BIRLA INSTITUTE OF TECHNOLOGY

CURRICULUM
BASED ON NEP-2020, CBCS & OBE MODEL

(Effective from Academic Session: 2024-25)

NAME OF THE PROGRAMME

B.TECH. (CHEMICAL ENGINEERING)

NAME OF THE DEPARTMENT

CHEMICAL ENGINEERING

Institute Vision

To become a Globally Recognized 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 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, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

2. **Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

3. **Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

4. **Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

5. **Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

6. **The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

7. **Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

8. **Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

9. **Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

10. **Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

11. **Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

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 the technical profession.
3. To prepare students for employment in industries such 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 knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
3. **Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
4. **Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
5. **Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
6. **The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
7. **Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
8. **Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
9. **Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
10. **Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one’s own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

11. **Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

(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.

Mapping of POs and PSOs with PEOs

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
PO1	3	3	3	2	3	
PO2	3	2	3	2	3	
PO3	3	3	3	2	3	
PO4	3	3	3	1	3	
PO5	3	3	2	1	3	
PO6	2	3	2	3	2	
PO7	3	1	2	1	2	
PO8	1	3	1	3	1	
PO9	3	3	2	2	2	
PO10	3	3	2	2	3	
PO11	3	2	2	1	3	
PSO1	3	3	3	3	3	
PSO2	3	3	3	2	3	
PSO3	3	2	3	2	3	

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping of PO vs DM (Department Mission)

	DM1	DM2	DM3
PO1	3	3	3
PO2	3	3	3
PO3	3	3	3
PO4	3	2	2
PO5	2	2	2
PO6	3	3	2
PO7	1	1	3
PO8	1	1	1
PO9	2	3	2
PO10	3	2	1
PO11	3	3	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Birla Institute of Technology, Mesra, Ranchi

Course Structure for B.Tech. (Chemical Engineering)

Based on NEP-2020, CBCS and OBE, Effective from 2024-2025

Sr. No.	Semester of Study (Recommended)	Category of Course	Course Code	Subjects	Mode of Delivery s Credits *L-Lecture; T-Tutorial; P-Practical*			Total Credits
					L *(Periods / Week)*	T *(Periods/ Week)*	P *(Periods/ Week)*	
	FIRST	**THEORY**						
I.1		FS	MA24101	Mathematics - I	3	1	0	4
I.2			PH24101	Physics	3	1	0	4
I.3			BE24101	Biological Science for Engineers	2	0	0	2
I.4		GE	CS24101	Programming for Problem Solving	3	1	0	4
I.5			EE24101	Basics of Electrical Engineering	2	1	0	3
		LABORATORIES						
I.6		FS	PH24102	Physics Laboratory	0	0	2	1
I.7		GE	CS24102	Programming for Problem Solving Laboratory	0	0	2	1
I.8			EE24102	Electrical Engineering Laboratory	0	0	2	1
I.9		HSS	HS24131	Communication Skill - I	0	0	3	1.5
I.10		MC	MC24 101/102/103 /104/105	Choice of : NCC/NSS/ PT C Games/ Creative Arts (CA) /Entrepreneurship	0	0	2	1
				TOTAL (Theory + Labs)				**22.5**
	SECOND	**THEORY**						
II.1		FS	MA24103	Mathematics - II	3	1	0	4
II.2			CH24101	Chemistry	3	1	0	4
II.3		GE	EC24101	Basic Electronics	2	1	0	3
II.4			ME24101	Basics of Mechanical Engineering	2	1	0	3
II.5		FS	CE24101	Environmental Science	2	0	0	2
		LABORATORIES						
II.6		FS	CH24102	Chemistry Laboratory	0	0	2	1
II.7		GE	EC24102	Basic Electronics Laboratory	0	0	2	1
II.8			ME24102	Engineering Graphics	0	0	4	2
I.9			PE24102	Workshop Practice	0	0	2	1
I.10		MC	MC24 106/107/108/109 /110	Choice of : NCC/NSS/ PT C Games/ Creative Arts (CA) /Entrepreneurship	0	0	2	1
				TOTAL (Theory + Labs)				**22**
				GRAND TOTAL FOR FIRST YEAR				**44.5**
Vocational Course I: CL 24102 (Introduction to Chemical Engineering)					1	0	4	3
Vocational Course II: (Basics of Process Calculations and Mechanical Operations)					1	0	4	3

	THIRD	THEORY						
III.1		PC	CL24201	Thermodynamics	3	1	0	4
III.2		PC	CL24203	Fluid Mechanics	3	1	0	4
III.3		PC	CL24205	Chemical Process Calculations	2	1	0	3
III.4		PC	CL24207	Heat Transfer Operations	3	1	0	4
III.5		FS	MA24201	Numerical Methods	2	0	0	2
III.6		HSS	MT24131	UHV-II: Understanding Harmony	3	0	0	3
		LABORATORIE S						
III.7		FS	MA24202	Numerical Methods Laboratory	0	0	2	1
III.10		MC	MC24 201/202/2 03/204 /205	Choice of : NCC/NSS/ PT C Games/ Creative Arts (CA) / Entrepreneurship	0	0	2	1
				TOTAL (Theory + Labs)				22
	FOURTH	THEORY						
IV.1		PC	CL24209	Mechanical Operations	3	0	0	3
IV.2			CL24211	Mass Transfer Operation - I	3	1	0	4
IV.3			CL24213	Chemical Reaction Engineering-I	3	1	0	4
IV.4			CL24215	Material Science C Engineering	3	0	0	3
IV.5		PE	CL24XXX	Program Elective (PE-I)	3	0	0	3
IV.6		OE	XX24XXX/ MO24201	Open Elective - I / MOOC - I	3	0	0	3
IV.7		MC	HS24211	Indian Knowledge System	2	0	0	0
		LABORATORIES						
IV.8		PC	CL24202	Chemical Engineering Lab -I	0	0	3	1.5
IV.12		MC	MC24 206/207/2 08/209/21 0	Choice of : NCC/NSS/ PT C Games/ Creative Arts (CA) / Entrepreneurship	0	0	2	1
				TOTAL (Theory + Labs)				22.5
				GRAND TOTAL FOR SECOND YEAR				44.5
Vocational Course III: CL24252 Introduction to Industrial Chemical Processes					1	0	4	3
Vocational Course IV: CL24254 (Fundamental of Process Control and Separation Processes)					1	0	4	3
	FIFTH	THEORY						
V.1		PC	CL24301	Mass Transfer Operation - II	3	1	0	4
V.2			CL24303	Chemical Reaction Engineering-II	3	1	0	4
V.3			CL24305	Project Engineering and Economics	3	0	0	3
V.4			CL24307	Chemical Process Technology	3	0	0	3
V.5		PE	CL24XXX	Program Elective-II)	3	0	0	3

V.6		OE	XX24XXX/ MO24301	Open Elective - II / MOOC - II	3	0	0	3
		LABORATORIES						
V.7		PC	CL24304	Computer Aided Process Engineering Lab.	0	0	3	1.5
V.8			CL24302	Chemical Engineering Lab -II	0	0	3	1.5
V.9		HSS	HS24133	Communication Skill - II	0	0	3	1.5
V.10		PC	CL24300	Project - I				2
TOTAL (Theory + Labs)								**26.5**
	SIXTH	**THEORY**						
VI.1		PC	CL24309	Transport Phenomena	3	1	0	4
VI.2		PC	CL24311	Process Control C Instrumentation	3	1	0	4
VI.3		PE	CL24XXX	Program Elective -III	3	0	0	3
VI.4		PE	CL24XXX	Program Elective -IV	3	0	0	3
VI.5		OE	XX24XXX/ MO24303	Open Elective - III / MOOC - III	3	0	0	3
		LABORATORIES						
VI.6		PC	CL24306	Process Equipment design Lab	0	0	3	1.5
VI.7			CL24308	Chemical Engineering Lab - III	0	0	3	1.5
VI.8			CL24350	Project-II				2
TOTAL (Theory + Labs)								**22**
GRAND TOTAL FOR THIRD YEAR								**48.5**
	SEVENTH	**THEORY**						
VII.1		PC	CL24401	Process Modeling, Simulation C Optimization	3	1	0	4
VII.2		PE	CL24XXX	Program Elective -V)	3	0	0	3
VII.3		PE	CL24XXX	Program Elective -VI)	3	0	0	3
VII.4		OE	XX24XXX/ MO24401	Open Elective (OE-IV)/MOOC-IV	3	0	0	3
VII.5		HSS	MT24204	Constitution of India	2	0	0	0
		LABORATORIES						
VII.6		PC	CL24402	Process Control C Instrumentation Lab	0	0	3	1.5
VII.7			CL24404	Plant Design	0	0	4	2
VII.8		PC	MC24400	Summer Training				4
VII.9		PC	CL24400	Project - III				3
TOTAL (Theory + Labs)								**23.5**
VIII.1	**EIGHTH**	PC	CL24450/ CL24490	Project-IV / Industry Internship				6
VIII.2			CL24498	Comprehensive Viva				1
	TOTAL (Theory + Labs)							**7**
GRAND TOTAL FOR FOURTH YEAR								**30.5**
GRAND TOTAL FOR B.TECH.								**168**

DEPARTMENT OF CHEMICAL ENGINEERING
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
2	PE 1 (IV Semester)	CL24231	Energy Engineering	CL24207, CL24205	3	0	0	3
2		CL24233	Macromolecular Science	CH24101, PH24101	3	0	0	3
2		CL24235	Computer Aided Process Engineering	MA24201, CL24201, CL24203	3	0	0	3
2		CL24237	Waste Management	CH24101, PH24101	3	0	0	3
2		CL24239	Safety & Hazards in Process Industries	CH24101, PH24101	3	0	0	3
3	PE 2 (V Semester)	CL24331	Petroleum Refinery Engineering	CH24101, CL24207, CL24211, CL24301	3	0	0	3
3		CL24333	Polymer Technology	CH24101, CL24233	3	0	0	3
3		CL24335	Fluid-Solid Operation	CL24203, CL24209	3	0	0	3
3		CL24337	Fertilizer Technology	CL24201, CL24205, CL24211, CL24207	3	0	0	3
3		CL24339	Biomaterials	CH24101, PH24101, CL24233	3	0	0	3
3		CL24341	Analytical Instrumental Methods	CH24101, PH24101	3	0	0	3
3	PE 3 (VI Semester)	CL24351	Polymer Processing	CL24233, CL24333	3	0	0	3
3		CL24353	Design and Analysis of Experiments	CH24101, PH24101	3	0	0	3
3		CL24355	Pollution Control and Equipment Design	CH24101, PH24101, MA24101	3	0	0	3
3		CL24357	Petrochemicals Technology	CH24101, CL24331	3	0	0	3
3		CL24359	Nanotechnology	CH24101, PH24101	3	0	0	3
3	PE 4 (VI Semester)	CL24371	Membrane Science & Technology	CL24201, CL24233, CL24211	3	0	0	3
3		CL24373	Reservoir Engineering	CL24201, CH24101, MA24201	3	0	0	3
3		CL24375	Colloid and Interfacial Science	CH24101, PH24101, CL24201	3	0	0	3
3		CL24377	Computational Fluid Dynamics	CL24203, MA24201, CL24207	3	0	0	3
3		CL24379	Environment & Plastics	CL2433, CL24351	3	0	0	3
4	PE 5 (VII Semester)	CL24431	Fibre Science & Technology	CH24101, CL24333, CL24351	3	0	0	3
4		CL24433	Introduction to Microelectronics Fabrication	EE24101, EC24101	3	0	0	3
4		CL24435	Microfluidics	CL24203	3	0	0	3
4		CL24437	Plastic Packaging Technology	CH24101, PH24101	3	0	0	3
4		CL24439	Chemical Process Intensification	CL24207, CL24211, CL24301	3	0	0	3
4	PE 6 (VII Semester)	CL24451	Polymer Composite	CH24101, PH24101, MA24101	3	0	0	3
4		CL24453	Elastomer Technology	CH24101	3	0	0	3
4		CL24455	Natural Gas Engineering		3	0	0	3
4		CL24457	Paints and Surface Coating Technology	CH24101, PH24101	3	0	0	3
4		CL24459	Biorefinery		3	0	0	3

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

DEPARTMENT OF CHEMICAL ENGINEERING
OPEN ELECTIVES (OE)*
OFFERED FOR LEVEL 1-4

OE / LEVEL	Code no.	Name of the PE courses	Prerequisites courses with code	L	T	P	C
OE1	CL24231	Energy Engineering	NIL	3	0	0	3
	CL24237	Waste Management	NIL	3	0	0	3
OE2	CL24341	Analytical Instrumental Methods	NIL	3	0	0	3
	CL24331	Petroleum Refinery Engineering	NIL	3	0	0	3
OE3	CL24353	Design and Analysis of Experiments	NIL	3	0	0	3
	CL24359	Nanotechnology	NIL	3	0	0	3
OE4	CL24435	Microfluidics	NIL	3	0	0	3
	CL24451	Polymer Composite	NIL	3	0	0	3
* OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS							

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2024-2025
Based on NEP 2020, CBCS & OBE model
Recommended scheme of study for
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**
		THEORY						
FIFTH (Monsoon)	Third	DS	CL24381	Multiphase flow	3	1	0	4
			CL24383	Numerical Heat Transfer and Fluid Flow	3	1	0	4
TOTAL								**8**
SIXTH (Spring)		**THEORY**						
	Third	DS	CL24385	Molecular Simulation	3	1	0	4
			CL24387	Process Integration	3	1	0	4
TOTAL								**8**
SEVENTH (Monsoon)		**THEORY**						
	Fourth	DS	CL24460	Project & Viva	0	0	8	4
TOTAL								**4**
GRAND TOTAL *Minimum requirement for in-depth specialization award*								**20**

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2024-2025
Based on NEP 2020, CBCS & OBE model
Recommended scheme of study for
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 (Recomended)	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
		THEORY						
FIFTH (Monsoon)	Third	DS	CL24391	Intoduction to Polymer Science	4	0	0	4
			CL24393	Polymer Technology - I	4	0	0	4
TOTAL								**8**
SIXTH (Spring)		**THEORY**						
	Third	DS	CL24395	Polymer Process Technology	3	1	0	4
		DS	CL24397	Polymer Technology - II	4	0	0	4
TOTAL								**8**
SEVENTH (Monsoon)		**THEORY**						
	Fourth	DS	CL24470	Project & Viva	0	0	8	4
TOTAL								**4**
GRAND TOTAL *Minimum requirement for in-depth specialization award*								**20**

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2024-2025
Based on NEP 2020, CBCS & OBE model
Recommended scheme of study for
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 (Recomended)	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**
		THEORY						
FIFTH (Monsoon)	Second	PC	CL24251	Unit Operation-I	3	1	0	4
	Second		CL24253	Unit Operation-II	3	1	0	4
TOTAL								**8**
SIXTH (Spring)		**THEORY**						
	Second	PC	CL24255	Fundamentals of Chemical Reaction Engineering	3	1	0	4
TOTAL								**4**
SEVENTH (Monsoon)		**THEORY**						
	Third	PC	CL24399	Unit Operation-III	3	1	0	4
	Fourth	PC	CL24480	Project & Viva	0	0	8	4
TOTAL								**8**
GRAND TOTAL *Minimum requirement for minor degree award*								**20**

BIRLA INSTITUTE OF TECHNOLOGY - MESRA, RANCHI
NEW COURSE STRUCTURE - To be effective from academic session 2024-2025
Based on NEP 2020, CBCS & OBE model

