation and analysis of rheological data using models for non-Newtonian fluids
3.	Predict the reasons behind specific product defect and propose probable solutions specific to processing technique
4.	Explain both practical and theoretical fundamentals of injection moulding and extrusion technology, including basic knowledge of the moulding process.
5.	Explain a wider range of polymer processes: thermoforming, compression and transfer moulding, rotational moulding, blow moulding, assembling techniques

Course Outcomes (CO)

After the completion of this course, students will be able to:

CO 327.1	Remembering: Choose the corresponding process to be used to manufacture a specific product from suitable polymers.
CO 327.2	Understanding: Compare the methods of different processing techniques for product manufacture with a given set of plastic materials for the specific use
CO 327.3	Apply: Apply most modern technology to modify the process variables on the existing machine to manufacture a specific plastic/ rubber/composite product
CO 327.4	Analyze: Inspect the defects in plastic products, examine the product quality in terms of machine parameters and list professional engineering solutions as remedies which will be sustainable and economical
CO 327.5	Evaluate: Explain processing difficulties and estimate numerical problems related to polymer processing

Syllabus

MODULE	No. of Lecture Hours
Module1 Rheology of Polymer melts, Viscosity models, Dependence of viscosity on Temperature, Pressure, molecular weight, Viscoelastic models. Extensional viscosity, Rheometers: Capillary, Rotational, cone & plate. Die swell.	8
Module2 Extrusion: Extruder Classification, Components- Drives, Bearing, Screw, Barrel, Breaker plate, Screen, hopper, Screw geometry, heating & cooling systems. Process analysis: Solids conveying, plasticating, melt conveying, Melt instabilities. Technology of product manufacturing: Pipe, Films, Wire coating, Tapes, Monofilaments.	10
Module3 Injection moulding – Moulding cycle. Machine construction – barrel, screw, nozzles, clamping system, Machine ratings, Basic mould construction – classification, sprue, runner, gate systems, mould cooling, ejection, Part cooling analysis, Effect of process variables on product quality. Special Injection Mouldings. Product defects and its remedies.	6
Module4 Classification, Machinery, process details, analysis, defects, remedies: Blow moulding, Thermoforming, Calendering..	8
Module 5 Classification, Machinery, process details, analysis, defects, remedies: Rotomoulding, Compression moulding and Transfer moulding.	8

Text Books:

1.Plastics Engineering, Crawford, R.J., Pergammon Press
2. Polymer Extrusion, Chris Rauwendaal, Hanser, 1994.
3. Plastics Product Design and Process Engineering, H. Belofsky, Hanser, 1995.
4. Blow Moulding Handbook, Rosato, D.V. and Rosato D.V., Hanser, 1989.
5. Plastic Extrusion Technology, Hensen, Hanser, 1997.
6. Polymer processing,D.H.Morton-Jones,Chapmman&Hall,New York,1989,

Reference books:

1. Principles of Polymer Processing, Tadmor, Z and Gogos, C.G., John Wiley and Sons, 1982.
2. Plastics: Product Design and Process Engineering, Belofsky, H., Hanser Pub. 1995.
3. Fundamentals of Polymer Processing, Middleman, Mc Graw Hill, 1979.
4. Rotational Moulding Technology, R.J Crawford and J.L.Throne, William Andrew publishing, 2002

5. Thermoforming, J.L.Throne, Hanser, 1987

Gaps in the syllabus (to meet Industry/Profession requirements)

- Guest lecture by Industry Personnel
- Mini project on Problems given by Industries

POs met through Gaps in the Syllabus

PO5,PO3

Topics beyond syllabus/Advanced topics/Design

Joining of Plastics Foam Processing, Metalizing, Machining Hot Stamping Adhesive Bonding, Mechanical fastening, mould design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2
CO2	1	2	3	3	3	2	2	2	1	1	2	3	2	3	3
CO3	2	1	1	1	1	3	2	3	1	2	1	2	3	2	1
CO4	1	2	3	3	3	2	2	2	1	1	2	3	2	3	3
CO5	3	3	3	2	2	2	2	1	3	2	1	2	3	2	2

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used

CD1	Lecture by use of boards/LCD projectors/ OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, and CD2
CD4	Mini projects/Projects	CO4	CD1
CD5	Laboratory experiments/teaching aids	CO5	CD1, and CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL328
Course title:	Paints and Surface Coating
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L:03 T:00 P:00
Class schedule per week:	03
Class:	B. TECH.
Semester / Level:	06
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Remembering: Identify the properties of paints
2.	Understanding: Explain the method of surface preparation for paint application
3.	Applying: Describe the basic principles of paint formulations.
4.	Analyze: Illustrate the preparation of paints
5.	Evaluate: Given a type of specifications formulate a paint system and Evaluate its properties

Course Outcomes
After the completion of this course, students will be able to:

CL328.1	Remembering: Define paints, lacquers, varnish, surface coating
CL328.2	Understanding: Describe the properties of binder, pigments, solvents and other additives
CL328.3	Applying: Basic understanding of designing paint formulation considering various ingredients .
CL328.4	Analyse: Given a type of paint defects examine the cause of failure and provide the necessary corrective actions.
CL328.5	Evaluate: Evaluate the quality of applied coating and suggest preventive measures

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Fundamental types of surface coating: Lacquer, paint, varnish, and enamel. Mechanism of film formation. Solvents, Thinners and Diluents properties and its functions in paint system. Toxicity and Environment Pollution. Solvent selection.	6
Module 2:	5

Non reactive binder: Acrylics, esters, vinylic etc. Reactive binder: Oleo resinous binder - (drying oil, semi drying oil, non-drying oil). Epoxy resins. Phenolic resins. Urethane resins. Melamine Formaldehyde resins.	
Module 3: Pigment properties and its role in paint system. White Inorganic pigments. Colour Inorganic pigments. Specialty pigments. Organic pigments. Extenders. Theory of pigment dispersion in paints. Paint formulations.	8
Module 4: Surface preparation for metals. Surface preparation for woods. Surface preparation for plastics. Spray coating. Electro deposition. Brush coating, Dip coating. Electro deposition. Water borne coating. Powder coating. Radiation curable coating. Marine coating. Can coating.	11
Module 5: Additives for paints. Industrial paint making processes. Quality control of dispersion and storage.Mechanical properties of coatings. Quality control of finished products. Type of coating defects. Reasons for coating defects. Type of printing inks. Manufacturing of printing inks. Drying of printing inks.	10

Text Books:

1. Surface Coating Science & Technology - Swaraj Paul, IInd edition, John Wiley & Sons, New York, 1996.
2. Surface Coatings: Vol II: Paints and Their Applications. 2nd edition OCCA, Chapman and Hall 1984
3. Introduction to Paint Chemistry and principles of Paint Technology, J.Bentley&G.P.ATurner, IVth ed., Chapman and Hall, 1998.
4. Paints and Surface Coatings- Theory and Practice 2nd edition R. Lambourne & T A Stevens, William Andrew Publishing 1999.