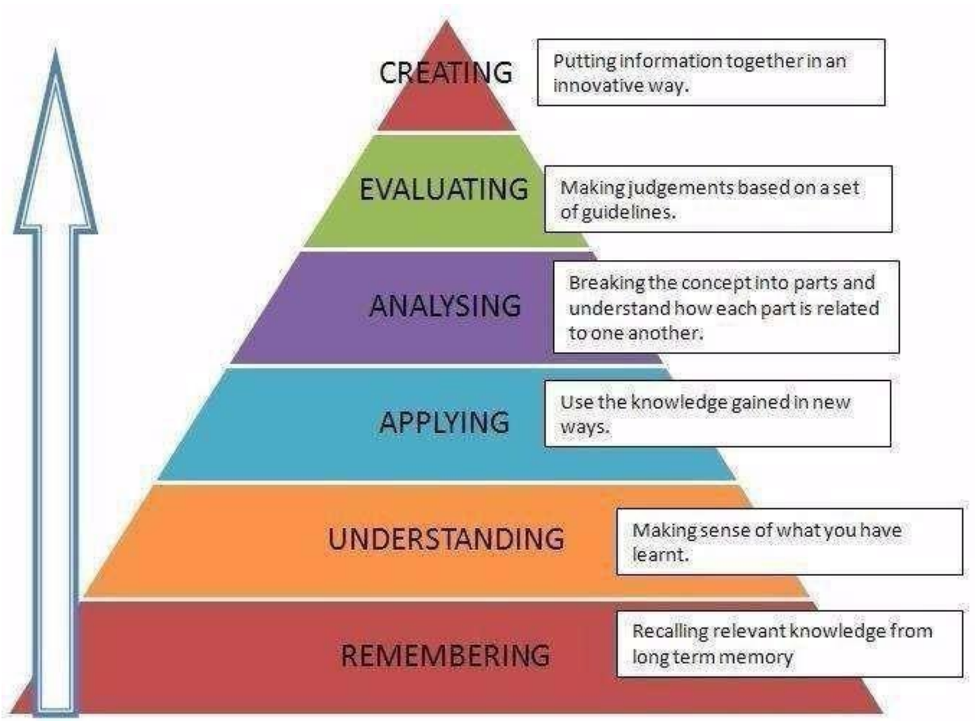
Vocational Courses

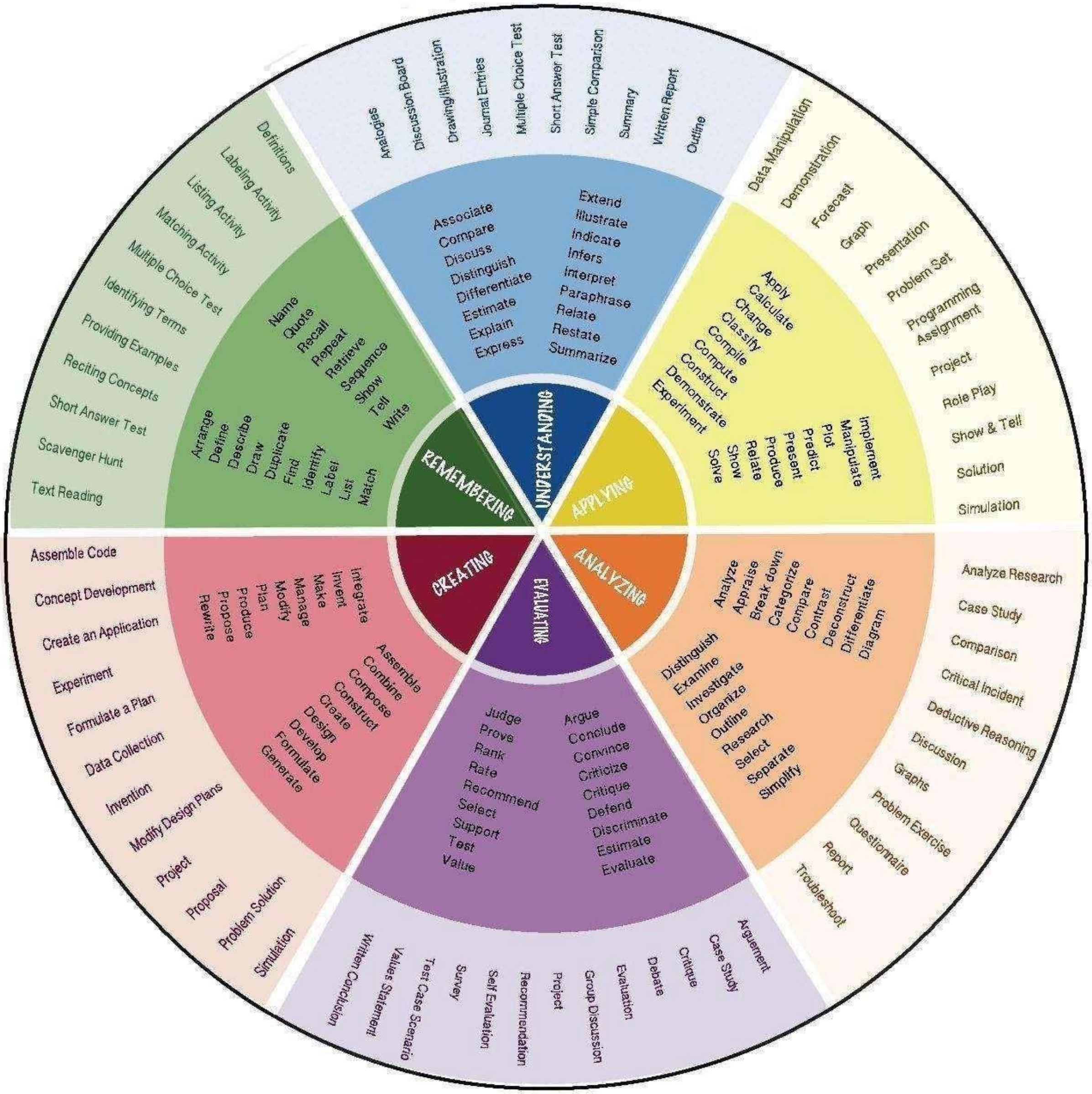
	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits L Lecture; T-Tutorial; P-Practical			Total Credits *C - Credits*
					L	T	P	C
	First	PC	CL24102	Introduction to Chemical Engineering	1	0	4	3
	First		CL24104	Basics of Process Calculations and Mechanical Operations	1	0	4	3
TOTAL (Minimum requirement for Certificate in Engineering)								**6**
	Second	PC	CL24252	Introduction to Industrial Chemical Processes	1	0	4	3
	Second		CL24254	Fundamentals of Process Control and Separation Processes	1	0	4	3
TOTAL (Minimum requirement for Diploma in Engineering)								**6**

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
Quote
Recall
Repeat
Retrieve
Sequence
Show
Tell
Write
Arrange
Define
Describe
Draw
Duplicate
Find
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
Compile
Compute
Construct
Demonstrate
Experiment
Implement
Manipulate
Plot
Predict
Present
Produce
Relate
Show
Solve
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

BIRLA INSTITUTE OF TECHNOLOGY

NEP-2020 CURRICULUM BOOK
(Effective from Academic Session: Monsoon 2024)

Bachelor of Technology

DEPARTMENT OF CHEMICAL ENGINEERING
FIRST YEAR (SEMESTER – I)

COURSE INFORMATION SHEET

Course Code: MA24101
Course Title: Mathematics-I
Pre-requisite(s): -
Co- requisite(s): --
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 4
Class: B.Tech.
Semester / Level: I/1
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	infinite sequences and series
2.	theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
3.	multivariable functions, partial differentiation, properties and applications of partial derivatives.
4.	integrals of multivariable functions viz. double and triple integrals with their applications
5.	properties like gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions

COURSE OUTCOMES (COs)

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

CO1	decide the behavior of sequences and series using appropriate tests.
CO2	handle problems related to the theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
CO3	get an understanding of partial derivatives and their applications in finding maxima - minima problems.
CO4	apply the principles of integrals (multivariable functions viz. double and triple integrals) to solve a variety of practical problems in engineering and sciences.
CO5	get an understanding of gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions and demonstrate a depth of understanding in advanced mathematical topics, enhance and develop the ability of using the language of mathematics in engineering.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
MODULE – I: Sequences and Series Sequences, Convergence of Sequence. Series, Convergence of Series, Tests for Convergence: Comparison tests, Cauchy's Integral test, Ratio test, Cauchy's root test, Raabe's test, Gauss test, Alternating series, Leibnitz test, Absolute and Conditional Convergence.	**9**
MODULE – II: Matrices Rank of a Matrix, elementary transformations. Vectors, Linear Independence and Dependence of Vectors. Consistency of system of linear equations. Eigenvalues, Eigenvectors, Cayley - Hamilton theorem.	**9**
III: Advance Differential Calculus Function of several variables, Partial derivatives, Euler's theorem for homogeneous functions, Total derivatives, Chain rules, Jacobians and its properties, Taylor series for function of two variables, Maxima – Minima.	**9**
MODULE – IV: Advance Integral Calculus Double integrals, double integrals in polar coordinates, Change of order of integration, Triple Integrals, cylindrical and spherical coordinate systems, transformation of coordinates, Applications of double and triple integrals in areas and volumes.	**9**
MODULE – V: Vector Calculus Scalar and vector point functions, gradient, directional derivative, divergence, curl. Line Integral, Work done, Conservative field, Green's theorem in a plane, Surface and volume integrals, Gauss – divergence theorem, Stoke 's theorem.	**9**

TEXTBOOKS:

1. M. D. Weir, J. Hass and F. R. Giordano: Thomas' Calculus, 11th edition, Pearson Educations, 2008E.
2. H. Anton, I. Brivens and S. Davis, Calculus, 10th Edition, John Wiley and sons, Singapore Pte. Ltd., 2013.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint,2010.

REFERENCE BOOKS:

1. M. J. Strauss, G. L. Bradley And K. J. Smith, Calculus, 3rd Ed, Dorling. Kindersley (India) Pvt. Ltd. (P Ed), Delhi, 2007.
2. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Ed. Asia, Indian Reprint, 2007.
3. Robert Wrede & Murray R. Spiegel, Advanced Calculus, 3rd Ed., Schaum's outline series, McGraw-Hill Companies, Inc.,2010.
4. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.

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
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internets
CD4	Laboratory experiments/teaching aids
CD5	Industrial/guest lectures
CD6	Industrial visits/in-plant training
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	1	0	0	0	0	1	2			
CO2	3	3	2	2	2	0	0	0	0	1	2			
CO3	3	3	2	2	1	0	0	0	0	1	2			
CO4	3	3	3	3	2	1	0	0	0	1	2			
CO5	3	3	2	3	2	1	1	1	1	2	2			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code: PH24101
Course Title: Physics
Pre-requisite(s): Intermediate Physics and Intermediate Mathematics
Co- requisite(s): Mathematics I
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 4
Class: B.Tech.
Semester / Level: I
Branch: All
Name of Teacher:

COURSE OBJECTIVES (numbers may vary depending on the course)

This course envisions to impart to students:

1.	The principles of physical optics and basic concept of fiber optics.
2.	Fundamental laws of electromagnetism leading to Maxwell's equations.
3.	The posulates of special theory of relativity, Lorenz transformation equation and their consequences: Einstein energy mass relation and relativistic energy-momentum relation
4.	The limitations of classical physics and basic concepts such as wave-particle duality, and working of quantum mechanics with the help of particles in a box problem
5.	Concepts of stimulated emission and working principle of laser with examples, concepts of nuclear physics and plasma physics

COURSE OUTCOMES (COs) (3 COs to 6 COs depending upon the course)

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

CO1	analyse the intensity variation of light due to polarization, interference and diffraction.
CO2	formulate and solve the problems on electromagnetism
CO3	explain and apply concepts of special theory of relativity and its consequences
CO4	Apply the concepts of quantum mechanics such as wave-particle duality and obtain the solution of simple quantum mechanical problems.
CO5	explain working principle of lasers and to summarize its applications, describe basic concepts of nuclear and plasma physics

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I: **Physical Optics:** Polarization, Malus' Law, Brewster's Law, Double Refraction, Interference in thin parallel films, Interference in wedge-shaped layers, Newton's rings, Fraunhofer diffraction by single slit and double slit. Elementary ideas of fibre optics and application of fibre optic cables	8
Module – II: **Electromagnetic Theory:** Gradient, Divergence and Curl, Statement of Gauss theorem & Stokes theorem, Gauss's law, Applications, Concept of electric potential, Relationship between E and V, Polarization of dielectrics and dielctric constant, Boundary conditions for E & D, Gauss's law in magnetostatics, Ampere's circuital law, Boundary conditions for B & H, Equation of continuity, Displacement current, Maxwell's equations.	8
Module – III: **Special Theory of Relativity:** Introduction, Inertial frame of reference, Galilean transformations, Postulates, Lorentz transformations and its conclusions, Length contraction, time dilation, velocity addition, Mass change, Einstein's mass energy relation.	6
Module – IV: **Quantum Mechanics:** Planck's theory of black-body radiation, Compton effect, Wave-particle duality, De Broglie waves, Davisson and Germer's experiment, Uncertainty principle, Brief idea of Wave Packet, Wave Function and its physical interpretation, Schrodinger equation in one-dimension, free particle, particle in an infinite square well	9
Module – V **Modern Physics:** Laser-Spontaneous and stimulated emission, Einstein's A and B coefficients, Population inversion, Light amplification, Basic laser action, Ruby and He-Ne lasers, Properties and applications of laser radiation, Nuclear Physics: Binding Energy Curve, Nuclear Force, Liquid drop model, Introduction to Shell model, Applications of Nuclear Physics, Concept of Plasma Physics and its applications.	9

TEXTBOOKS:
1. A. Ghatak, Optics, 4th Edition, Tata Mcgraw Hill, 2009
2. Mathew N.O. Sadiku, Elements of Electromagnetics, Oxford University Press, 2001
3. Arthur Beiser, Concept of Modern Physics, 6th edition, Tata McGraw- Hill, 2009
4. F. F. Chen, Introduction to Plasma Physics and controlled Fusion, Springer, Edition 2016.

REFERENCE BOOKS:
1. Fundamentals of Physics, Halliday, Walker and Resnick

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
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment/Quiz	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internets
CD4	
CD5	
CD6	
CD7	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	2	2	0	1	1	0	0	1	0	0	2			
CO2	2	2	0	1	1	0	0	1	0	0	2			
CO3	2	1	0	1	1	0	0	1	0	0	2			
CO4	2	1	0	1	1	0	0	1	0	0	2			
CO5	2	1	0	1	1	0	0	1	0	0	2			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method

CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code: BE24101
Course Title: Biological Science for Engineers
Pre-requisite(s): -
Co- requisite(s): -
Credits: 2 (L:2 T: 0 P: 0)
Class schedule per week: 2
Class: B. Tech
Semester / Level: FIRST
Branch: Biotechnology
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Understand fundamental concepts of biology relevant to engineering.
2.	Explore the structure and function of biological molecules and cells.
3.	Learn about genetic principles and molecular biology techniques.
4.	Understand the applications of biological science in various engineering fields considering global challenges and ethical considerations.

COURSE OUTCOMES (COs)

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

CO1	Comprehend and apply the fundamental concepts of biological sciences in the context of engineering.
CO2	Analyze the structure and function of biological molecules and cells and their relevance to engineering solutions.
CO3	Demonstrate understanding of genetic principles and molecular biology techniques and their applications in engineering.
CO4	Apply knowledge of biological sciences to innovate and develop solutions in various engineering domains and critically evaluate the role of biological sciences in addressing global challenges, including ethical and safety considerations.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module I: Introduction to Biological Sciences Overview and importance of biology in engineering, Origin of Life, Cell Theory and Structure.	**6**
Module II: Molecular Biology and Genetics Central Dogma of Molecular Biology, DNA, RNA and Protein structure and function, Mendelian Genetics, rDNA Technology and Genome Editing.	**6**

Module III: Biochemistry Cell Metabolism, Enzymes and Catalysis, Cell Communication and Signalling.	**6**
Module IV: Applications of Biological Sciences in Engineering Biomaterials, Bioinformatics, Biosensors and Bioelectronics (Biological Sensors- Ear & Eye), Synthetic Biology, Nanobiotechnology.	**6**
Module V: Global Challenges and Ethical Considerations Convergence of AI and Biology, Climate change and food security, Biosafety and Biohazards, Ethical Considerations.	**6**

TEXTBOOKS:

1. Lehninger A, Principals of Biochemistry
2. Stryer L, Biochemistry
3. K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry.
4. Biology for Engineers" by Arthur T. Johnson

REFERENCE BOOKS:

1. Purves et al, Life: The Science of Biology
2. R. Dulbecco, The Design of Life.
3. Biological Science Edited by Soper, Cambridge low price edition.
4. Synthetic Biology: A Primer" by Paul S. Freemont and Richard I. Kitney
5. "Introduction to Bioinformatics" by Arthur Lesk Genomes" by T.A. Brown

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
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	√	√	√	√
Semester End Examination	√	√	√	√

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

Course Outcomes (CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1:	3	3	3	3	1	1	1	2	1	1	1	3	2	3
CO2:	3	3	3	3	1	1	1	2	1	1	1	3	3	3
CO3:	1	3	3	3		1	1	1		1	1	2	3	3
CO4:	2	2	2	2		2	2	2		1	1	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code: CS24101
Course Title: Programming for Problem Solving
Pre-requisite(s): School-level mathematics and Science
Co- requisite(s):
Credits: L: 3 T: 1 P:0
Class schedule per week: 4
Class: UG
Semester / Level: II
Branch: ALL
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Develop Programming Skill.
2.	Understand the fundamental Concepts of Coding
3.	Learn how to Debug Programs
4.	Convert Problems to Programs

COURSE OUTCOMES (COs)

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

CO1	Formulate Algorithms for arithmetic and logical problems.
CO2	Translate the algorithms to programs.
CO3	Test and execute the programs and correct syntax and logical errors.
CO4	Apply programmatic skills for solving scientific problems.
CO5	Decompose problems into functions and structured programming.

SYLLABUS

MODULE	**(NO. OF LECTURE HOURS)**
Module – I Representation of an Algorithm: Flowchart/Pseudo code with examples. From algorithms to programs: source code, variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.	**6**
Module – II Structure of a C program, variables and data types, Operators – precedence and associativity, Evaluating expressions, Basic I/O – use of printf, scanf, getchar etc. and format specifiers, Conditional Branching statements – If, If - else, If-else- if, switch case, Writing nested conditional statements.	**8**
Module – III Iterative programming structures – for loops, while loops, do while loops. Understanding break and continue and their usage. Writing Nested loops, Arrays – creation and usage, Strings and string handling.	**8**

Module – IV Functions (including using built in libraries), Parameter passing in functions, call by value, Recursion, as a different way of solving problems, Nested function calls. Understanding scope and lifetime of a variable.	**8**
Module – V Structures - Defining structures, Accessing structures elements, Creating an array of Structures, Nested structures. Some advanced concepts – typedef, enum, macros. An introduction to pointers – understanding, creating pointers and accessing variables using pointers. Passing arrays to functions: idea of call by reference, passing parameters to main.	**10**

TEXTBOOKS:

1. Let us C, Yashwant Kanetkar, 18th Edition, BPB Publications
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
3. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
4. R.G.Dromey, How to Solve it by Computer, Pearson Education

REFERENCE BOOKS:

• Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

1. The syllabus focused on the concepts and basics of Program writing skills.
2. Industry often requires debugging of their existing programs/software compare to the new program, which is a knowledge beyond the basics, including real-world software (collection of programs) experience.
3. More memory management practices, file handling and library functions

POS MET THROUGH GAPS IN THE SYLLABUS: YES [PO1-PO5 & PO10-PO12]

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

File Handling with memory management, pre processor directives, Graphics, Data Arrangement, Task scheduling and assembly level programs.

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: YES [PO1-PO5]

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

- **Student Feedback on Course Outcome**
- **Student Feedback on Faculty/Content Delivery**
- **Student Feedback on Evaluation Procedures**

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars/ Quiz (s)
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Self-Learning, Group Study, Coding Contest

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	**3**	**3**	**3**	**3**	**3**	**2**	**0**	**1**	**2**	**2**	**2**			
CO2	**3**	**3**	**3**	**3**	**3**	**2**	**0**	**1**	**2**	**2**	**2**			
CO3	**3**	**3**	**3**	**3**	**3**	**2**	**0**	**1**	**2**	**2**	**2**			
CO4	**3**	**3**	**3**	**3**	**3**	**2**	**0**	**1**	**2**	**2**	**2**			
CO5	**3**	**3**	**3**	**3**	**3**	**2**	**0**	**1**	**2**	**2**	**2**			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD3, CD5
CO3	CD3, CD5, CD7
CO4	CD2, CD3, CD4, CD6, CD7
CO5	CD1, CD3, CD5, CD7

COURSE INFORMATION SHEET

Course Code: EE24101

Course Title: Basics of Electrical Engineering

Pre-requisite(s):

Co- requisite(s): Basic Sciences

Credits: 3 L: 2 T: 1 P: 0

Class schedule per week: 03

Class: B.Tech.

Semester / Level: I (II)/01

Branch: All

Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	realize the electrical signals, elements, and their properties.
2.	understand the mathematical representation of AC, DC signals and theorems/laws for solving electrical circuits with variations of voltage and frequency.
3.	perceive the 3-phase AC signal representation and 3-phase circuit analysis for balanced and unbalanced condition.
4.	understand the characteristics of magnetic material and analysis of magnetic circuits.

COURSE OUTCOMES (COs)

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

CO1	explain the voltage, current signals and their characteristics in electrical circuit elements.
CO2	apply the theorems/laws for electrical circuit analysis.
CO3	solve the electrical circuits for variable voltage and frequency to observe the resonance, power and power factor in the electric circuit.
CO4	analyze the 1-phase and 3-phase AC balanced and unbalanced circuits
CO5	apply the concept of magnetic circuits for magnetic circuit analysis.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Introduction:** Importance of Electrical Engineering in day-to-day life, Electrical elements, properties (linear, non-linear, unilateral, bilateral, lumped and distributed, etc.) and their classification, Ideal and Real Sources, Source Conversion, Star-Delta conversion, KCL and KVL, Mesh current and Nodal voltage method.	**8**
Module – II **D.C. Circuits**: Steady state analysis with independent and dependent sources; Series and Parallel circuits. **Circuit Theorems:** Superposition, Thevenin's, Norton's, and Maximum Power Transfer theorems for Independent and Dependent Sources applied to DC circuits.	**8**
Module – III **Single-phase AC Circuits:** Common signals and their waveforms, RMS and Average value. Form factor & Peak factor of a sinusoidal waveform. **Series Circuits:** Impedance of Series circuits. Phasor diagram. Active Power. Power factor. Power triangle. **Parallel Circuits:** Admittance method, Phasor diagram, Power and Power factor Power triangle, Series-parallel Circuit, Power factor improvement, Circuit Theorems applied to AC circuits. **Series and Parallel Resonance**: Resonance curve, Q–factor, Dynamic Impedance, and Bandwidth.	**12**
Module – IV **Three-Phase AC Circuits:** Importance and use of a 3-phase network, types of 3-phase connections- Star and Delta, Line and Phase relations for Star and Delta connection, Phasor diagrams, Power relations, analysis of balanced and unbalanced 3-phase circuits, Measurement of Power in 3-phase star and delta network.	**6**
Module – V **Magnetic Circuits:** Introduction, Series-parallel magnetic circuits, Analysis of Linear and Non-linear magnetic circuits, Energy storage, A.C. excitation, Eddy currents and Hysteresis losses. **Coupled Circuits:** Dot rule, Self and mutual inductances, Coefficient of coupling, working of transformer.	**6**

TEXTBOOKS:

1. W. H. Hayt, Jr J. E. Kemmerly and S. M. Durbin, Engineering Circuit Analysis, 7^{th} Edition TMH, 2010.

2. Hughes, Electrical Technology, Revised by McKenzie Smith, Pearson.
3. Fitzgerald and Higginbotham, Basic Electrical Engineering, McGraw Hill Inc, 1981

REFERENCE BOOKS:

1. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, 3rd Edition, TMH, New Delhi, 2009.
2. Electrical Engineering Fundamental, Vincent Del Toro, Prentice Hall, New Delhi.
3. Rajendra Prasad, Fundamentals of Electrical Engineering, 2nd Edition, PHI, New Delhi, 2011.
4. Raymond A. DeCarlo, Prn-Min Lin, Linear Circuit Analysis Time Domain, Phasor and Laplace Transform Approaches, 2nd Edition, Oxford University, 2001
5. Abhijit Chakrabarti, Sudipta Nath, Chandan Kumar Chanda, Basic Electrical Engineering, Tata McGraw Hill Publication, 2009.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

1. Application of principles of magnetic circuits to electrical machines like transformers, generators and motors.
2. Field applications of three phase equipment and circuits in power system.
3. Applications of circuit theorems in electrical and electronics engineering

POS MET THROUGH GAPS IN THE SYLLABUS: 6, 4, 11

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

1. Concepts of electric, magnetic and electromagnetic fields.
2. 3 - Φ power generation, transmission, and distribution.
3. Power factor improvement for three phase systems.
4. Utility of reactive power for creation of electric and magnetic fields.

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: 3, 4, 6.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Quiz (s)	10
Mid Semester Examination	25
End Semester Examination	50
Assignment	10
Teacher Assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Self- learning such as use of NPTEL materials and internets
CD8	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	**3**	**1**	**3**	**2**	**3**	**1**	**1**	**2**	**3**	**1**	**2**	**1**	**2**	
CO2	**3**	**1**	**3**	**3**	**3**	**1**	**1**	**2**	**3**	**1**	**2**	**3**	**3**	
CO3	**3**	**2**	**3**	**3**	**3**	**1**	**2**	**1**	**3**	**1**	**2**	**3**	**3**	
CO4	**3**	**2**	**3**	**3**	**3**	**2**	**2**	**1**	**3**	**1**	**2**	**3**	**3**	
CO5	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**1**	**3**	**1**	**2**	**3**	**3**	

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD5
CO2	CD1, CD2, CD4, CD5, CD7
CO3	CD1, CD2, CD5, CD7, CD8
CO4	CD1, CD2, CD5, CD7, CD8
CO5	CD1, CD2, CD4, CD5, CD7, CD8

COURSE INFORMATION SHEET

Course Code: PH24102
Course Title: Physics lab
Pre-requisite(s): Intermediate Physics
Co- requisite(s):
Credits: 1 L: 0 T: 0 P: 2
Class schedule per week: 2
Class: B.Tech.
Semester / Level: I
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course enables the students to:

1.	Understand the fundamentals of physical measurements and learn to account for inevitable errors in physical measurements.
2.	Understand and verify the basic principles of physics by hands-on experiments and making suitable measurements.
3.	Make electrical connections reliably to form functional circuits for measuring electrical quantities such as voltage, current, resistance, and resistivity
4.	Learn to set up different types of oscillating systems to study their characteristics, viz -a-viz resonant frequency, frequency response, phase relationship, bandwidth, and quality factor
5.	Develop an understanding of optical phenomena like dispersion, interference and diffraction and make measurements on the patterns produced to obtain physical quantities such as wavelength of light and refractive index of transparent materials.

COURSE OUTCOMES (COs)

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

CO1	Make reliable measurements and report results along with errors.
CO2	Wire simple electrical circuits for experimentally determining measurable electrical quantities.
CO3	Build electral and mechanical oscillating systems, characterize them, and make measurements over them.
CO4	Construct setups to produce interference and diffraction patterns and make measurements for determining physical quantities.

SYLLABUS (List of experiments)

1. Error analysis in Physics Laboratory (CO: 1)
2. To determine the frequency of AC mains with the help of a sonometer. (CO:1, 2, 3)
3. To determine the resistance per unit length of a Carey Foster's bridge wire and resistivity of unknown wire. (CO:1, 2)
4. Measurement of electrical equivalent of heat (CO:1, 2)
5. To determine the wavelength of sodium lines by Newton's rings method (CO:1, 4)
6. To determine the frequency of tuning fork using Melde's Experiment (CO:1,3)
7. Measurement of voltage and frequency of a given signal using CRO (CO: 1,2, 3)
8. To determine the emf of a cell using stretched wire potentiometer (CO:1, 2)
9. Determination of refractive index of the material of a prism using spectrometer and sodium light (CO:1, 4)
10. To study the frequency response of a series LCR circuit (CO:1, 2, 3)
11. To study Lorentz force using Current balance (CO:1,2)
12. To study electromagnetic induction and verification of Faraday's laws. (CO:1,2,3)
13. To measure the wavelength of prominent spectral lines of mercury light by a plane transmission grating. (CO:1, 4)
14. To determine the Planck's constant using photocell and optical wavelength filters. (CO:1, 2)

REFERENCE MATERIALS:

1. Lab manuals (available on department website)

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
Lab Journal	30
Lab quizes	20
Progressive viva	20
End Sem Examination	30

Continuous Internal Assessment	% Distribution
Lab Journal	30
Lab quiz	10
Progressive viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	Y
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Introductory lecture by use of boards/LCD projectors
CD2	Laboratory experiments/ teaching aid
CD3	Self- learning such as use of NPTEL materials and internets
CD4	
CD5	
CD6	
CD7	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	2	1	0	1	2	0	0	2	0	0	2			
CO2	2	1	0	1	2	0	0	2	0	0	2			
CO3	2	1	0	1	2	0	0	2	0	0	2			
CO4	2	1	0	1	2	0	0	2	0	0	2			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code: CS24102
Course Title: Programming for Problem Solving Laboratory
Pre-requisite(s):
Co- requisite(s): Programming for Problem Solving (CS24101)
Credits: L: T: P:
Class schedule per week:
Class:
Semester / Level: Ist, 1
Branch:All
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students:

1.	The basics of computer programming.
2.	Ideas about converting problem statements to programs.
3.	Ideas about handling data at scale.
4.	Knowledge about accessing the memory of a computer using code.

COURSE OUTCOMES (COs)

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

CO1	Write basic programs using fundamental control structures.
CO2	Demonstrate the accessing of arrays.
CO3	Write simple functions to modularize programs.
CO4	Work with user defined data types.
CO5	Access memory using pointers and manipulate data using them.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Programming using basic control structures including sequential programs, selection logic including nested selection logic switch structures.**	**3**
Module – II **Write programs using basic iterative structures, nested iterations, programs using looping with selections, controlled loop exit, Manipulating n-dimensional arrays.**	**3**
Module – III **Modularize programs using functions, functions calling functions, elementary string handling programs, recursive programs.**	**3**
Module – IV **Programs using user defined data types, arrays of user defined data types, basic usage of pointers, functions and pointers.**	**3**
Module – V **Advanced usage of pointers, string handling using pointers, parameterizing main, manipulating arrays using pointers.**	**3**

TEXTBOOKS:

1) Programming in C, Yashwant Kanetkar, BPB Publications.

REFERENCE BOOKS:

1) C Programming, Byron Gottfried, Addison Wesley Press

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

1) Elementary file handling

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

<u>DIRECT ASSESSMENT</u>

Assessment Tool	% Contribution during CO Assessment
Laboratory Quiz	20
Laboratory Performance	30
Laboratory Viva	20
Continuous Evaluation	30

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	2			3	1					
CO2	3	3	2	1	2			3	1					
CO3	3	3	2	1	2			3	1					
CO4	3	3	2	1	2			3						
CO5	3	2	2	1	2			1						

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

COURSE INFORMATION SHEET

Course code: EE 24102

Course Title: Electrical Engineering Laboratory

Pre-requisite(s): Physics, Fundamentals of Mathematics and Electrical Engineering.

Co- requisite(s):

Credits: 01 L: 0 T: 0 P: 2

Class schedule per week: 02

Class: B. Tech

Semester / Level: I (II)/1

Branch: EEE

Name of Teacher

Course Objectives

This course enables the students:

1.	To describe students' practical knowledge of active and passive elements and operation of measuring instruments
2.	To demonstrate electrical circuit fundamentals and their equivalent circuit models for both 1-φ and 3- φ circuits and use circuit theorems
3.	To establish voltage & current relationships with the help of phasors and correlate them to experimental results
4.	1. To conclude performance of 1 – Φ AC series circuits by resonance phenomena 2. To evaluate different power measurements for both 1-φ and 3- φ circuits

Course Outcomes

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

CO1	classify active and passive elements, explain working and use of electrical components, different types of measuring instruments;
CO2	illustrate fundamentals of operation of DC circuits, 1-φ and 3- φ circuits and also correlate the principles of DC, AC 1-φ and 3- φ circuits to rotating machines like Induction motor and D.C machine
CO3	measure voltage, current, power, for DC and AC circuits and also represent them in phasor notations;
CO4	analyze response of a circuit and calculate unknown circuit parameters;
CO5	recommend and justify power factor improvement methods in order to save electrical

LIST OF EXPERIMENTS ***(The experiment list may vary to accommodate recent development in the field)***

EXPERIMENT – 1

Name: - Measurement of low and high resistance of a DC shunt motor

Aim: - (i) To measure low resistance of armature winding of DC shunt motor.