Reference books:

1.Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
2. Organic Coatings-Applications. Properties and Performance. Vol II. Wicks Z.W. Wiley Interscience Pub. Ltd. 1992.
3. Resins for Coating: Chemistry Properties and Applications 1st ed. Stoye D. Hanser Publishers, 1996.
4. Basics of Paint Technology, Vol I, and II, V.C. Malshe, 2008

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	**CL329**
Course title:	Elastomer Technology
Pre-requisite(s):	**CL213, CL313**
Co- requisite(s):	**Nil**
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	**03**
Class:	**B. Tech**
Semester / Level:	**06/3**
Branch:	**Chemical Engineering- Plastics and Polymer**
Name of Teacher:	Prof.G. Sarkhel, Prof. S.Goswami, Dr.P.Datta

Course Objectives

This course enables the students:

1.	To interpret the history and evolution of elastomer and to understand the basic physico-chemical character of elastomer
2.	To understand the processing and compounding of Natural Rubber
3.	To make the students aware of various rubbers – their preparations, properties and uses
4.	To interpret chemical additives mixed with elastomers, and processing technology for manufacturing rubber products
5.	To understand the material selection and fabrication of different rubber-based products

Course Outcomes

After the completion of this course, students will be able to

CO 329.1	***Remembering: List*** *the* synthesis procedure and characteristics of industrially available elastomers
CO 329.2	***Understanding: Explain the*** compounding recipe with given chemical additives and infer appropriate raw rubber materials for a given application
CO 329.3	***Applying: Select*** the elastomer processing operations depending on the materials characteristics and final product requirements
CO 329.4	***Analysing: Examine*** the rubber compound formula, list suitable processing parameters and conditions of rubber processing with a given equipment and material
CO 329.5	***Evaluating: Recomend the*** product manufacturing technique with rubber and ***estimate*** the manufacturing cost of rubber based products at industry scale

Syllabus

MODULE	No. of Lecture Hours
Module - 1 History and growth of rubber technology, general consideration of diene polymers. Physics of raw vulcanised rubber, **Natural rubber**: Chemical structure, auto oxidation and other reactions, blending with other polymers, compounding, vulcanisation. composition, stability, gelation, preparation of dry rubber from natural rubber latex, types and grades of rubber.	7
Module - 2 Chemistry and technology of synthetic rubbers -Poly isoprene, SBR, nitrile, polybutadiene, polychloroprene, EVA, EPDM, Butyl rubber, poly sulphide rubbers, chlorosulfonated polyethylene, silicones, thermoplastic elastomers.	12
Module 3 Rubber compounding and mixing, Mastication, Additives - fillers, accelerators, activators, antioxidants, antiozonants, sulphur etc. Theory and technology of reinforcement. Mechanism and practice of sulphur vulcanization and non-sulphur, vulcanization (peroxide, metal oxides and other special curing systems)	8
Module 4 Machineries: Two roll Mill, Mixers, Extruders, Calendars, Testing equipments: mooney viscometer, oscillating disc rheometer	5
Module - 5 Manufacturing of Latex based product. Tyre technology Compounding & processing technology, footwear technology. Extruded rubber profile. Hose technology, conveyor & V- Belt, metal rubber bonding.	8

Text books:

1. Rubber Technology and Manufacture: Blow C.M. 2nd Edn. Numbers Butterworth London. 1982
2. Rubber Technology Handbook, Werner Hoffmann Hanser Publication, NY, 1996
3. Rubber Technology, Morton,M., N.Y. Vannostrand Reinhold Company, 1973. 2nd Ed
4. Polymer Physics, Rubinstein,M,Colby R.H. Oxford University press , 2003

Reference books:

1. Encyclopedia of Polymer Science and Engineering, Johan Wiley and Sons, Inc 1988.
2. Elastomers and Rubber Compounding materials, Elsevier, 1989.
3. Rubber Materials, Ane Books, KothandaramanB, 2008.
4. Rubber Technology Compounding and testing for Performance, Dick. J.S., Hanser Publisher, 2001.
5. Physical Testing of Rubber, Brown.R.P. Elsevier, 1986.
6. Testing and Evaluation of Plastics, Mathur A B., Allied Publishers (P) Ltd., 2003
7. Practical Rubber Compounding and processing, Evans.C.W Applied Science Publishers, London, 1981.

8. Rubber Processing Technology Materials, Principles, White.J.L., Hanser Publication, New York, 1995.
9. The Mixing of Rubber, Richard F.Grossman,Chapman& Hall,1997.
10. Elastomer Procesing, Kleemann, Weber Hansar, 2005

List of Open Source Software/learning website:•www.sciencedirect.com/science/book/9780857096838

Gaps in the syllabus (to meet Industry/Profession requirements)

- visit to Rubber Industry to get hands on experience of the course objectives
- Guest lecture by industry personnel

POs met through Gaps in the Syllabus

PO5, PO3, PO10

Topics beyond syllabus/Advanced topics/Design

1. Advanced rubber rheology
2. Material selection and case study
3. Thermoplastics vulcanizate and dynamic vulcanisation
4. Rubber Blends and application of them

POs met through Topics beyond syllabus/Advanced topics/Design

- PO11, PO9, PO8, PO3

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3

CO2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1
CD2	Tutorials/Assignments	CO2	CD1
CD3	Seminars	CO3	CD1 and CD2
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL330
Course title:	Natural Gas Engineering
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Understand natural gas utilization, reserves and sources.
2.	Develop an appreciation for the properties of Natural Gas.
3.	Understand natural gas processing.
4.	Understand natural gas transportation.
5.	Understand production of natural gas through unconventional sources.