(ii) To measure high resistance of field winding of DC shunt motor.

EXPERIMENT – 2

Name: - AC RLC series circuit

Aim: - To obtain current and voltage distribution in AC RLC series circuit and draw the phasor diagram of voltage distribution.

EXPERIMENT – 3

Name: - Single phase power factor measurement by three voltmeter method

Aim: - To obtain power and power factor of the single-phase load using three voltmeter method and draw the phasor diagram.

EXPERIMENT – 4

Name: - AC RLC parallel circuit

Aim: - To obtain current and voltage distribution in a AC RLC parallel circuit and draw the current phasor diagram.

EXPERIMENT – 5

Name: - Single phase power factor measurement by three Ammeter method

Aim: -To obtain power and power factor of single-phase load using three ammeter method and draw the phasor diagram.

EXPERIMENT – 6

Name: -Study of resonance in a RLC series circuit

Aim: - To obtain the resonance condition in AC RLC series circuit and draw the phasor diagram.

EXPERIMENT – 7

Name: -Three phase Delta connection

Aim: - To obtain the relation between line and phase quantities in a three-phase Delta connected load and obtain the phasor diagram.

EXPERIMENT – 8

Name: - Three phase Star connection

Aim: -To obtain the relation between line and phase quantities in a three-phase Star connected load and draw the phasor diagram.

EXPERIMENT – 9

Name: - Measurement of three phase power by two wattmeter method.

Aim: - To measure the power input to a three-phase induction motor by two-wattmeter method and draw the phasor diagram.

EXPERIMENT – 10

Name: - Verification of superposition and Thevenin's Theorems.

Aim: - (i) To verify Thevenin's Theorem for a given circuit.

(ii) To verify Superposition Theorem for a given circuit.

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

1. Application of principles of magnetic circuits to electrical machines like transformers, generators and motors.
2. Visualize Phase sequence.

POs met through Gaps in the Syllabus: 1, 2, 4, 6.

Topics beyond syllabus/Advanced topics/Design

1. Assignment: Simulation of electrical circuits with dependent/independent sources by various techniques (Mesh current/Node Voltage/Thevenin's theorem/Norton's theorem/Maximum power transfer theorem etc.) using MATLAB/PSIM/C++ software.
2. Active/reactive power calculation for 3 – Φ circuits

POs met through Topics beyond syllabus/Advanced topics/Design: 3, 4, 5, 6.

Mapping lab experiment with Course Outcomes

Experiment	Course Outcomes				
	CO1	CO2	CO3	CO4	CO5
1	3	3	1	1	
2	3	3	3	3	3
3	3	3	3	3	3
4	3	3	3	3	3
5	3	3	3	3	3
6	3	3	3	3	
7	3	3	3	1	
8	3	3	3	1	1
9	3	3	3	2	2
10	3	3	2	2	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	1	2	3	3	1	2	1	2	
CO2	3	2	3	2	3	1	2	3	3	1	2	3	3	
CO3	3	2	3	2	3	1	2	3	3	1	2	3	3	
CO4	3	2	3	2	3	1	2	3	3	1	2	3	3	
CO5	3	2	3	2	3	2	2	3	3	1	2	3	3	

Course Delivery methods	
CD1	Laboratory experiments/teaching aids
CD2	Mini projects/Projects
CD3	Tutorials/Assignments
CD4	Self- learning, such as the use of NPTEL materials and the internet

BIRLA INSTITUTE OF TECHNOLOGY

NEP-2020 CURRICULUM BOOK
(Effective from Academic Session: Monsoon 2024)

Bachelor of Technology

DEPARTMENT OF CHEMICAL ENGINEERING
FIRST YEAR (SEMESTER – II)

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

Course Code: MA24103
Course Title: Mathematics II
Pre-requisite(s): Mathematics - I
Co- requisite(s): --
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 4
Class: B.Tech.
Semester / Level: II/1
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	various methods to solve linear differential equations of second and higher order
2.	special functions viz. Legendre's and Bessel's and different properties associated with them
3.	diverse mathematical techniques for solving partial differential equations of first order, along with their applications in wave and heat equations using Fourier series
4.	the theory of functions of a complex variable, complex differentiation and integration
5.	about random variables and elementary probability distribution

COURSE OUTCOMES (COs)

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

CO1	investigate the occurrence of ordinary differential equations in real-life problems and identify the suitable methods available for their solutions.
CO2	develop skills to solve and implement various forms of differential equations and special functions in diverse domains.
CO3	learn to solve various forms of partial differential equations arising in real-world.
CO4	gain an understanding of complex variable functions and their properties in science and engineering.
CO5	comprehend and apply the concept of probability distributions in solving problems related to uncertainty.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Ordinary Differential Equations – I Linear differential equations, Wronskian, Linear independence and dependence of solutions, Linear differential equations of 2^{nd} and higher order with constant coefficients, Operator method, Euler – Cauchy's form of linear differential equation, Method of variation of parameters.	**9**
Module – II Ordinary Differential Equations – II Ordinary and singular points of differential equation, Power and Frobenius' series solutions (root differ by non integer and equal roots). Bessel's differential equation, Bessel function of first kind and its important properties. Legendre's differential equation, Legendre's polynomial and its important properties.	**9**
Module – III Fourier series and Partial Differential Equations Fourier series: Euler formulae for Fourier series, Half range Fourier series. Partial Differential Equations: Method of separation of variables and its application in solving one dimensional wave and heat equations.	**9**
Module – IV Complex Variable-Differentiation & Integration Function of a complex variable, Analyticity, Analytic functions, Cauchy – Riemann equations. Cauchy's theorem, Cauchy's Integral formula, Taylor and Laurent series expansions. Singularities and its types, Residues, Residue theorem.	**9**
Module – V Applied Probability Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, variance. Introduction to Binomial, Poisson and Normal Distribution.	**9**

TEXTBOOKS:

1. E. Kreyszig, Advanced Engineering Mathematics, 9^{th} Edition, John Wiley & Sons, 2006.
2. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.
3. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7^{th} Ed., McGraw Hill, 2004.
4. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing, 3^{rd} Ed, 2009.
5. R. A. Johnson, I. Miller and J. Freund: Probability and Statistics for Engineers, PHI
6. S. C. Gupta and V. K. Kapoor: Fundamental of Mathematical Statistics, Sultan Chand and Sons

REFERENCE BOOKS:

1. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9^{th} Edition, Wiley India, 2009.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
3. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
4. G. F. Simmons, Differential Equations with Applications and Historical Notes, TMH, 2^{nd} ed., 2003.
5. P. L. Meyer: Introductory Probability and Statistical Applications, Oxford & IBH.

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
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internets
CD4	Laboratory experiments/teaching aids
CD5	Industrial/guest lectures
CD6	Industrial visits/in-plant training
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	3	2	3	2	1	0	0	0	1	2			
CO2	3	3	2	3	2	1	0	0	1	1	2			
CO3	3	3	2	3	2	1	0	0	1	1	2			
CO4	3	2	2	2	2	1	0	0	1	1	2			
CO5	3	3	2	2	2	1	1	1	1	2	3			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code: CH24101
Course Title:Chemistry
Pre-requisite(s): Intermediate level Chemistry
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 4
Class: B.Tech.
Semester / Level: I
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students:

1.	To create concept of chemical bonding in coordination chemistry
2.	To understand the basics of stereochemistry, aromaticity and reaction mechanism of organic molecules
3.	To understand the reaction dynamics and to know different types of catalysis
4.	To apprehend the basic principles and the application of vibrational, electronic and NMR spectroscopy
5.	To develop knowledge on the physical state and electrochemistry of molecules

COURSE OUTCOMES (COs) (3 COs to 6 COs depending upon the course)

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

CO1	Able to explain the bonding in a coordination complex
CO2	Able to explain the 3D structure, aromaticity and stereochemistry of organic molecules
CO3	Able to predict the rate, molecularity and mechanism of a simple as well as catalytic reaction
CO4	Able to explain the UV-vis, IR and NMR spectra of unknown molecules
CO5	Able to interpret the phase diagram of simple one and two component heterogeneous systems in equilibrium and the electrochemical behavior of the molecules

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I: Bonding in Coordination Complex Introduction to Chemical Bonding, Werner's Theory, Bonding in coordination complexes, Crystal Field Theory, Octahedral, Tetrahedral and Square planar complexes, CFSE, Jahn Teller theorem, Spectral, electronic and magnetic properties of coordination complexes.	**8**
Module – II: Organic Structure and Reactivity Aromaticity, Geometrical isomerism: cis–trans, E/Z, and syn-anti isomerism; Optical isomerism & Chirality; Wedge, Fischer, Newmann and Sawhorse projection formulae and interconversions; D/L, R/S nomenclature system; Conformational studies of n-butane. Addition, Elimination, Substitution and Rearrangement reaction.	**8**
Module – III: Kinetics and Catalysis Kinetics of Chain, Parallel/Competing/Side, Consecutive reactions; Fast reactions; Outline of Catalysis, Acid-base catalysis, Enzyme catalysis (Michaelis-Menten equation), Important catalysts in industrial processes: Hydrogenation using Wilkinsons catalyst, Phase transfer catalyst.	8
Module – IV: Spectroscopic Techniques Absorption Spectroscopy, Lambert-Beers law, Principles and applications of UV-Visible spectroscopy, Principles and applications of Vibrational spectroscopy; Introduction of NMR spectroscopy.	8
Module – V: Phase and Chemical equilibrium Phase rule: terms involved, Phase diagram of one component (Water) & two component (Pb/Ag) system & their applications; Gibbs Free energy, Van't Hoff equation and Chemical Equilibrium; Nernst Equation, Standard electrode potential, EMF measurement and its application, Batteries and Fuel Cells.	8

TEXTBOOKS:

1. Huheey, J. E., Inorganic Chemistry: Principles of Structure and Reactivity, 4 th edition, Pearson.
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Seventh Edition, Pearson
3. Atkins, P. W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.

REFERENCE BOOKS:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier (2009).
3. William Kemp, Organic Spectroscopy, 3 rd Ed., 2008 Macmillan.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

Limited exposure to computational tools, industrial case studies, and skill-based training needed for industry readiness.

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
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. **Student Feedback onCourse Outcome**

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internets
CD4	Seminars
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	0	0	0	0	1	0	2			
CO2	3	3	2	1	0	0	0	0	1	0	2			
CO3	3	3	3	2	1	1	0	0	1	0	3			
CO4	3	2	1	3	3	0	0	0	2	0	2			
CO5	3	3	2	2	1	2	0	0	1	0	3			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3

CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

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

Course Code: CH24102
Course Title: Chemistry Lab
Pre-requisite(s): Intermediate level Chemistry
Co- requisite(s):
Credits: 1 L: 0 T: 0 P: 2
Class schedule per week: 2
Class: B.Tech.
Semester / Level: I
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course enables the students to:

1.	To gain an understanding of the synthesis of organic and inorganic compounds.
2.	To interpret and analyze spectroscopic data effectively.
3.	To develop a strong concept of potentiometric and pH-metric titrations of acids and bases.
4.	To understand and calculate the rate constant of chemical reactions.
5.	To acquire knowledge of determining melting points and estimating eutectic and transition temperatures.

COURSE OUTCOMES (COs)

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

CO1	Able to perform the synthesis of organic and inorganic compounds.
CO2	Able to interpret and analyze spectroscopic data.
CO3	Able to carry out potentiometric and pH-metric titrations of acids and bases.
CO4	Able to determine the rate constant of chemical reactions.
CO5	Able to measure melting points and estimate eutectic and transition temperatures.

SYLLABUS (List of experiments)

1. Gravimetric estimation of Nickel using Dimethylglyoxime.

2. Determination of total Hardness of a given water Sample (Complexometric Titration).

3. Verification of Beer's Law using Fe^{3+} solution by spectrophotometer/colorimeter, and determination of the concentration of an unknown Fe^{3+} solution.

4. Preparation of Diazoamino Benzene and reporting of its melting point and yield.

5. Construction of a melting point–mass percent composition diagram for a two-component mixture and determination of its eutectic temperature.

6. Study of the kinetics of acid-catalyzed hydrolysis of ethyl acetate and evaluation of the rate constant.

7. Determination of the strength of a strong acid using potentiometric titration with a strong base.

8. Determination of the transition temperature of a given salt hydrate.

9. Separation of binary organic mixture by acid-base extraction and analysis using given FTIR and NMR spectrum.

10.Construction of a pH-titration curve for a strong acid versus a strong base

REFERENCE MATERIALS:

1. https://bitmesra.ac.in/edudepartment/content/1/140/553 (link of Lab Manual)
2. **Experimental Physical Chemistry** – B. Viswanathan, P. S. Raghavan, Narosa Publishing House (1997).
3. **Vogel's Textbook of Practical Organic Chemistry**
4. **Experiments in General Chemistry** – C. N. R. Rao, U. C. Agarwal.
5. **Experimental Organic Chemistry, Vol. 1 & 2** – P. R. Singh, D. S. Gupta, K. S. Bajpai, Tata McGraw-Hill

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
Lab Journal	30
Lab quizes	20
Progressive viva	20
End Sem Examination	30

Continuous Internal Assessment	% Distribution
Lab Journal	30
Lab quiz	10
Progressive viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	Y
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. **Student Feedback onCourse Outcome**

COURSE DELIVERY METHODS

CD1	Introductory lecture by use of boards/LCD projectors
CD2	Laboratory experiments/ teaching aid
CD3	Self- learning such as use of NPTEL materials and internets
CD4	Seminars (discussion of experimental results and error analysis).
CD5	Group discussions/problem-solving sessions (to analyze experimental data and calculations).
CD6	Industrial/guest lectures (applications of chemical analysis techniques in industry).
CD7	Industrial visits (exposure to real chemical laboratories and processes).

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	PSO 1	PSO 2	PSO 3
CO1	3	2	3	2	2	2	3	1	1	2	2			
CO2	3	2	2	3	3	2	1	1	3	2	3			
CO3	3	3	1	3	3	1	2	1	2	2	2			
CO4	3	3	1	3	2	1	1	1	1	2	3			
CO5	3	2	1	2	2	2	1	1	1	1	3			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course code: EC24101
Course title:Basic Electronics
Pre-requisite(s):N/A
Co- requisite(s): N/A
Credits: L:2 T:1 P: 0 C:3
Class schedule per week: 03
Class: B. Tech.
Semester / Level:0I/01
Branch:ALL B.TECH.

Course Objectives

This course enables the students:

1.	To understand PN Junction, diodes and their applications.
2.	To comprehend BJT and the bias configurations.
3.	To understand operating principles of FETs
4.	To understand op amp and its applications.
5.	To apprehend number system, Logic Gates and Boolean algebra.

Course Outcomes

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

CO1	Understand the characteristics of electronic devices like PN-diode, BJT, JFET and MOSFET
CO2	Classify and analyze the various circuit configurations of BJTs and MOSFETs.
CO3	Analyze the characteristics of operational amplifier.
CO4	Design electronic circuits using diodes, transistors, op-amp and logic gates for analogand digital applications.
CO5	Solve day-to-day life problems using electronic circuits.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Diodes and Applications:** Introduction to semiconductor materials, PN junctiondiode, barrier potential, depletion layer width, junction capacitance,diode current equation, I-Vplot, diode-resistance, temperature dependence,breakdown mechanisms, Zener diode – operation and applications, Diode as a Rectifier: Half Wave and Full Wave Rectifiers with and without C-Filters.	**8**

Module – II **Bipolar Junction Transistors (BJT):** Basic operation of PNP and NPN Transistors, Input and Output Characteristics of CB, CE and CC Configurations.Transistor biasing: operating point, Fixed bias, emitter bias, voltage divider bias, stability factor, small signal analysis (h-parametermodel) of CE configuration.	**8**
Module – III **Field Effect Transistors:** JFET: Principle of operation,transfer characteristics, MOSFET: Operation of N-MOS, P-MOS, enhancement and depletion type, transfer characteristics, CS biasing of JFET and MOSFET.	**8**
Module – IV **Operational Amplifiers:** Introduction of Operational Amplifier, Characteristics of Operational Amplifier, Differential Amplifier, CMRR, Slew Rate, input and output offset voltages, Inverting and non-inverting amplifiers, Summing Amplifier, Difference amplifier, Differentiator and Integrator.	**8**
Module – V **Boolean Algebra and Logic Gates:** Boolean Algebra, Boolean operators, Truth table of different digital logic gates (AND, OR, NOT, NAND, NOR, EXOR, EX-NOR),application of diode for design of logic gates, realization of logic gates using universal gates, adder, subtractor.	**8**

Textbooks:

1. Millman J., Halkias C.C. "Integrated Electronics: Analog and Digital Circuits and Systems", Tata McGraw-Hill.
2. Boylstead R.L., Nashelsky L., "Electronic Devices and Circuit Theory", Pearson Education, Inc, 11/e.
3. Mano M.M., Michael D. Ciletti, "Digital Design", Pearson Education, Inc, 5/e, 2011.

Reference books:

1. Millman J., Halkias C.C., Parikh Chetan, "Integrated Electronics: Analog and Digital Circuits and Systems", Tata McGraw-Hill, 2/e.
2. Millman J., Halkias C.C., Satyabrata Jit, "Millman's Electronic Devices and Circuits", Tata McGraw-Hill, 3/e.
3. Albert Paul, Malvino, David J. Bates, "Electronic principles", McGraw-Hill, 8/e, 2015.

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

POs met through Gaps in the Syllabus: 3, 11, 12

Topics beyond syllabus/Advanced topics/Design: NA

POs met through Topics beyond syllabus/Advanced topics/Design: 2, 3, 11, 12

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

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

Indirect Assessment

1. Student Feedback on Faculty
2. Students' 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**	**1**	**2**	**3**
CO1	3	3	1	2	3	1	2	2	3	2	2	3	3	1
CO2	3	3	1	2	3	1	2	2	3	2	2	3	3	1
CO3	3	3	1	2	3	1	2	2	3	2	2	3	3	1
CO4	3	3	1	2	3	1	2	2	3	2	2	3	3	1
CO5	3	3	1	2	3	1	2	2	3	2	2	3	3	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	CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
CD3	Seminars	CO3	CD1, CD2, CD3, CD8
CD4	Mini Projects/Projects	CO4	CD1, CD2, CD3, CD8
CD5	Laboratory Experiments/Teaching Aids	CO5	CD1, CD2, CD3, 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:	**ME24101**
Course Title:	**Basics of Mechanical Engineering**
Pre-requisite(s):	**NIL**
Co- requisite(s):	**NIL**
Credits:	**3** (L: 2 T:1 P: 0)
Class schedule per week:	**3**
Class:	**B. Tech**
Semester / Level:	**SECOND**
Branch:	**Mechanical Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Introduce system of forces, and write equation of equilibrium.
2.	Analyse motion of particle and rigid body subjected to force.
3.	Grasp the importance of internal and external combustion engines.
4.	Apprehend the fundamentals of friction.
5.	Understand the different sources of energy.

COURSE OUTCOMES (COs)

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

CO1	Explain the basics of Mechanical Engineering.
CO2	Apply various laws of mechanics on static and dynamic elements and bodies.
CO3	Analyse various problems of mechanics related to static and dynamic bodies.
CO4	Evaluate the real life problem related to mechanics and energy for its probable solution.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **System of Forces and Structure Mechanics;** Addition of Forces, Moment of a Force, Couple, Varignon's theorem, Free Body Diagram, Equilibrium in Two and Three Dimensions, Equivalent Forces and Moment. Types of Plane Trusses, Analysis of Plane Trusses by: Method of Joints and Method of Sections. Hooke's Law of elasticity, Stress and Strain, Relation between elastic constants.	**8**
Module – II **Kinematics & Kinetics of rigid bodies:** Types of rigid body motion– translation, rotation about fixed axis, equations defining the rotation of a rigid body about a fixed axis, plane motion, absolute and relative velocity in plane motion, instantaneous center of rotation. Equation of motion and D'Alembert's principle.	**8**
Module – III **Friction :** Interfacial Friction (a) Laws of dry friction, static & kinetic co-efficient of friction, Analysis of static, kinetic and rolling friction. (b) Analysis of frictional forces in inclined planes, wedges, screw jacks and belt drives.	**8**
Module – IV **Boilers and Internal Combustion Engine;** Classification of Boilers, Fire tube and Water Tube boilers. Boiler Mountings and Accessories. Boiler efficiency. Classification of I C Engines. Basic components and terminology of IC engines, working principle of four stroke and two stroke - petrol and diesel engine.	**6**
Module – V **Non-Conventional Energy Sources** Renewable and Non-renewable Energy Resources, Advantages and Disadvantages of Renewable Resources, Renewable Energy Forms and Conversion- Solar Energy, Wind Energy, Hydro Energy.	**5**

TEXTBOOKS:

1. Engineering Mechanics, Irving H. Shames, P H I. ltd, 2011.
2. Boiler operator, Wayne Smith, LSA Publishers, 2013.
3. Internal Combustion Engines, M. L. Sharma and R. P. Mathur, Dhanpat Rai Publications, 2014.
   Fundamentals of Renewable Energy Processes, Aldo Vieira Da Rosa, Elsevier publication, 2012.

REFERENCE BOOKS:

1. Engineering Mechanics : statics, James L. Meriam, L. G. Kraige, Wiley, 7th Edition, 2011.
2. Engineering Mechanics, S. Rajasekaran & G. Sankarasubramaniam, Vikash publishing house, 2018.
3. An Introduction to Steam Boilers, David Allan Low, Copper Press Publisher, 2012.
4. Internal Combustion Engines – V Ganesan, McGraw hill, 2017.
5. Non Conventional Energy Resources, B. H. Khan, McGraw Hill Education Publisher, 2017.
6. Principles of Mechanical Engineering, R. P. Sharma & Chilkesh Ranjan, Global Academic Publishers, 2016.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS) : NIL

POS MET THROUGH GAPS IN THE SYLLABUS: NA

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NIL

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NA

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Continuous Internal Assessment	% Distribution
Mid Semester Examination	25
Quiz	10
Assignment	10
Teacher’s Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	√	√	√	√
Semester End Examination	√	√	√	√

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	1		2	1	1		2	2	1	2
CO2	3	3	2	2	2	1	1	2	1	1	2	2	1	2
CO3	3	3	3	3	2	1	1	2	2	2	2	2	2	2
CO4	2	3	3	3	3	2	2	2	2	2	3	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course Code:	**ME24102**
Course Title:	**Engineering Graphics**
Pre-requisite(s):	**NIL**
Co- requisite(s):	**NIL**
Credits:2	(L:0 T: 0 P:4)
Class schedule per week:	**4**
Class:	**B. Tech.**
Semester / Level:	**SECOND**
Branch:	**Mechanical Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Understand the basic principles of Engineering Graphics, which include projections of 1D, 2D and 3D objects.
2.	Visualize a solid object (including sectioned) and convert it into drawing.
3.	Visualize different views of any object.
4.	Develop skill to draw objects using AutoCAD software.
5.	Inculcate the imagination and mental visualization capabilities for interpreting the geometrical details of common engineering objects.

COURSE OUTCOMES (COs)

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

CO1	Explain the fundamentals of Engineering Graphics and projection and acquire visualization skills.
CO2	Demonstrate the concept of projections of points and lines for various engineering applications.
CO3	Apply the concept of projections to construct planes and solids, and its orthographic projections which are positioned in various configurations..
CO4	Demonstrate the understanding of AutoCAD software commands to draw projections of points, lines, planes and solids.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Introduction to Engineering Graphics, dimensioning and projections, orthographic projections, Fundamentals of First and Third Angle projection, Orthographic projections of points.	9
Module – II Orthographic projections of straight lines: lines parallel to HP and VP, lines inclined to HP and Parallel to VP, line inclined to VP and parallel to HP, line inclined to both reference planes. Orthographic projections of planes/lamina: lamina perpendicular to both HP and VP, lamina parallel to HP and perpendicular to VP (and vice versa), lamina inclined to HP and perpendicular to VP, lamina inclined to VP and perpendicular to HP, lamina inclined to both reference planes.	9
Module – III Projections of solids (cube, prism, pyramid, tetrahedron) - axis perpendicular to HP and inclined to VP and inclined to one or both planes. Section of solids: sectional plane perpendicular to one plane and parallel/inclined to another plane.	9
Module – IV Working with AutoCAD Commands, Cartesian Workspace, Basic Drawing & Editing Commands, Drawing: Lines, Rectangles, Circles, Arcs, Polylines, Polygons, Ellipses, Creating Fillets and Chamfers, Creating Arrays of Objects, Working with Annotations, Adding Text to a Drawing, Hatching, Adding Dimensions, Dimensioning Concepts, Adding Linear Dimensions, Adding Radial & Angular Dimensions, Editing the Dimensions.	9
Module – V Create views of points, lines, planes, and various types of solids (cube, prism, pyramid, tetrahedron, etc.) using AutoCAD software.	9

TEXTBOOKS:

1. Engineering Drawing by N. D. Bhatt, Charotar Publishing House Pvt.Ltd., 53rd, Edition, 2014.
2. Engineering Drawing and Graphics + AutoCAD by K. Venugopal, New Age International (P) Limited, 4th Reprint: June, 2017.

REFERENCE BOOKS:

1. Engineering Graphics with Autocad by J. D. Bethune, Prentice Hall, 2007.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS) : NIL

POS MET THROUGH GAPS IN THE SYLLABUS: NA

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NIL

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NA

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	60
End Semester Test	40

Continuous Internal Assessment	**% Distribution**
Day to day performance & Lab files	30
Lab Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Lab Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	√	√	√	√
Semester End Examination	√	√	√	√

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	2		2				2		2	2	2	2
CO2	3	3	2		2				2		2	2	2	2
CO3	3	3	3	2	2			2	2		2	2	2	2
CO4	2	2	2	2	3			2	3	2	2	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD3
CO2	CD3
CO3	CD3
CO4	CD3

COURSE INFORMATION SHEET

Course code: CE24101
Course title: Environmental Science
Pre-requisite(s): NA
Co- requisite(s): NA
Credits: 3 L:3 T:0 P:0
Class schedule per week: 2
Class: B.Tech.
Semester / Level: 1st Semester/1
Branch: ALL
Name of Teacher:

COURSE OBJECTIVES

This course enables the students to:

1.	To develop basic knowledge of ecological principles and their applications in environment.
2.	To identify the structure and composition of the spheres of the earth, the only planet sustaining life.
3.	To analyse, how the environment is getting contaminated and probable control mechanisms for them.
4.	To generate awareness and become a sensitive citizen towards the changing environment.

COURSE OUTCOMES (COs)

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

CO1	Able to explain the structure and function of ecosystems and their importance in the holistic environment.
CO2	Able to identify the sources, causes, impacts and control of air pollution
CO3	Able to distinguish the various types of water pollution happening in the environment and understand about their effects and potential control mechanisms.
CO4	Able to judge the importance of soil, causes of contamination and need of solid waste management.
CO5	Able to know the impacts of noise pollution and its management.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I: Ecosystem and Environment Concepts of Ecology and Environmental Science, ecosystem: structure, function and services, Biogeochemical cycles, energy and nutrient flow, ecosystem management. Concept of Biodiversity.	6
Module – II: Air Pollution Structure and composition of unpolluted atmosphere, classification of air pollution sources, types of air pollutants, effects of air pollution, monitoring of air pollution, Air pollution control and management.	6
Module – III: Water Pollution Water Resource; Water Pollution: types and Sources of Pollutants; effects of water pollution; Water quality monitoring, Water quality index, water and wastewater treatment: primary, secondary and tertiary.	6
Module – IV: Soil Pollution and Solid Waste Management Soil profile, soil properties, soil pollution, and Municipal solid waste management. MSW – Functional elements of MSW.	6
Module – V: Noise Pollution Noise pollution: introduction, sources, outdoor and indoor noise propagation, Effects of noise on health, criteria noise standards and limit values, Noise measurement techniques, prevention and control of noise pollution.	6

TEXTBOOKS:

1. A, K. De. (3rd Ed). 2008. Environmental Chemistry. New Age Publications India Ltd.
2. R. Rajagopalan. 2016. Environmental Studies: From Crisis to Future by, 3rd edition, Oxford University Press.
3. Eugene P. Odum. 1971. Fundamentals of Ecology (3rd ed.) -. WB Sunders Company, Philadelphia.
4. C. N. Sawyer, P. L. McCarty and G. F. Parkin. 2002. Chemistry for Environmental Engineering and Science. John Henry Press.
5. S.C. Santra. 2011. Environmental Science. New Central Book Agency.

REFERENCE BOOKS:

1. D.W. Conell. Basic Concepts of Environmental Chemistry, CRC Press.
2. Peavy, H.S, Rowe, D.R, Tchobanoglous, G. Environmental Engineering, Mc-Graw - Hill International
3. G.M. Masters & Wendell Ela. 1991. Introduction to Environmental Engineering and Science, PHI Publishers.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS): NA

POS MET THROUGH GAPS IN THE SYLLABUS: NA

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NA

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED

TOPICS/DESIGN: NA

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internet

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	0	1	1	0	0	1	0	0	0	0	0			
CO2	0	1	1	0	0	1	0	0	0	0	0			
CO3	0	1	1	0	0	1	0	0	0	0	0			
CO4	0	1	1	0	0	1	0	0	0	0	0			
CO5	0	1	1	0	0	1	0	0	0	0	0			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2

CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1, CD2

COURSE INFORMATION SHEET

Course Code: **PE24102**
Course Title: **Workshop Practice**
Pre-requisite(s): **None**
Co-requisite(s): **None**
Credits: **1 (L:0 T:0 P: 2)**
Class schedule per week: **2**
Class: **B.Tech.**
Semester / Level: **SECOND**
Branch: **Production and Industrial Engineering**
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Familiarize with the basics of manufacturing processes.
2	Impart knowledge and skill to use tools, machines, equipment, and measuring instruments.
3	Practice on manufacturing of components using workshop trades.
4	Educate students on the safe handling of machines and tools.
5	Exercise individual as well as group activity with hands-on training in different workshop trades.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	Be conversant with the basic manufacturing processes.
CO2	Identify and apply suitable tools and instruments for carpentry, foundry, welding, fitting, and conventional and modern machining.
CO3	Manufacture different components using various workshop trades.
CO4	Take safety and precautionary measures for self and machines during operations.
CO5	Develop skills to work as an individual or in a team during trade practices.