Course Outcomes:
After the completion of this course, students will be able to:

CO 330.1	Calculate Properties of Natural gas.
CO 330.2	Evaluate Gas Reservoir Deliverability, Choke Performance and wellbore performance.
CO 330.3	Explain Gas Treating, disposal and Sulfur recovery processes.
CO 330.4	Describe Gas Dehydration, Hydrocarbon Recovery, Nitrogen Rejection Processes, Trace component recovery or removal, Transportation and Storage.
CO 330.5	Explain Unconventional Natural Gas and Natural Gas in Energy Transitions.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Introduction: What is Natural Gas, Utilization of Natural Gas, Natural Gas Industry, Natural Gas Reserves, Sources of natural gas (conventional and unconventional). Properties of Natural Gas: Specific Gravity, Pseudocritical Properties, Viscosity, Compressibility Factor, Formation Volume Factor and Expansion Factor, Compressibility of Natural Gas, Real Gas Pseudo-pressure.	8
Module 2 Gas Reservoir Deliverability: Analytical Methods, Empirical Methods, Construction of Inflow Performance Relationship Curve, Well Deliverability Testing, Wellbore Performance, Choke Performance, Well Deliverability.	8
Module 3 Overview of Gas Plant Processing, Field Operations and Inlet Receiving, Compression. Gas Treating: Chemical Absorption Processes, Physical Absorption, Adsorption, Cryogenic Fractionation, Membranes. Acid gas Processing and disposal: Sulfur recovery processes.	8
Module 4 Gas Dehydration: Absorption Processes, Adsorption processes. Hydrocarbon Recovery: Retrograde condensation, Liquids Removal Processes. Nitrogen Rejection Processes: Cryogenic distillation, Pressure swing adsorption, Membranes. Trace component recovery or removal. Liquids Processing: Condensate Processing, NGL Processing. Transportation and Storage.	8
Module 5 Unconventional Production of Natural Gas: Tight Gas, Gas Shale, Gas Hydrates, Coal Bed Methane. Natural Gas in Energy Transitions: LNG, CNG.	8

Text books:

1. Natural Gas Engineering Handbook, 2nd Edition, Boyun Guo and Ali Ghalambor, Gulf Publishing company.
2. Fundamentals of Natural Gas Processing, Third Edition, Arthur J. Kidnay, William R. Parrish, Daniel G. McCartney, CRC Press.
3. Natural Gas Processing- Technology and Engineering Design, Alireza Bahadori, Gulf Professional Publishing.

References:

1. Petroleum Refining and Natural Gas Processing, M.R. Riazi, Semih Eser, Suresh S. Agrawal, and José Luis Peña Díez, ASTM International.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3

CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	CL333
Course title:	Polymer Technology
Pre-requisite:	PH113, CH101, CH102, CL213
Co- requisite(s):	Programme Elective-III to BE Chemical Engineering students
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	03
Class:	B. Tech
Semester / Level:	06/03
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Understanding: to explain the types and kinetics of synthesis reactions of various polymers
2.	Apply: to identify the compounding ingredients to be used in specific plastic compounding for specific end use
3.	Analyze: to make use of knowledge of structure /properties relationship of polymers while selecting them for specific product manufacturing
4.	Compose: to write down the recipe of a specific polymer compound suitable for specific application
5.	Understand the physical and chemical characterization of polymeric raw materials.

Course Outcomes:
After the completion of this course, students will be able to:

CO.333.1	Remember: Recall the preparation, properties and application of various commodity and engineering plastics.
CO.333.2	Understand: Explain preparation, properties and application of commodity and engineering plastics.
CO.333.3	Apply: Apply the importance of structure property relationship to choose the materials for various applications.
CO.333.4	Analyze: Categorize the methods of the preparation, properties and application of specific copolymers.
CO.333.5	Evaluate: Select additives for different plastics and formulate recipe for specific product manufacturing

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Fundamental concept of Macromolecules-Classification of polymer, Polymer structure property relationship, Molecular forces and chemical bonding in polymer, Glassy to rubber transition in polymer, Concept of Molecular weight and Molecular weight distribution for polymers, Determination of average molecular Weight by viscometry, Gel permeation Chromatography	6
Module 2:Types of polymerization- Principles of Step-reaction (condensation) polymerization, Carothers Equation, Mechanism of stepwise polymerization, Kinetics and statistics of linear stepwise polymerization, Polyfunctional step-reaction polymerization, Gel point, Principles of radical chain (addition) polymerization. Initiators and initiator systems, Kinetics of vinyl radical polymerization, initiator efficiency, cage effect	10
Module 3: AdditivesforPlastics:Definition,classification,mechanismofaction:fillers, couplingagents, plasticizer, cross linkingagents,stabilizer, blowingagents	8
Module 4: Structure and property relation of Polyethylene,(LDPE, HDPE, LLDPE, XLPE, UHMHDEP), Polytetrafluoroethylene,Polypropylene, Polystyrene, Polyvinyl chloride,Polyvinyl alcohol, Acrylics, nylon 6,nylon66, Phenol-formaldehyde resins, alkyl & aryl epoxies, polyurethanes, silicones, Unsaturated Polyester	10
Module 5: Crystal structure of polymer, Morphology of crystalline polymer, Crystallization and melting, Strain induced morphology, Mechanical properties of crystalline polymer, Viscous flow, Kinetic theory of rubber elasticity. Viscoelasticity, melt flow Index, die swell, viscoelastic models, principles of cone and plate rheometer	6

Text Books:

1. Text book of Polymer Science: Billimeyer F.W., 3rd Edn., Wiley Interscience, 1984
2. Principles of polymerization: G. Odian, 2nd Edn. Wiley Interscience New York, 1981
3.Flow properties of polymer Melts, J.A. Brydson, Godwin in association with the Plastics and Rubber Institute, 2nd Edn.1981, ISBN071145681X, 9780711456815
4. Plastic Materials, J.A.Brydson, ISBN-13: 978-0750641326, ISBN-10: 0750641320, Butterworth Heinemann, 7th Edition, Oxford

Reference books:

1. Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.
2. The Element of Polymer Science & Engineering: Rudin.
3. Introduction to Polymer Science 3rd edition, L.H.Sperling, John Wiley and Sons 2001.