SYLLABUS

LIST OF EXPERIMENTS	(NO. OF PRACTICAL HOURS)
1. **CARPENTRY SHOP** **EXPERIMENT-I: Carpentry Tools and Instruments** **Objective**: To study the various tools, instruments, and equipment used in carpentry practice.	2
2. **CARPENTRY SHOP** **EXPERIMENT-II: Carpentry Practice** **Objective:** To perform the carpentry work by making a wooden job using different tools.	2
3. **FOUNDRY SHOP** **EXPERIMENT-I: Green Sand Moulding** **Objective:** To get acquainted with various tools and equipment used in making green sand mould (to practice green sand mould making with single-piece patterns).	2
4. **FOUNDRY SHOP** **EXPERIMENT-II: Aluminium Casting** **Objective:** To get acquainted with melting and pouring metal in a mould (given two-piece patterns of handle) and to make aluminium casting.	2

5. **WELDING SHOP** **EXPERIMENT-I: Manual Metal Arc Welding** **Objective:** To study arc welding processes including arc welding machines (AC & DC), electrodes and equipment. To join two pieces of given metal by the arc welding process.	**2**
6. **WELDING SHOP** **EXPERIMENT-II: Gas Welding** **Objective:** To study gas welding processes, including types of flames produced, filler metals and fluxes, etc. To join two pieces of given metal by the gas welding process.	**2**
7. **FITTING SHOP** **EXPERIMENT-I: Fitting Tools and Measuring Instruments** **Objective**: To study the various tools used in the fitting shop and perform fitting operations (like marking, chipping, hack-sawing, filing, drilling, etc.)	**2**
8. **FITTING SHOP** **EXPERIMENT-II: Fitting Assembly Practice** **Objective:** To make a job clamping plate as per the given drawing by fitting operations and to check for its assembly with a given component.	**2**
9. **MACHINE SHOP** **EXPERIMENT – I: Centre Lathe Machine** **Objective**: To study lathe machine and to machine a given job on the center lathe as per drawing.	**2**
10. **MACHINE SHOP** **EXPERIMENT-II: Shaper Machine** **Objective:** To study the Shaper machine and to machine a given job on the shaper as per drawing.	**2**
11. **MODERN MACHINE SHOP** **EXPERIMENT – I: CNC Lathe Machine** **Objective**: To provide an introduction to the functionality and operation of the CNC Lathe Machine through practical demonstration.	**2**
12. **MODERN MACHINE SHOP** **EXPERIMENT-II: CNC Surface Grinding Machine** **Objective:** To provide an introduction to the functionality and operation of the CNC Surface Grinding Machine through practical demonstration	**2**

Books recommended:

TEXT BOOK

1. S K Hajra Choudhury, A K. Hajra, "Elements of Workshop Technology: Vol- I and Vol -II", Media Promotors Pvt Ltd. **(T1)**
2. B S Raghuwanshi, "A course in Workshop Technology", Dhanpat Rai Publications. **(T2)**

REFERENCE BOOK

1. P.N. Rao, "Manufacturing Technology Vol-1and Vol-II", Tata McGraw Hill. **(R1)**
2. Kalpakjian, "Manufacturing Engineering and Technology", Pearson. **(R2)**

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 Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	**% Distribution**
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	1	0	1	1	1	1	1	1	2	3	2	2
CO2	2	3	2	1	3	1	1	1	2	2	2	3	2	3
CO3	2	2	3	2	3	1	1	2	2	2	2	2	2	3
CO4	1	1	2	1	2	2	3	1	1	1	2	1	1	2
CO5	1	1	2	0	1	0	1	3	3	3	2	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD6
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD3

COURSE INFORMATION SHEET

Course code: EC24102
Course title:Basic Electronics Lab
Pre-requisite(s): N/A
Co- requisite(s): N/A
Credits: L: 0 T: 0 P: 2 C:1
Class schedule per week: 02
Class: B. Tech.
Semester / Level: I/01
Branch: ALL B.TECH.

Course Objectives

This course enables the students:

1.	To measure magnitude, time-period, frequency, phase of signals using CRO
2.	To know PN junction characteristics and its applications
3.	To understand the working of transistor amplifier
4.	To understand the working of operational amplifier and circuits
5.	To realize logic gates and implement simple Boolean expression

Course Outcomes

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

CO1	Familiarize with electronics components like diode, transistors, ICs
CO2	Make use of measuring instruments and function generators
CO3	Verify characteristics of diodes,transistors and op-amp
CO4	Design electronic circuits using diodes, transistors, op-ampfor analogapplications
CO5	Design electronic circuits using logic gates for digital applications

List of Experiments

Experiment No.	**Name of the Experiments**
(A) HARDWARE BASED EXPERIMENTS	
1.	**MEASURMENTS USING CRO** AIM-1: To understand the Measurement of voltage, time-period and frequency of different signals on CRO. AIM-2: To measure the frequency and phase of two different signals using Lissajous pattern.

2.	**HALF-WAVE AND FULL WAVE RECTIFIER CIRCUITS** AIM-1: To understand the basic operation principle of Half-wave rectifier circuit and measurement of rectification efficiency and ripple factor with and without C-Filter. AIM-2:To understand the basic operation principle of Full-wave rectifier circuit and measurement of rectification efficiency and ripple factor with and without C-Filter.
3.	**COMMON EMITTER (CE) TRANSISTOR AMPLIFIER** AIM-1: To understand the basic operation principle of CE transistor amplifier circuit and finding its frequency response. AIM-2: To determine the gain bandwidth product of CE transistor amplifier from its frequency response.
4.	**INVERTING OPERATIONAL AMPLIFIER (OP-AMP)** AIM: To design the inverting operational amplifier using IC741 OP-AMP and find its Gain and Frequency Response.
5.	**DIFFERENTIAL AMPLIFIER** AIM-1: To design common mode and differential mode circuit using IC741 OP-AMP AIM-2:To obtain common mode gain and differential mode gain and calculate CMRR.
6.	**REALIZATION OF LOGIC GATES** AIM-1: To understand basic Boolean logic functions (NOT, AND, OR). AIM-2: To realize the basic logic gates (AND, OR, NOT) using NAND Gate (IC-7400).
(B) SOFTWARE BASED EXPERIMENTS	
1.	**PN JUNCTION CHARACTERISTICS** AIM-1: To determine the forward bias V-I characteristics of PN junction diode and finding itsforward cut-in voltage. AIM-2: To determine the reverse bias V-I characteristics of PN junction diode and finding its reverse breakdown voltage.
2.	**ZENER DIODECHARACTERISTICS** AIM-1: To design a basic voltage regulator circuit using Zener diode. AIM-2: To determine the reverse bias V-I characteristics of Zener diode and finding its reverse breakdown voltage.
3.	**FIELD EFFECT TRANSISTOR CHARACTERISTICS** AIM-1: To determine the output and transfer characteristics of JFET. AIM-2: To measure the voltage,gain of JFET.
4.	**NON-INVERTING OPERATIONAL AMPLIFIER (OP-AMP)** AIM:To design the non-inverting operational amplifier using IC741 OP-AMP and find its Gain and Frequency Response.
5.	**DIFFERENTIATOR AND INTEGRATOR CIRCUITS USING OP-AMP** AIM-1: To design differentiator circuit using IC741 OP-AMP and observe waveforms. AIM-2:To design integrator circuit using IC741 OP-AMP and observe waveforms.
6.	**IMPLEMENTATION OF BOOLEAN FUNCTION** AIM-1: To understand the AND Gate IC (IC 7408) and OR Gate IC (IC 7432) AIM-2: To implement a given Boolean expression using logic gate ICs.

Text Books:

1. Millman J., Halkias C.C., Parikh Chetan, “Integrated Electronics: Analog and Digital Circuits and Systems”, Tata McGraw-Hill, 2/e.
2. Mano M.M., “Digital Logic and Computer Design”, Pearson Education, Inc, Thirteenth Impression, 2011.

Reference Book:

1. Boylstead R.L., Nashelsky L., “Electronic Devices and Circuit Theory”, Pearson Education, Inc, 10/e.

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

POs met through Gaps in the Syllabus: N/A.

Topics beyond syllabus/Advanced topics/Design: N/A

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

<u>Course Outcome (CO) Attainment Assessment tools & Evaluation procedure</u>

<u>Direct Assessment</u>

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	**(60)**
Attendance Marks	**12**
Day-to-day performance Marks	**06**
Lab Viva marks	**20**
Lab file Marks	**12**
Lab Quiz-I Marks	**10**
End SEM Evaluation	**(40)**
Lab Quiz-II Marks	**10**
Lab performance Marks	**30**

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	1	2	3
CO1	3	3	1	2	3	1	1	2	2	2	2			
CO2	3	3	1	2	3	1	1	2	2	2	2			
CO3	3	2	1	2	3	1	1	2	2	2	2			
CO4	3	3	1	2	3	1	1	2	2	2	2			
CO5	3	2	1	2	3	1	1	2	2	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	CO1	CD1, CD5, CD9
CD2	Tutorials/Assignments	CO2	CD1, CD5, CD9
CD3	Seminars/ Quiz (s)	CO3	CD1, CD5, CD9
CD4	Mini Projects/Projects	CO4	CD1, CD5, CD9
CD5	Laboratory Experiments/Teaching Aids	CO5	CD1, CD5, CD9
CD6	Industrial/Guest Lectures		
CD7	Industrial Visits/In-plant Training		
CD8	Self- learning such as use of NPTEL Materials and Internets		
CD9	Simulation		

SYLLABUS (IIIrd to VIIIth SEMESTERS)

COURSE INFORMATION SHEET

Course code	CL24201
Course title	Thermodynamics
Pre-requisite(s)	**CH24201, PH24201, MA24201**
Co- requisite(s)	
Credits	**4** (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 equipment.

Course Outcomes

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

CO24201.1	Apply the laws of thermodynamics on closed and open systems.
CO24201.2	Evaluate the properties of real gases.
CO24201.3	Solve problems involving various thermodynamic cycles.
CO24201.4	Evaluate the thermodynamic properties (Such as Partial molar properties, Fugacity coefficients, activity coefficients) of pure fluid and mixtures.
CO24201.5	Predict equilibrium composition of mixtures under phase and chemical-reaction equilibria.

SYLLABUS

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

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 Maxwell relations, Helmholtz free energy, Gibbs free energy, Gibbs energy as a generating function, Joule-Kelvin Effect, Clausius/Clapeyron equation, Antoine equation, Residual properties, Thermodynamic properties of real gases.	8
Module 3: 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, Gibbs-Duhem relation.	8
Module 4: 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 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

Textbooks:

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/seminar/assignment/others	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		1	2	3
CO24201.1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO24201.2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO24201.3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO24201.4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO24201.5	3	3	1	2	3	2	2	1	1	2	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
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	CL24203
Course title	Fluid Mechanics
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

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:

CO24203.1	Describe fluid pressure, its measurement and calculate forces on submerged bodies.
CO24203.2	Explain the flow visualization, boundary layer and momentum correction factor, state the Newton’s law of viscosity and Reynolds number. Analyze fluid flow problems with the application of the continuity and momentum equation.
CO24203.3	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.
CO24203.4	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.
CO24203.5	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 displacement pumps (rotary, piston, plunger, diaphragm pumps); pump specification; basic characteristics curves for centrifugal pumps; fan, blower and compressor.	8

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/Assignment/Seminar/Other	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		1	2	3
CO 1	3	3	2	2	2	2	2	2	3	3	1		3	3	2
CO 2	3	3	2	2	2	2	2	2	3	3	1		3	3	2
CO 3	3	3	2	2	2	2	2	2	3	3	1		3	3	2
CO 4	3	3	3	2	2	2	2	2	3	3	1		3	3	2
CO 5	3	3	3	2	2	2	2	2	3	3	1		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:	CL24205
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:

CO24205.1	Apply the concept of dimension and unit conversion to check dimensional consistency of balanced equation and understand the specific terms used in process calculation.
CO24205.2	Solve problems related to ideal and real gas and solution.
CO24205.3	Solve material balance problems without chemical reactions.
CO24205.4	Solve material balance problems with chemical reactions.
CO24205.5	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, Mole Fraction and Mole Percent, Mass Fraction and Mass Percent, Concentration	8

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. Vapor 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/seminar/assignment/others	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		1	2	3
CO 1	3	3	1	1	2	1	1	1	1	1	1		3	0	2
CO 2	3	3	2	1	1	1	1	1	1	1	1		3	0	2
CO 3	3	3	1	1	1	2	2	2	2	2	2		3	3	2
CO 4	3	3	2	1	1	2	2	2	2	2	2		3	3	2
CO 5	3	3	2	1	1	2	2	2	2	2	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
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 24207
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: III / 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:

CO24207.1	Understand the basic laws and constraints of heat transfer to analyze problems involving steady state or transient heat conduction in simple geometries..
CO24207.2	Explore the analytical solutions of different types of convection problems to apply in modern sectors of heat transfer.
CO24207.3	Understand the principles of radiation heat transfer and obtain numerical solutions of combined modes of heat transfer in practice..
CO24207.4	Explain and apply the concept of phase change.
CO24207.5	Analyze the effectiveness of several type of heat exchanger and develop skills for industrial design solutions of complex problems.

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	8

through plane wall, conduction through cylindrical wall, spherical wall, conduction through composite slab, cylinder and sphere, critical radius of 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/seminar/assignment/others	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		1	2	3
CO24207.1	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO24207.2	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO24207.3	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO24207.4	3	3	3	3	2	2	2	1	2	3	1		3	2	2
CO24207.5	3	3	3	3	2	2	2	1	2	3	1		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		

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

Course Code: MA24201
Course Title: Numerical Methods
Pre-requisite(s):
Co- requisite(s): Numerical Methods Lab.
Credits: 2 L: 2 T: 0 P: 0
Class schedule per week: 2
Class: B.Tech.
Semester / Level: III-IV/2
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	comprehend suitable numerical methods to solve algebraic and transcendental equations
2.	learn proper numerical methods to solve linear system of equations
3.	approximate a function using various interpolation techniques
4.	evaluation of derivatives and integrals using interpolating polynomials
5.	find the numerical solutions of initial value problems

COURSE OUTCOMES (COs)

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

CO1	solve algebraic and transcendental equations using numerical methods for real-world problem solving
CO2	apply numerical techniques to solve linear system of equations in scientific and engineering computations
CO3	use interpolation methods to approximate functions in data analysis and modeling
CO4	compute derivatives and integrals for complex mathematical and physical problems
CO5	solve ordinary differential equations numerically for dynamic system modeling and simulations

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I: ERRORS AND NONLINEAR EQUATIONS Types and sources of errors, Propagation of errors. Bisection method, Regula-Falsi method, Secant method, Newton-Raphson method and its variants, General Iterative method.	**5**
Module – II: SYSTEM OF LINEAR EQUATIONS Gaussian Elimination, Gauss-Jordan, LU Decomposition (Crout's method), Gauss-Jacobi and Gauss-Siedel methods to solve linear system of equations.	**5**
Module – III: INTERPOLATION Lagrange's interpolation, Newton's divided differences interpolation formulas, Interpolating polynomial using Newton forward and backward differences	**5**
Module – IV: DIFFERENTIATION AND INTEGRATION Differentiation using interpolation formulas, Integration using Newton-Cotes formulas: Trapezoidal rule, Simpson's one-third and three-eighth rules.	**5**
Module – V: SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS Euler's method, modified Euler's method, Runge-Kutta Methods of second and fourth order to solve initial value problems.	**5**

TEXTBOOKS:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Publications, Fourth Edition, 2004.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, Fourth Edition, 2005.
3. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

REFERENCE BOOKS:

1. S.C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw Hill, Seventh Edition, 2014.
2. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Seventh Edition, 2003.
3. R. W. Hamming, Numerical Methods for Scientists and Engineers, Second Edition, Dover Publications Inc. 1987

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
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internets
CD4	Laboratory experiments/teaching aids
CD5	Industrial/guest lectures
CD6	Industrial visits/in-plant training
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	2	0	0	0	1	1	2			
CO2	3	3	2	2	2	0	0	0	1	1	2			
CO3	3	2	2	2	3	0	0	0	1	1	2			
CO4	3	2	2	2	3	0	0	0	1	1	2			
CO5	3	3	2	3	3	0	0	0	1	1	2			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

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

Course Code: MA24202
Course Title: Numerical Methods Lab.
Pre-requisite(s): MA24201 Numerical Methods
Co- requisite(s): --
Credits: 1 L: 0 T: 0 P: 2
Class schedule per week: 2 Sessional
Class: B.Tech.
Semester / Level: III-IV/2
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	execute appropriate numerical methods to solve algebraic and transcendental equations correct up to some certain level of significance
2.	solve linear system of equations using direct and iterative methods
3.	approximate a function by polynomial using various interpolation techniques along with computation of derivatives and integrals
4.	compute numerical solutions of initial value problems
5.	handle numerical problems efficiently through programming languages like C, C++ etc. on computer

COURSE OUTCOMES (COs)

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

CO1	employ numerical techniques to solve algebraic and transcendental equations
CO2	analyze and implement numerical methods for solving systems of linear equations
CO3	use interpolation methods to approximate functions in data analysis and modeling
CO4	compute derivatives and definite integrals using numerical differentiation and integration methods
CO5	develop solutions of ordinary differential equations using appropriate numerical schemes

SYLLABUS

	List of Assignments
Write a program to	
1	find a simple root of $f(x) = 0$ using Bisection method. Read the end points of the interval in which the root lies, maximum number of iterations and error tolerance eps.
2	find a simple root of $f(x) = 0$ using Regula-Falsi method. Read the end points of the interval in which the root lies, maximum number of iterations and error tolerance eps.
3	find a simple root of $f(x) = 0$ using Secant method. Read the end points of the interval in which the root lies, maximum number of iterations and error tolerance eps.
4	find a simple root of $f(x) = 0$ using Newton Raphson method. Read any initial approximation, maximum number of iterations and error tolerance eps.
5	find the solution of a system of linear equations using Gauss elimination method.
6	find the solution of a system of linear equations using Gauss-Jordan method.
7	find the solution of a system of linear equations using Jacobi method.
8	find the solution of a system of linear equations using Gauss-Seidel method.
9	approximate the function using Lagrange interpolation formula.
10	approximate the function using Newton divided difference formula.
11	approximate the function using Newton's forward and backward interpolation formulae.
12	evaluate the integral using Trapezoidal rule.
13	evaluate the integral using Simpson's one-third and three-eighth rules.
14	solve an IVP, $\frac{dy}{dx} = f(x, y), y(x_0) = y_0$ using Euler method.
15	solve an IVP, $\frac{dy}{dx} = f(x, y), y(x_0) = y_0$ using the classical Runge-Kutta fourth order method.