Gaps in the syllabus (to meet Industry/Profession requirements)

- Testing procedure of polymer properties are not included in the syllabus

POs met through Gaps in the Syllabus:

PO11, PO9, PO2

Topics beyond syllabus/Advanced topics/Design

- Testing procedure of polymer properties are not included in the syllabus

POs met through Topics beyond syllabus/Advanced topics/Design

PO2, PO3 and PO4

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3

CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL332
Course title	Membrane Science and Technology
Pre-requisite(s)	Fluid Mechanics, Mass Transfer, Thermodynamics
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	VI
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students to:

1.	Learn basic principles of membrane science and technology.
2.	Explain basics of membrane transport and related mechanism.
3.	Describe membrane structure and their formation processes.
4.	Acquire knowledge on Membrane based Separation Processes.
5.	Design the suitable membrane separation techniques for intended problems.

Course Outcomes

After the completion of this course, students will be able to:

CO.332.1	Explain Membrane Processes and Types of Membranes.
CO.332.2	Explain the Membrane Preparation Methods and Membrane Characterization Techniques.
CO.332.3	Explain the Principles and application of different Membrane processes and their characteristics.
CO.332.4	Develop skills to choose appropriate membrane process for a specific application.
CO.332.5	Explain the principles and applications of advanced membrane separation processes.

SYLLABUS

MODULE	**NO. OF LECTURE HOURS**
Module 1: Basic Principle of Membrane Separation, Classification of Membrane Processes, Advantages and Disadvantages of Membrane Processes, Major Areas of Application. Types of Synthetic Membranes- Micro porous (Isotropic and Anisotropic), Asymmetric, Thin film composite, Electrically Charged,	8

Inorganic. Membrane Modules, Typical Flow Patterns, Membrane Materials, Pore Characteristics. General Methods of Membrane Manufacture – Phase Inversion Process, Track-etch method, Sol-gel Peptisation Method, Interfacial Polymerization, Melt Pressing, Film Stretching, Template Leaching, Preparation of Ion-exchange Membranes. Characterisation of porous membranes-Electron microscopy, Atomic force microscopy, Bubble-point method, Bubble-point with gas permeation, Mercury intrusion method, Permeability method, Gas Adsorption-Desorption, Thermoporometry, Permporometry, Liquid displacement, Solute rejection measurements. Characterisation of nonporous membranes- Permeability methods, Physical methods (DSC/DTA methods), Plasma Etching, Surface Analysis methods.	
Module 2: Reverse Osmosis: Concept of Osmosis, Phenomenon of Reverse Osmosis, Membrane Materials and Modules, Models for Reverse Osmosis Transport, Design and Operating Parameters, Concentration Polarization, Membrane Plugging, Design of an RO Module, Reverse Osmosis for Non-Aqueous System, Forward Osmosis. Nanofiltration: Principle of Nanofiltration, Nanofiltration Membranes, Mass Transfer in Nanofiltration, Process Limitations, Industrial Applications	8
Module 3: Ultrafiltration: Basic Principle of Ultrafiltration, Ultrafiltration Membranes (Membrane Modules and Characterisation), Configuration of UF Unit, Factors affecting the performance of Ultrafiltration, Flux Equation for Ultrafiltration, Models for solvent Flux, Fouling and Flux Decline, Methods to Reduce Concentration Polarization, Micellar-enhanced Ultrafiltration, Affinity Ultrafiltration. Microfiltration: Basic Principle of Microfiltration, Microfiltration Membranes, Mechanism of Transport, Retention Characteristics, Flow Characterisation, Fouling in MF Membranes.	8
Module 4: Principle of Dialysis, Dialysis Systems, Dialysis Membranes, Mass Transfer in Dialysis, Hemodialysis. Ion Exchange Membrane Processes: Basic Principle, Ion Exchange Membranes, Batch and Continuous Electrodialysis, Electrodialysis Reversal, Electrodeionization.	8
Module 5: Gas Separation: Basic Principle, Membranes for Gas separation, Membrane Modules, Mechanism of Gas Transport-Knudsen Diffusion, Molecular Sieving, Solution-Diffusion, Dual Sorption Model, Factors affecting Gas Permeation. Pervaporation- Basic Principle, Advantages, Mass Transfer in Pervaporation, Design of a Pervaporation Module, Factors Affecting Pervaporation. Liquid Membranes: Bulk Liquid Membranes, Emulsion Liquid Membranes, Thin Sheet Supported Liquid Membranes, Hollow Fibre Supported Liquid Membranes, Polymer Inclusion Membrane, Mechanism of Mass Transfer. Facilitated Transport: Mechanism of Facilitated Transport, Coupled Transport, Active and Passive Transport, Applications of Facilitated Transport.	8

Text books:

1. Membrane Technology and Applications, Richard W. Baker, 2nd Edition, John Wiley & Sons, Ltd.
2. Basic Principles of Membrane Technology, Marcel Mulder, 2nd Edition, Kluwer Academic Publishers.
3. Separation Process Principles, J.D. Seader, E.J. Henley, D. Keith Roper, 4th Edition, Wiley.
4. Membrane Separation Processes, Kaushik Nath, PHI Pvt. Ltd.

Reference books:

1. Principles and Applications of Membrane Separations Technology: Edited by R.D. Nobbe, S. A. Stern, Elsevier Publication.
2. Handbook of Industrial Membrane Technology, Edited by Mark C. Porter, Noyes Publication, Westwood, New Jersey, USA.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

PROGRAMME ELECTIVE – 4 (PE-4)

COURSE INFORMATION SHEET

Course code: **CL421**
Course title: **FIBRE SCIENCE AND TECHNOLOGY**
Pre-requisite(s):
Co- requisite(s):
Credits: L: 03 T: 00 P: 00
Class schedule per week: **03**
Class: **B. Tech.**
Semester / Level: **07**
Branch: Chemical Engineering, Chemical Engineering-Plastics & Polymer
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Build conceptual understanding of fibre manufacturing process
2.	Provide a systematic understanding of the principles, equipment used in fibre manufacturing process
3.	Systematic understanding of the advanced material characterization techniques based on microscopy, chemical, physical, and structural analysis.
4.	Relate the interdependence of structure, properties, and applications of these fibres
5.	Familiarize with recent advances in the field of fabric manufacturing, textile finishing processes

Course Outcomes

After the completion of this course, students will be able to:

CO 421.1	Remembering: Choose & relate the suitable fibres for a specific application.
CO 421.2	Understanding: Classify & compare the different fibres, can outline the process involved in the manufacture of fabrics
CO 421.3	Applying: Utilize the knowledge of different types of fibre manufacture process.
CO 421.4	Analyzing: Examine the performance of basic fibre properties using empirical relations.
CO 421.5	Evaluating: Justify suitable additives composition for particular applications and recommend the cost effective formulation.

Syllabus

MODULE	No. of Lecture Hours
Module:1 Definition and classification of fibre. Natural fibre - chemical structures, source, use and limitations of Cotton, jute, linen, hemp, sisal, coir, wool, silk. Conventional man-made fibres: Rayon, Polyethylene terephthalate, Nylon 6 and nylon 66, Acrylic fibres, Polyolefins. High performance fibres: Aramid - Nomex and Kevlar, Ordered polymeric fibre, Aromatic polyesters. Inorganic fibres: Carbon fibre, Glass fibre, Boron fibre, Ceramic fibre, Alumina fibre. Metallic fibre. Conducting polymeric fibre. Optical fibre	10
Module2 Melt-spinning principles, classification, Melt-spinning line-extruder, spinning manifold, spin pack and the spinneret, cooling system, wind-up device, process variables. Structure formation during spinning- molecular orientation, crystallinity and morphology, integrated spin-draw process.	7
Module3 Solution spinning, process variables. Dry spinning & wet spinning – dope preparation, spinning process, Influence of process parameters on fibre cross-section formation, spin-stretch, finish application and winding. Post spinning operations: Drawing, Spin finish, Heat setting. Tow process, intermingling.	8
Module4 Characterization of fibres - Fineness- denier &tex, length, twists, crimping properties, Fibre Morphology, Shrinkage, Dye uptake, Mechanical properties, Thermal properties, Electrical properties, optical properties, Frictional properties, Chemical stability.	7
Module 5 Manufacture of textiles: Fibres to yarn, Yarns to fabrics- weaving, knitting, braiding, Compound fabric constructions, Finishing processes, Dyeing and printing. Non-woven Fabrics: Spunbonding and Melt-blowing processes.	8

Text books:

1. Gupta, V.B., and Kothari, V.K., Manufactured Fibre Technology, Chapman & Hall, 1997.
2. E-learning courses from IITs and IISc, NPTEL (Web based Text book).
3. Fourne,Franz, "Synthetic Fibres, Machines, and Equipment, Manufacture, Properties", Hanser Publishes, 1999.
4. Corbman, Bernard P, "TEXTILES fibre to fabric", Sixth Edition, McGraw Hill, 1983.

Reference books:

1) W. E. Morton and J. W. S. Hearle, Physical properties of textile fibres, Woodhead publishing limited, Fourth edition, Cambridge, England, 2008.
2) Andrzej Ziabicki, Fundamentals of fibre formation, John wiley& Sons, NY, 1976 (Reference)
3) T. Nakajima (English edition by K. kajiwara and J E McIntyre, Advanced fiber spinning technology, English edition, Woodhead Publishing Limited, England, 1994. (Reference)

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/ OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, and CD2
CD4	Mini projects/Projects	CO4	CD1
CD5	Laboratory experiments/teaching aids	CO5	CD1, and CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	**CL422**
Course title:	Polymer Composite
Pre-requisite(s):	
Co- requisite(s):	**Nil**
Credits:	L: 03 T: 00 P: 00
Class schedule per week:	**03**
Class:	**B. Tech**
Semester / Level:	**07**
Branch:	**chemical engg/ Chemical Engineering- Plastics and Polymer**
Name of Teacher:	

Course Objectives

This course enables the students to:

1.	Impart the fundamentals of polymer composites and its applications.
2.	Know about manufacture, properties and application of polymer and fibre.
3.	Explain the basic properties, characteristics and constituents of composite materials
4.	Present and apply the different fabrication processes for composite materials, including bonding, fastening, laminating, and finishing techniques
5.	Perform design, construction, and fabrication of laminate parts. Define and use appropriate terminology as it relates to composite structure design and manufacturing

Course Outcomes

After the completion of this course, students will be able to:

CO 422.1	Remember: Classify the different type of polymeric composites and its applications.
CO 422.2	Understanding: Ability to select the process for fabrication of polymer composites.
CO 422.3	Applying: Select different types of matrix and reinforcement materials.
CO 422.4	Analysing: Relate theoretical knowledge with typical products and its stress – strain behavior.
CO 422.5	Evaluate: Aware of different testing and characterization of polymer composites.

Syllabus

MODULE	No. of Lecture Hours
Module1 Polymer composite systems: Types of composites, reinforcements, Types of Resin..	8
Module2 Natural fibre: Jute, sisal, cotton, hemp ceramic fibre: silicon carbaide, zinc, Alumina, glass,synthetic fibre: polyethylene, polyester, nylon, Kevlar etc.	8
Module3 Thermoset, elastomer - resins (polyesters, epoxide, vinyl ester, phenol formaldehyde, polyimide, reinforced polyolefin, Semicrystalline and amorphous polymers - PEEK, PP, PEK, PBT, PC, ABC, nylon etc.) additives, reinforcements (particulate, fibrous, gaseous).	8
Module4 Processing techniques - open mould, hand lay up spray up, vacuum bag moulding, pressure bag moulding, autoclave moulding, closed mould, SMC, DMC, RTM., Continuous manufacturing process - pultrusion, filament winding, centrifugal casting. Application (sandwich constructions - aircraft, racing cars, helicopter rotor blades etc.)..	8
Module 5 Mechanical behaviour of composites – Analysis of continuous fibre composites, and shortfibre composites. Deformation behaviour of single ply and laminates. Creep, Fatigue Impact. Electrical,and thermal properties..	6

Text books:

1. Dyson, R.W., "Engineering Polymers", Blackie, 1990.
2. Crawford, R.J., Plastics Engineering, Pergamon Press.
3. Richardson, T., Composites – a design guide industrial press Inc., New York, 1987.