TEXTBOOKS:

1. Jain M.K, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Publications, 2004.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, Fourth Edition, 2005.
3. Y. Kanetkar, Let Us C, BPB Publications, Fifteenth Edition, 2016.

REFERENCE BOOKS:

1. S.C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw Hill, Seventh Edition, 2014.
2. R. W. Hamming, Numerical Methods for Scientists and Engineers, Second Edition, Dover Publications Inc. 1987.
3. H. Schildt, C++: The Complete Reference, McGraw-Hill Education, Fourth Edition, 2017.

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
Lab Journal	30
Lab quizzes	20
Progressive viva	20
End Sem Examination	30

Continuous Internal Assessment	60 % Distribution
Lab Journal	30
Lab quiz	10
Progressive viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	Y
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internets
CD4	Laboratory experiments/teaching aids
CD5	Industrial/guest lectures
CD6	Industrial visits/in-plant training
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	1	2	3	0	0	1	1	1	2			
CO2	3	3	2	2	3	0	0	1	1	1	2			
CO3	3	2	2	2	3	0	0	1	1	1	2			
CO4	3	2	2	2	3	0	0	1	1	1	2			
CO5	3	3	2	3	3	0	0	1	1	2	3			

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD2, CD3
CO2	CD2, CD3
CO3	CD2, CD3
CO4	CD2, CD3
CO5	CD2, CD3

COURSE INFORMATION SHEET

Course code	CL24209
Course title	Mechanical Operations
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
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.	Develop an understanding of the 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:

CO24209.1	Understanding the methods for solid particles characterization and transportation
CO24209.2	Applying the laws of size reduction understanding the machineries
CO24209.3	Analysis of size reduction machineries for various industries and solid-fluid separation units .
CO24209.4	Applying the concept of filtration and solving related problems
CO24209.5	Applying the concept of solid-solid separation processes

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 Thickener,**. 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, Hydraulic classifiers, Tabling, Jigging, Froth floatation, Dense media separation etc.Magnetic separation, Electrostatic 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/seminar/assignment/others	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**		**1**	**2**	**3**
1	3	3	3	2	3	2	2	1	1	1	1		3	3	3
2	3	3	3	2	3	2	2	1	1	1	1		3	3	3
3	3	3	3	2	3	2	2	1	1	1	1		3	3	3
4	3	3	3	2	3	2	2	1	1	1	1		3	3	3
5	3	3	3	2	3	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: CL24211
Course title: Mass Transfer Operations-I
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 1 P: 0
Class schedule per week: 4
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:

CO24211.1	Explain the basic mechanism of mass transfer including diffusion and convective mass transfer.
CO24211.2	Determine the mass transfer coefficient and solve problems related to interphase mass transfer.
CO24211.3	Explain the gas-liquid contacting process and solve problems related to design calculation.
CO24211.4	Solve problems on design calculation of distillation column.
CO24211.5	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 diffusion, Diffusion in solids. Convective mass transfer and Mass transfer coefficient, Correlation of mass transfer coefficients.	8
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	8
Module-3 The mechanism of absorption, Concept of stage wise contact processes. Equipment for Gas Liquid contact, plate and plate type towers, absorption factor, number of plates, Kremser equation, plate efficiency, 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	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-Savarit method, Steam distillation, Azeotropic & Extractive Distillations, batch distillation with reflux	8
Module-5 Introduction to multicomponent distillation, Shortcut method on multi component distillation, Fenske-Underwood- Gilliland method, MESH equations (HK, LK component	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/seminar/assignment/others	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**		**1**	**2**	**3**
CO24211.1	3	3	1	2	2	1	1	1	1	1	1		3	1	2
CO24211.2	3	3	1	1	2	1	1	1	1	1	1		3	1	2
CO24211.3	3	3	3	3	2	2	2	2	2	3	1		3	2	2
CO24211.4	3	3	3	3	2	2	2	2	2	2	2		3	3	2
CO24211.5	3	3	3	3	2	2	2	2	2	2	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, 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 24213
Course title: Chemical Reaction Engineering-I
Pre-requisite(s): CL24205 Chemical Process Calculations
Co- requisite(s):
Credits: 4 (L: 3 T: 1 P: 0)
Class schedule per week: 4
Class: B. Tech.
Semester / Level: IV/ Second
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.	Analyze 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:

CO 24213.1	Explain the concepts of Kinetics and Rate Laws.
CO 24213.2	Analyze ideal batch reactor kinetics for homogeneous reactions.
CO 24213.3	Design of ideal isothermal reactors for single and multiple reactions.
CO 24213.4	Design of ideal non-isothermal reactors.
CO 24213.5	Analyzing the non-ideality in the flow reactors

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Overview of chemical reaction engineering. Classification of reactions. Rate of a chemical reaction. Temperature and concentration-dependent terms for a homogeneous reaction. Elementary and Nonelementary Reactions, Molecularity and Order of Reaction, Kinetic models for nonelementary reactions.	8

Module 2: Interpretation of batch reactor data: data collection, plotting, and analysis. Determination of kinetics of homogeneous reactions using Integral, differential, and half-life methods analysis of data. Series and parallel reactions. Autocatalytic reactions.	8
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, Design for Parallel Reactions.	8
Module 4: **Non-Isothermal Operation and Stability of Reactors:** Heat of reaction and equilibrium Constants. Non-isothermal design of ideal reactors, 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 model.	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/seminar/assignment/others	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		1	2	3
CO 24213.1	3	3	3	2	2	2	1	1	1	2	1		3	2	2
CO 24213.2	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO 24213.3	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO 24213.4	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO 24213.5	3	3	3	2	2	2	2	1	3	2	1		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 24215
Course title: Material Science and Engineering
Pre-requisite(s): **PH24101 Physics, CH24101 Chemistry**
Co- requisite(s):
Credits: L: 3 T: 0 P: 0
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.	Knowledge: Define crystal structure, crystal 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 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:

CO24215.1	Define: Define crystal structure, crystal defects and microstructural change during processing
CO24215.2	Demonstrate: Demonstrate the phase diagram and on the properties of processing of steel
CO24215.3	Analyze: Analyze the microstructure and find out the processing techniques which relate to the properties.
CO24215.4	Synthesize: Given a set of specification synthesize a material based on available resources
CO24215.5	Evaluate: Apply the basic principles of composite materials evaluate the properties for specific functions

SYLLABUS

MODULES	NO. OF LECTURE HOURS
MODULE I Introductory concept: Crystal structures, Space lattice, Symmetry elements, Unit cells, Crystal systems, Packing factors, Miller indices, Single crystals, 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.	8
MODULE II Solidification of pure metal. Plastic deformation of pure metal. Diffusion in solids. Solidification in binary alloys. Fe-C phase diagram. Ternary phase diagram. Metal working, Deformation processing. Preparation of a 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. Pyrometallurgy: Calcination, roasting, smelting. Predominance area diagram, Hydrometallurgy: leaching, solvent extraction, ion exchange, precipitation and Electrometallurgy: electrolysis, electrorefining. Stress-strain behavior 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. Mechanical properties of polymers-toughness, resilience, necking Thermodynamics of Polymer solutions. Properties and application of commodity polymers (PE, PP, PVC, PS, PMMA, PET, Nylon, PTFE). Properties of elastomer (NR, SBR, Silicone rubber) and application	10
MODULE V Basic concepts of glass structure, Common Refractory Materials, Glass ceramics. Optical Fibre. Bioceramics, Sol-gel technology. Fiber reinforced composites. Transducers, Sensors and actuators.	6

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.
6. P.Ghosh,Polymer Science and Technology - Plastics, Rubber, Blends and Composites-McGraw-Hill Education 2011

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

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

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

Direct Assessment: Quiz/Examination/seminar/assignments

Indirect Assessment –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	1	2	3
CO24215.1	3	3	3	1	2	2	2	3	2	2	1	3	2	1
CO24215.2	3	3	3	1	2	2	2	3	2	2	1	3	2	1
CO24215.3	3	3	3	1	1	2	2	3	2	2	1	3	2	1
CO24215.4	3	3	3	2	1	2	2	3	2	2	1	3	2	1
CO24215.5	3	3	3	2	1	2	2	3	2	2	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		

LABORATORY

COURSE INFORMATION SHEET

Course code: CL24202
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:

CO24202.1	Demonstrate various fluid flow measuring devices and examine the performance of a centrifugal pump.
CO24202.2	Operate mechanical separation equipment and Analyze the results.
CO24202.3	Evaluate heat transfer in composite wall and shell and tube heat exchanger.
CO24202.4	Analyze the experimentally derived quantities with estimates from correlations/models discussed in the related theory courses.
CO24202.5	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

Continuous internal assessment	**60%**
i) Day to day performance and Lab. files	**30%**
ii) Quiz -I	**10%**
iii) Viva	**20%**
Semester-End Examination	**40%**
i) Examination Experiment performance	**30%**
ii) Quiz-II	**10%**

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		1	2	3
CO24202.1	1	1	3	3	3	3	1	1	3	1	1		3	3	3
CO24202.2	3	3	3	1	1	3	1	1	3	3	1		3	3	3
CO24202.3	1	3	3	1	3	3	3	1	1	3	1		3	3	3
CO24202.4	1	1	1	3	3	3	1	1	3	3	1		3	3	3
CO24202.5	1	1	1	1	1	3	1	1	1	3	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
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:	CL24301
Course title:	Mass transfer operation - II
Pre-requisite (s):	Mass transfer Operation-I (CL24211)
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.	Understand the principles of mass transfer operations such as extraction, humidification, drying, adsorption, crystallization which has high relevance to industrial applications.
2.	Learn the equilibrium characteristics of two phase mass transfer processes.
3.	Understand the hydrodynamics and modes of operations in mass transfer equipment.
4.	Learn application of gas-liquid operation and simultaneous heat and mass transfer operations.
5.	Gain knowledge of various membranes separation processes.

Course Outcomes

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

CO24301.1	Solve design calculation problems on liquid-liquid and solid-liquid extraction.
CO24301.2	Apply the concept of humidification, cooling tower and solve the related problems.
CO24301.3	Explain the drying operations, different dryers and analyze & solve the related problems.
CO24301.4	Explain the various adsorption isotherms and solve problems related to adsorption.
CO24301.5	Apply the knowledge of crystallization and membrane-based separation processes and solve the related problems.

SYLLABUS

MODULE	No.of Lecture Hours
Module1: **Liquid-liquid extraction:** Introduction to Extraction, Liquid-liquid equilibria, Ternary diagram, solvent selection, Stagewise contact: single stage and multistage cross-current & counter- current extraction, number of equilibrium stages by graphical method, 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, and it's different application.	8

Text books:

1. Mass Transfer Operations: R.E.Treybal Mc Graw Hill,1981.
2. Principles of Mass Transfer and Separation Processes, Binay K. Dutta, 2nd edition, Prentice Hall of India, 2007.
3. Unit Operations of Chemical Engineering: W.L.Mc Cabe, and J.C.Smith Mc Graw 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/seminar/assignment/others	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		1	2	3
CO24301.1	3	3	3	1	1	1	2	2	2	1	1		3	1	1
CO24301.2	3	3	1	1	1	2	2	1	1	2	1		3	1	1
CO24301.3	3	2	1	2	1	2	1	1	1	2	2		3	3	1
CO24301.4	3	2	1	1	1	1	1	1	1	1	1		3	1	1
CO24301.5	2	1	1	1	1	3	2	3	1	2	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, 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:	CL 24303
Course title:	Chemical Reaction Engineering-II
Pre-requisite(s):	Chemical Reaction Engineering-I (CL 24213)
Co- requisite(s):	
Credits:	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.	Explain the basic concepts of heterogeneous catalysis.
2.	Calculate and explain the physical properties of the catalysts.
3.	Development the kinetics of heterogeneous 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:

CO24303.1	Describe the heterogeneous reactions and evaluate the physical properties of the catalysts.
CO24303.2	Derive the kinetics for heterogeneous catalytic reaction.
CO24303.3	Explain the transport effects of reaction in the heterogeneous catalysis.
CO24303.4	Derive the kinetics for heterogeneous non-catalytic reaction.
CO24303.5	Describe the kinetics of multiphase and biochemical reaction systems.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction to heterogeneous reactions. Classification of heterogeneous reactions. Concept of intrinsic and global rate of reaction. Components of the Catalyst formulation. Catalyst preparation. Determination of physical properties (BET surface area, pore volume, and pore size distribution) of heterogeneous catalysts.	8
Module 2: Steps in a catalytic reaction: Adsorption isotherms, Surface reaction, Desorption. Rate limiting step. Mechanism and synthesizing a rate law.	8
Module 3: Kinetics of solid catalyzed gas phase reaction; isothermal and non-isothermal inter-and-intraphase effectiveness factors, catalytic gas-solid reactor design.	8
Module 4: 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 5: Gas liquid reactions: Enhancement factor in gas-liquid reactions, design of gas-liquid reactors. Gas-Liquid Reactions on Solid Catalyst, Suspended Solids Reactors: Bubbling fluidized bed (BFB), K-L Model for BFB.	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/seminar/assignment/others	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		1	2	3
CO24303.1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO24303.2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO24303.3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO24303.4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO24303.5	3	3	1	2	3	2	2	1	1	2	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
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 CL24305

Course Title PROJECT ENGINEERING AND ECONOMICS

Prerequisite(s) Chemical Process Calculations (CL24205)
Chemical Reaction Engineering-I (CL 24213)

Co-requisite(s)

Credits L:3 T:0 P: 0

Class Scheduler week 3

Class B.TECH.

Semester/Level V/ Third

Branch Chemical Engineering

Name of Teacher

Course Objectives:

This course enables the students to:

1.	To develop the concept of plant start-up with process design and flow sheet development.
2	To understand the various components of the project cost and the estimation methods.
3.	To understand the paying capital cost, plant profit and loss, depreciated values, profitability.
4.	To understand the optimization methodology in a process plant.
5.	Identify and understand various hazards and safety measures and analysis in the chemical industry.