Reference books:

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/ OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, and CD2
CD4	Mini projects/Projects	CO4	CD1
CD5	Laboratory experiments/teaching aids	CO5	CD1, and CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code	CL423
Course title	Introduction to Microelectronics Fabrication
Pre-requisite(s)	Basic Electrical and Electronics Engineering
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	VII
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:
This course enables the students to:

1.	Understand the basics of micromachining processes, including surface micromachining.
2.	Understand the bulk micromachining and LIGA (Lithography, Electroplating and Micro molding) processes.
3.	Learn the concepts and details on all techniques and processes of patterning, deposition, and material removal.
4.	Describe microelectronics fabrication processes for IC, MEMS, NEMS, FET, SENSORS manufacture.
5.	Learn the basic micro-fabrication processes and different characterization techniques.

Course Outcomes:
After the completion of this course, students will be able to:

CO 423.1	Understand the theoretical principles of all processes involved in microelectronics fabrication.
CO 423.2	Identify, formulate, and solve problems relating to microelectronics manufacturing.
CO 423.3	Select a fabrication process or sequence of processes suitable for production of a microelectronic device.
CO 423.4	Design micro-machines by using fundamental skills learned in this course.
CO 423.5	Understand the processes for IC, MEMS, NEMS, FET, SENSORS manufacturing technology

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction: Review of Chip Manufacturing Process, Front-End-Of-Line (FEOL) and Back-End-Of Line (BEOL) concepts; Patterning: Introduction; Patterning techniques classification- Top down, bottom up, combined, serial, parallel techniques, introduction to polymer thin films	8
Module 2: Lithography: basics, Types – Photolithography, Microcontact printing, Nano-imprint lithography, Hot embossing, Replica Molding (REM), Mircomolding in capillaries (MIMIC), Capillary Force Lithography, Polymer bonding lithography, Elastic contact lithography, Lithography induced self-assembly	8
Module 3: Deposition: Physical and Chemical Vapor Deposition (PVD & CVD) basics, Electrochemical deposition, Electro-migration & grain size, Implantation basics, Constant source and limited source diffusion, Mask making, Phase shift mask;	8
Module 4: Material Removal: Plasma and wet etching, Aluminum and Oxide etching, Chemical Mechanical Polishing (CMP) basics, Dishing, Erosion, Issues in Shallow Trench Isolation, Oxide Polish and Copper Polish, Dummy fill; Process Integration: BEOL Issues, Cu/Al metallization, oxide/low-k integration	8
Module 5: Introduction to MEMS, NEMS, FET, organic memory devices, VOC sensors, actuators and other applications. Testing: Scribeline Test for process evaluation, Functional Test for product evaluation, Process stability and control, Yield Models	8

TEXT BOOK:

1. The Science and Engineering of Microelectronic Fabrication (2nd Edition) by S.A. Campbell, Oxford Univ Press, 2001

Reference Books:

1. VLSI Technology by C.Y. Chang and S.M.Sze, McGraw Hill, 1996
2. Introduction to Microelectronic Fabrication, Vol 5 of Modular Series on Solid State Devices (2nd Edition) by Richard C. Jaeger, Prentice Hall, 2001
3. Microchip Fabrication: A Practical Guide to Semiconductor Processing (2nd Edition) by Peter Van Zant, Carol Rose (Editor), Daniel Gonneau (Editor), Semiconductor devices, 1990

Gaps in the syllabus (to meet Industry/Profession requirements)
Applications of Microelectronic fabrication to wide variety of applications other than covered in syllabus

POs met through Gaps in the Syllabus
PO2, PO3, PO4, PO5 and PO5

Topics beyond syllabus/Advanced topics/Design
Detailed concepts for design and fabrication of MEMS, NEMS, FET, OFET, advanced transistors, medical devices and others

POs met through Topics beyond syllabus/Advanced topics/Design
PO2, PO3, PO4, PO5 and PO5

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	2	2	3	2	1	1	3	3	1	3	3	3	3
CO2	3	3	2	2	3	2	1	1	3	3	1	3	3	3	3
CO3	3	3	2	2	3	2	1	1	3	3	1	3	3	3	3
CO4	3	3	1	1	3	1	1	1	3	3	1	3	3	1	3
CO5	3	3	1	1	3	1	1	1	3	3	1	3	3	1	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL424
Course title: Microfluidics
Pre-requisite(s):
Co- requisite(s):
Credits: L:03 T:00 P:00
Class schedule per week: 03
Class: B. Tech.
Semester / Level:
Branch: Chemical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Define the basics of microfluidics.
2.	Describe the behaviour of fluids in Microsystems.
3.	Explain the operating principles and physical mechanism unique to microfluidics.
4.	Explain different technological and scientific applications of microfluidics technology.
5.	Demonstrate an understanding of scaling of fundamental dynamics in microfluidic systems.

Course Outcomes
After the completion of this course, students will be able to:

CO.424.1	Explain the theory and physical principles of fluid mechanics on the microscale.
CO.424.2	Solve problems related to surface tension and interfacial energy in microfluidic systems.
CO.424.3	Describe the electrohydrodynamics fundamentals and solve related problems for microfluidic systems.
CO.424.4	Mathematically model microfluidic devices and systems.
CO.424.5	Propose design strategies for microfluidic systems based on fluid mechanics principles.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws. Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels. Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel.	8
Module 2: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.	8
Module 3: Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electroosmotic flow, Ideal EOF with back pressure, Cascade electroosmotic micropump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere.	8
Module 4: Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer microfabrication, PMMA/COC/PDMS substrates, micromolding, hot embossing, fluidic interconnections.	8
Module 5: Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps. Microvalves, Pneumatic valves, thermopneumatic valves, Thermomechanical valves, Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves. Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors. Micromixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion. Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport. Microparticle separator, principles of separation and sorting of microparticles, design and applications. Microreactors, Design considerations, Liquid-phase	8

reactors, PCR, Design consideration for PCR reactors. **Few applications of microfluidics:**Drugdelivery, Diagnostics, Bio-sensing.	

Books:

1. Nguyen, N. T., Werely, S. T., Fundamentals and applications of Microfluidics, Artech house Inc., 2002.
2. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
3. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.
4. Tabeling, P., Introduction to microfluidics, Oxford University Press Inc., 2005.

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	3	3	2	2	2	2	0	1	2	0	3	3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0	3	3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0	1	3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0	3	3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used

CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: **CL425**
Course title: **Plastic Packaging Technology**
Pre-requisite(s):
Co- requisite(s):
Credits: L:03 T:00 P:00
Class schedule per week: **03**
Class: **B. Tech.**
Semester / Level:
Branch: **Chemical Engineering, Chemical Engineering-Plastics & Polymer**
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Study the basic concepts of packaging technology
2.	Understand marketing as an integral tool to packaging
3.	Recognize the importance of product-package interaction & its quality aspects in packaging
4.	Study the overall perspective of the packaging industry
5.	Apply and examine the knowledge of properties for selection of packaging materials

Course Outcomes

After the completion of this course, students will be able to:

CO 425.1	Remember: Effectively observe and compare the different package forms
CO 425.2	Understand: Describe the importance of compatibility studies and their associated parameters.
CO 425.3	Apply: Select the suitable types of packaging material for a particular application(s).
CO 425.4	Analyze: Analyze the various hazards & environmental issues, aesthetics of a package and the differentiating factors.
CO 425.5	Evaluate: Able to judge the right kind packaging material with the help of quality parameter(s).

Syllabus

MODULE	No. of Lecture Hours
Module:1 Definition of Packaging, Benefits of Packaging, Types of Packaging, Principles of Food Packaging, Climate Hazards on Packages, Functions of Packages. Protective Packaging – Principle, Materials used, Functions. Design Fundamentals- Need for Chances in Package Design, Features of Effective Design, Design Factors, Customer Appeal, Packaging Graphics, Package Colour.	9
Module:2 Packaging in Metal cans - Raw materials, Coatings, film laminates and inks, Processing of food and drinks in metal packages, Shelf life of canned foods Packaging in glass containers- Glass containers market sectors for foods and drinks, Attributes of food packaged in glass containers, Environmental profile Paper and paperboard packaging- Paper and paperboard – fibre sources and fibre separation (pulping), Paper and paperboard manufacture, Properties of paper and paperboard, Package types, Environmental profile.	8
Module3 Plastics in packaging - Use of plastics in food packaging, Types of plastic used in packaging – Polyethylene, Polypropylene (PP), Polyethylene terephthalate, Ethylene vinyl acetate (EVA), Polyamide (PA), Polyvinyl chloride (PVC), Polyvinylidene chloride (PVdC), Polystyrene (PS), Acrylonitrile butadiene styrene (ABS), Ethylene vinyl alcohol (EVOH) etc.	7
Module4 Coating of plastic films – types and properties, Acrylic coatings, PVdC coatings, PVOH coatings, Low-temperature sealing coatings (LTSCs), Metallising with aluminium, Extrusion coating with PE, Printing and labelling, Novel MAP applications for fresh-prepared produce, Novel MAP gases, Food contact and barrier properties, Sealability and closure, Retort pouch..	9
Module 5 Active and intelligent packaging, Active packaging techniques, Intelligent packaging techniques, Environmental and waste management issues with plastic packaging, Legislative issues, developing novel biodegradable materials, Modern packaging systems: Green plastics for food packaging, Recycling packaging materials.	7

Text books:

1. Ahvenainen R. 2001. Novel Food Packaging Techniques.CRC.
2. Crosby NT. 1981.Food Packaging Materials. App. Sci. Publ.
3. Mahadeviah M &Gowramma RV. 1996. Food Packaging Materials. Tata McGraw Hill.
4. FA Paine & H Y Paine, 1992, springer A Handbook of Food Packaging. Blackie.

Reference books:

1. Palling SJ. 1980. Developments in Food Packaging. App. Sci. Publ.
2. Rooney ML. 1988. Active Food Packaging.Chapman& Hall.
3. Sacharow S & Griffin RC.1980.Principles of Food Packaging. AVI Publ.
4. Stanley S & Roger CG. 1998. Food Packaging. AVI Publication.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –
1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
CO1	3	2	2	1	1	2	3	2	1	2	2	2	3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2	2	3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3	2	1	1	1

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method Used**
CD1	Lecture by use of boards/LCD projectors/ OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8
CD3	Seminars	CO3	CD1, and CD2
CD4	Mini projects/Projects	CO4	CD1
CD5	Laboratory experiments/teaching aids	CO5	CD1, and CD2
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL426
Course title: Chemical Process Intensification
Pre-requisite(s):
Co- requisite(s):
Credits: L: 03 T: 00 P: 00
Class schedule per week: 3
Class: B. Tech.
Semester / Level:
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understand process intensification and mechanisms involved in it.
2.	Understand role of process intensification in sustainable development.
3.	Understand Process Intensification by monolith reactor and membrane.
4.	Understand Process intensification in distillation and extraction.
5.	Understand Micro process Technology in process intensification.

Course Outcomes:
After the completion of this course, students will be able to:

CO 426.1	Explain process intensification and mechanisms involved in the process intensification.
CO 426.2	Explain role of process intensification in sustainable development and design techniques in process intensification.
CO 426.3	Explain mechanism of cavitation-based process intensification.
CO 426.4	Explain Process Intensification by monolith reactor and membrane.
CO 426.5	Explain Process intensification in distillation and extraction.

Syllabus

Module 1 Introduction on Process Intensification: History, Philosophy and Concept, Principle Features, Strategies and domain based techniques. Mechanism involved in the process intensification: Intensification by fluid flow process, Mechanism of Intensification by mixing, Intensification in Reactive system.	8
Module 2 Role of Process intensification in sustainable development: Problems leading to sustainable development, Concept, Issues and Challenges, Strategies in process design. Design Techniques for Process Intensifications : Scales and stages of process intensification, Methods and Tools for Achieving sustainable design, Multi-level Computer aided tools.	8
Module 3 Process intensification by cavitation: Introduction and Mechanism of Cavitation-based PI, Cavitational Reactor Configurations and activity, Parametric effects on cavitation. Process Intensification by monolith reactor: Introduction of monolith reactor, Preparation of monolithic catalyst, Application of monolithic catalyst, Hydrodynamics, transport of monolithic reactor.	8
Module 4 Process intensification in distillation: Introduction and Principles, Types of Intensified Distillation Units, Design of membrane-assisted distillation. Process intensification in extraction: Introduction and Principles, Supercritical extraction for process intensification.	8
Module 5 Process intensification by membrane: Introduction to membrane and its principles, Membrane engineering in process intensification. Micro Process Technology in process intensification: Introduction to microprocess technology, Process Intensification by Microreactors, Hydrodynamics and transport in microchannel based microreactor.	8

Text books:

1. Kamelia Boodhoo and Adam Harvey. Process Intensification for Green Chemistry Engineering Solutions for Sustainable Chemical Processing, Edited by Kamelia Boodhoo and Adam Harvey , School of Chemical Engineering & Advanced Materials Newcastle University, UK. Willey, 2013.

2. Juan¬Gabriel¬Segovia-Hernández¬ Adrián¬Bonilla-Petriciolet Editors, Process Intensi cation in Chemical Engineering Design Optimization and Control, Springer, 2016.

3. David Reay, Colin Ramshaw, and Adam Harvey, Process Intensification: Engineering for effgiciency, sustainability and flexibility, IchemE, 2nd edition, 2013, Elsevier.
4. S. K. Majumder, Hydrodynamics and Transport Processes of Inverse Bubbly Flow, 1st ed. Elsevier, Amsterdam (2016)

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CO303.1	3	3	1	1	1	2	1	1	2	1	0	2	3	2	3
CO303.2	3	3	0	3	3	1	0	0	3	2	0	2	3	3	3
CO303.3	3	3	1	3	3	1	0	0	2	2	0	2	3	3	2
CO303.4	3	3	2	2	3	1	1	1	3	3	1	3	3	3	3

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8, CD9
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD8, CD9
CD3	Seminars	CO3	CD1, CD2, CD8, CD9
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8, CD9
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8, CD9
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: CL427
Course title: Computer Aided Process Engineering
Pre-requisite(s): Numerical methods MA203,Chemical process calculations CL204, Transport phenomena CL210.
Co- requisite(s): Chemical reaction engineering-I CL302
Credits: 4 (L:3 T:1 P:0)
Class schedule per week: 4
Class: B. Tech.
Semester / Level: VII / Fourth
Branch: Chemical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Learn the method and basic concept of steady state and unsteady state process simulation, preliminary flowsheet development.
2.	Develop model formulation and numerical method for continuous process with multiple units.
3.	Learn the application and methods for vapor-liquid equilibrium and liquid-liquid equilibrium VLE/LLE calculations in a chemical process.
4.	Learn the application of probability distribution function in engineering field and model feeding with real data.
5.	Learn the ASPEN plus commercial software and Excel VBA in flow sheeting of a chemical process.

Course Outcomes
After the completion of this course, students will be able to:

CO427.1	Adapt the basic flowsheet in a chemical process plant.
CO427.2	Formulate the conservation equations for a continuous process from the concept of chemical engineering to evaluate and examine steady state operating conditions.
CO427.3	Formulate the conservation equations for a continuous process from the concept of chemical engineering to evaluate and examine unsteady state process with transient analysis.
CO427.4	Formulate the Vapor-liquid equilibrium and liquid-liquid equilibrium data in a chemical process to analyze the yield, quality of a chemical process.
CO427.5	Make use of different commercial software's to formulate and analyze a chemical process.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Macroscopic view with steady state: mass conservation equation for multiple unit with and without chemical reaction, energy conservation equation of multiple unit with chemical reaction. Their application and flowsheet formulation; model equations and numerical methodology for continuous process with recycle, purge streams	9
Module 2: Microscopic view: Mass, momentum and energy conservation equations for a unit, unsteady state model formulation and numerical methodology. Modeling / simulation of different process equipment - heat exchangers, furnaces, flash drum, distillation, absorption, other staged / differential contacting processes, reactors etc. Techniques of process flow sheeting.	8
Module 3: Vapor-liquid equilibrium and liquid-liquid equilibrium VLE/LLE calculations for process simulation and its importance. Algorithms for VLE / LLE calculation methods for ideal and non-ideal systems	8
Module 4: Probability distribution functions in engineering application and its statistics, Probability distribution of discrete variables, Probability distribution of continuous variables, fitting real data to a probability distribution function.	7
Module 5: Commercial steady state process simulators. Simulator components and structures. Salient features of simulators like ASPEN plus, DESIGN II etc. Excel VBA as a problem-solving tool for chemical engineering.	8

Text books:

1. Himmelblau, D.M., “Basic Principles and Calculation in chemical engineering”, Prentice Hall.
2. Stephenopolos, S., "Chemical process control", Prentice Hall of India, New Delhi, 1984.
3. Introduction to Chemical Engineering Computing, Bruce A Finlayson, JOHN WILEY & SONS, INC., PUBLICATION.

Reference books:

1. DELANCEY, G., PRINCIPLES OF CHEMICAL ENGINEERING PRACTICE, Wiley, 2013.
2. DeCoursey, W.J., Statistics and Probability for Engineering Applications with Microsoft® Excel, Newnes, Elsevier, 2003.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second Quiz	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
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CO303.1	3	3	1	1	1	2	1	1	2	1	0	2	3	2	3
CO303.2	3	3	0	3	3	1	0	0	3	2	0	2	3	3	3
CO303.3	3	3	1	3	3	1	0	0	2	2	0	2	3	3	2
CO303.4	3	3	2	2	3	1	1	1	3	3	1	3	3	3	3

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1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8, CD9
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CD3	Seminars	CO3	CD1, CD2, CD8, CD9
CD4	Mini projects/Projects	CO4	CD1, CD2, CD8, CD9
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD8, CD9
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		