Course Outcomes:

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

CO24305.1	Evaluate process design parameters and estimate capital cost and product cost.
CO24305.2	Calculate interest on loan, profit, and cash flow to evaluate the breakeven point.
CO24305.3	Evaluate the feasibility of the project in terms of profit, payback period and other components.
CO24305.4	To solve optimization problems in chemical process industries.
CO24305.5	Adopt safety measures in chemical process industries through HAZOP studies, hazard Analyzes, and hazard quantifications.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Process design development, Preliminary design methodology, Process flow diagram, Flow sheet, Computer aided design Cash flow diagram, Capital investment, Total production cost, Cost index Estimations of equipment cost, total capital cost, and total product cost, and manufacturing cost, Estimations of revenue, gross profit, net profit, Break-even analysis and estimation of break-even point.	8
Module 2: Time value of money: Interests and Investment costs, Simple Interest, Compound interest, Nominal and Effective interest rates, Continuous interest, Cost of Capital, Cash Flow Patterns, Compounding and discounting factors, Present worth and Discount, Annuities, Perpetuities, and Capitalized costs of investments.	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. Profitability analysis: Gross profit, Income tax, Net profit, Rate of return on investment. Present worth and discounted cash flow rate of return, Payback period, Capitalized costs.	8
Module 4: Optimum design and design strategy: Procedure with one, two and more variables, Optimum cost, equipment size and production rates in plant operation, Optimization case studies in chemical process plant, 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 (HAZOP), Fault tree analysis (FTA). Case studies of HAZOP and FTA in chemical process plants.	8

Text books:

1. Plant Design and Economics for Chemical Engineers, M. S. Peters, K. D. Timmerhaus, and R. E. West, 5th Edition, McGraw-Hill Inc.

2. Coulson & Richardson's Chemical Engineering Design, R K Sinnott, Vol. 6., Fourth Edition, Elsevier.

3. Project planning and control with PERT & CPM, B. C. Punmia, and K. K. Khandelwal. Firewall media, 2002.

Reference books:

1. Process Engineering Economics, J. R. Couper, Marcel DekkerInc.
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.

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

Process modeling, simulation, computer aided design, Plant design

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

Process modeling, simulation, computer aided design, plant design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second quiz/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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	CL24307
Course title	Chemical Process Technology
Pre-requisite(s)	**CL24201** Thermodynamics, CL24205 Chemical Process Calculations
Co- requisite(s)	**CL24211/CL24301** Mass Transfer Operation I & II, CL24207 Heat Transfer Operation, CL24213 Chemical Reaction Engineering-I
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.	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:

CO24307.1	Describe manufacturing processes involved in the productions of various chemicals such as inorganics, synthetic organics, natural products, foods etc.
CO24307.2	Understand the role of different unit operations and unit processes in a process flow diagram.
CO24307.3	Determine the effect of various process parameters on a chemical process for plant operation.
CO24307.4	Identify major engineering problems in a chemical process
CO24307.5	Modify the process for economic and environmental sustainability.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Sulfuric acid: Production of sulfuric acid, Hydrates of sulfuric acid and uses, Contact process, Catalysts developments, Process modification: Double contact double absorption (DCDA) process, Shell Claus off gas treating (SCOT). Chlor-alkali industries: Manufacture of Soda Ash, Solvay and modified Solvay processes, Caustic Soda and Chlorine; Electrolytic processes and developments. 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. Design challenges, process modifications: Pool reactor (urea synthesis) and others. 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: Bio 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. Chemical Process Technology, J. A. Moulijn, M. Makkee, and A. E. Van Diepen, 2nd Edition, John Wiley & Sons.
2. Kirk &Othmer (Ed.), Encyclopedia of Chemical Technology.
3. 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/seminar/assignment/others	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**		**1**	**2**	**3**
CO24307.1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO24307.2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO24307.3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO24307.4	2	2	1	1	1	1	1	1	1	2	3		1	1	3
CO24307.5	2	2	1	1	1	1	1	1	1	2	3		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		

LABORATORIES

COURSE INFORMATION SHEET

Course code: CL24304
Course title: Computer Aided Process Engineering Lab
Pre-requisite(s): **CS24101** Programming for Problem Solving
Co- requisite(s):
Credits: 1.5 (L: 0 T: 0 P: 3)
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.	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:

CO24304.1	Solve steady state models using computational tools.
CO24304.2	Solve dynamic models and transient problems using computational tools.
CO24304.3	Develop flowsheets of chemical processes with mixer, reactor, separator, heat exchanger, purge, recycle, bypass, etc. using computational tools.
CO24304.4	Evaluate techno-economic feasibility of chemical processes.
CO24304.5	Solve fluid flow and heat transfer using CFD tools.

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Computation of the steady state operating conditions of a system with multiple unit operations without chemical reaction using MATLAB®.
2	Computation of the steady state operating conditions of a system with multiple unit operations and unit processes using MATLAB®.
3	Dynamic simulation and transient analysis of unit operation and unit process.
4	Solving VLE problems for ideal and non-ideal systems using MATLAB® (Bubble point, dew point, flash vaporization).
5	Steady state simulation, design, and optimization of multiple component distillation train using ASPEN PLUS®.
6	Reactor modeling and design using ASPEN PLUS®.
7	Steady state simulation of a complete chemical process using ASPEN PLUS®.
8	Solving Fluid flow and Heat transfer problems using CFD tools.

Text books:

1. Introduction to Chemical Engineering Computing, B. A. Finlayson, JOHN WILEY & SONS, INC., PUBLICATION.
2. ASPEN PLUS, 1988, "ASPEN PLUS User Guide", Aspen Technology, Inc., Cambridge, Massachusetts.

Reference books:

1. Principles of chemical engineering practice. G. DeLancey, John Wiley & Sons, 2013.

Gaps in the syllabus (to meet Industry/Profession requirements)
Process modeling and simulation, Equipment design

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design
Process modeling and simulation

POs met through Topics beyond syllabus/Advanced topics/Design

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Continuous internal assessment	**60%**
i) Day to day performance and Lab. files	**30%**
ii) Quiz -I	**10%**
iii) Viva	**20%**
Semester-End Examination	**40%**
i) Examination Experiment performance	**30%**
ii) Quiz-II	**10%**

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		1	2	3
CO24304.1	1	1	3	3	3	3	1	1	3	1	1		3	3	3
CO24304.2	3	3	3	1	1	3	1	1	3	3	1		3	3	3
CO24304.3	1	3	3	1	3	3	3	1	1	3	1		3	3	3
CO24304.4	1	1	1	3	3	3	1	1	3	3	1		3	3	3
CO24304.5	1	1	1	1	1	3	1	1	1	3	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**
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: CL24302
Course title: Chemical Engineering Lab II
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: 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 equipment/instruments.
4.	Develop experimental skills.
5.	Examine the theory through experiments

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

CO24302.1	Operate mass separation equipment and analyze the results.
CO24302.2	Evaluate heat transfer in various heat exchangers.
CO24302.3	Estimate heat and mass transfer parameters for unit operation equipment.
CO24302.4	Analyze the experimentally derived quantities with estimates from correlations/models discussed in the related theory courses.
CO24302.5	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 an agitated vessel.
7	Spiral Heat exchanger.
8	Plate heat exchanger.
9	Membrane preparation by phase inversion and studies on cross-flow and hollow fiber membranes.
10	Studies on Heat and Mass Transfer in Cooling Tower.
11	Steam Distillation of turpentine.
12	Batch Distillation with reflux in a packed column with stacked packing.
13	Liquid-Liquid extraction in York Scheibel 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

Continuous internal assessment	**60%**
i) Day to day performance and Lab. files	**30%**
ii) Quiz -I	**10%**
iii) Viva	**20%**
Semester-End Examination	**40%**
i) Examination Experiment performance	**30%**
ii) Quiz-II	**10%**

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	1	2	3
CO24302.1	1	1	3	3	3	3	1	1	3	1	1	3	3	3
CO24302.2	3	3	3	1	1	3	1	1	3	3	1	3	3	3
CO24302.3	1	3	3	1	3	3	3	1	1	3	1	3	3	3
CO24302.4	1	1	1	3	3	3	1	1	3	3	1	3	3	3
CO24302.5	1	1	1	1	1	3	1	1	1	3	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
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: CL24309
Course title: Transport Phenomena
Pre-requisite(s): Fluid Mechanics (CL24203) , Heat Transfer Operations (CL24207), Mass Transfer Operations -I (CL24211)
Co- requisite(s): Mathematics I (MA24101) and II (MA24103)
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.	Understand the transport mechanisms in a flow system and derive the exact transport equation.
2.	Understand the momentum transport problems to derive the transport equations and velocity profile using the initial and boundary conditions.
3.	Understand the energy or heat transport problems to derive the transport equations and temperature profile using the initial and boundary conditions.
4.	Understand the species transport problems to derive the transport equations and concentration profile using the initial and boundary conditions.
5.	Understand the turbulent transport and analogies that drive transport phenomena.

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

CO24309.1	Identify mechanisms of transport phenomena and establish the equations of changes in the isothermal/non-isothermal and flow systems.
CO24309.2	Apply the equation of changes in momentum transport problems and derive the velocity and stress profile.
CO24309.3	Apply the non-isothermal equation of changes in energy transport problems/ coupled transport processes and derive the temperature profile.
CO24309.4	Apply the equation of changes in species transport problems, with/without chemical reactions and derive the concentration profile.
CO24309.5	Introduction to turbulent transport processes with analogies and empirical equations.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Laws of conservation, Transport equations and mechanisms of transports, Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity.	8
Module 2: Momentum transport: Shell Momentum balances, velocity profiles, average velocity, momentum flux, Equations of Change (Isothermal), equation of continuity, equation of motion in laminar flow.	8
Module 3: Energy transport: Shell energy balances, temperature profiles, average temperature, energy flux, Concept of heat transfer coefficient, Equations of change (non-isothermal systems), equation of continuity, equation of motion, and energy equations for forced and free convection, Coupled heat and momentum transport.	8
Module 4: Species transport: Shell mass balances, concentration profiles, average concentration, mass flux, Concept of mass transfer coefficient, Equations of change (multi-component) in laminar flow.	8
Module 5: Introduction to Turbulent Flow— distributions of velocity, temperature, and species, Time-smoothed equations of changes, Transport analogies, Reynolds stresses, Prandtl mixing length, Empirical expressions	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".

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

Mass transfer with chemical reaction, Turbulent flow models

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

1. Turbulent flow behavior
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/seminar/assignment/others	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		1	2	3
CO24309.1	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO24309.2	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO24309.3	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO24309.4	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO24309.5	3	3	3	3	1	1	1	1	1	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:	CL 24311
Course title:	Process Control and Instrumentation
Pre-requisite(s):	Mathematics - I -MA24101; Mathematics - II-MA24103; Chemical Process Calculations-CL24205
Co- requisite(s):	Chemical Reaction Engineering – I CL24213
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.	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:

CO24311.1	Define the operating principles of various instruments and measurements in a chemical process plant.
CO24311.2	Developing transfer function models, block diagram and compute the response of the developed transfer function for various forcing functions.
CO24311.3	Analyze the stability of a control system given a mathematical model of a control system including its components.
CO24311.4	Design of controller using different tuning techniques.
CO24311.5	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.	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. Stephanopoulos, 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/seminar/assignment/others	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	1	2	3
CO24311.1	3	3	1	3	1	1	1	1	1	1	1	3	1	1
CO24311.2	3	3	3	2	3	1	1	1	2	1	1	3	3	2
CO24311.3	3	3	2	2	3	1	1	1	2	1	1	3	3	1
CO24311.4	2	3	3	3	3	2	3	2	2	2	1	2	2	3
CO24311.5	2	3	3	3	3	2	3	2	2	2	1	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		

LABORATORIES

COURSE INFORMATION SHEET

Course code: CL24306
Course title: Process Equipment Design Lab
Pre-requisite(s): **ME24101 Basics of mechanical Engineering, CL24207 Heat Transfer Operations, CL24211/CL24301 Mass Transfer Operation I & II**
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.	Understand and apply fundamental principles to design key process equipment used in the chemical industry.
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:

CO24306.1	Design of shell and tube heat exchanger.
CO24306.2	Design of tray distillation column.
CO24306.3	Design of packed bed absorption column.
CO24306.4	Design of cooling tower and rotary dryer.
CO24306.5	Design of pressure vessels.

LIST OF EXPERIMENTS:

Sl. No.	Description
1	Design of shell and tube heat exchangers.
2	Design of tray distillation column.
3	Design of packed absorption column.
4	Design of rotary dryer.
5	Design of pressure vessels.
6	Design of cooling tower.

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

Continuous internal assessment	60%
i) Day to day performance and Lab. files	30%
ii) Quiz -I	10%
iii) Viva	20%
Semester-End Examination	**40%**
i) Examination Experiment performance	30%
ii) Quiz-II	10%

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		1	2	3
CO24306.1	1	1	3	3	3	3	1	1	3	1	1		3	3	3
CO24306.2	3	3	3	1	1	3	1	1	3	3	1		3	3	3
CO24306.3	1	3	3	1	3	3	3	1	1	3	1		3	3	3
CO24306.4	1	1	1	3	3	3	1	1	3	3	1		3	3	3
CO24306.5	1	1	1	1	1	3	1	1	1	3	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
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD6, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD6, CD8
CD3	Seminars	CO3	CD1, CD2, CD6, CD8

CD4	Mini projects/Projects	CO4	CD1, CD2, CD6, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, 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: CL24308
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 equipment/instruments.
4.	Develop experimental skills.
5.	Examine the theory through experiments

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

CO24308.1	Learn to employ various methods to determine the kinetics of reactions.
CO24308.2	Quantify the effects of non-ideality of flow in chemical reactors.
CO24308.3	Estimate physical parameters of different types of fuels.
CO24308.4	Analyze the experimentally derived quantities with estimates from correlations/models discussed in the related theory courses.
CO24308.5	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

Continuous internal assessment	**60%**
i) Day to day performance and Lab. files	**30%**
ii) Quiz -I	**10%**
iii) Viva	**20%**
Semester-End Examination	**40%**
i) Examination Experiment performance	**30%**
ii) Quiz-II	**10%**

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		1	2	3
CO24308.1	1	1	3	3	3	3	1	1	3	1	1		3	3	3
CO24308.2	3	3	3	1	1	3	1	1	3	3	1		3	3	3
CO24308.3	1	3	3	1	3	3	3	1	1	3	1		3	3	3
CO24308.4	1	1	1	3	3	3	1	1	3	3	1		3	3	3
CO24308.5	1	1	1	1	1	3	1	1	1	3	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**
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	CL24401
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: 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.	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:

CO24401.1	Develop mathematical models for chemical engineering systems.
CO24401.2	Formulate optimization problem.
CO24401.3	Solve unconstrained Single Variable Optimization problems.
CO24401.4	Solve unconstrained Multivariable Optimization problems.
CO24401.5	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 toOptimization: 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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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:	CL24402
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:

CO24402.1	Perform experiments on temperature, pressure, flow, and level control trainer and evaluate various related parameters.
CO24402.2	Evaluate temperature of a system using various temperature measuring instruments.
CO24402.3	Evaluate pressure of a system using Flapper-nozzle.
CO24402.4	Analyze the characteristics of control valve in a control system.
CO24402.5	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:

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

Continuous internal assessment	**60%**
i) Day to day performance and Lab. files	**30%**
ii) Quiz -I	**10%**
iii) Viva	**20%**
Semester-End Examination	**40%**
i) Examination Experiment performance	**30%**
ii) Quiz-II	**10%**

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		1	2	3
CO24402.1	1	1	3	3	3	3	1	1	3	1	1		3	3	3
CO24402.2	3	3	3	1	1	3	1	1	3	3	1		3	3	3
CO24402.3	1	3	3	1	3	3	3	1	1	3	1		3	3	3
CO24402.4	1	1	1	3	3	3	1	1	3	3	1		3	3	3
CO24402.5	1	1	1	1	1	3	1	1	1	3	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
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: CL 24404
Course title: Plant Design
Pre-requisite(s): Chemical Process Calculations, HTO, MTO, CRE
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.	Explain the concepts of plant design and project management.
2.	Estimate the capital cost, total product cost and profitability.
3.	Estimate mass and energy balances for a processing plant.
4.	Develop processes based on economics using Aspen Plus/DWSIM.
5.	Analyze the heat integration using pinch technology

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

CO 24404.1	Develop material and energy balance equations for a process involving several processing units
CO 24404.2	Explain the concept of Process Integration/ pinch technology and develop efficient processes.
CO 24404.3	Evaluate project cost based on economics for plant design.
CO 24404.4	Select suitable site for plant.
CO 24404.5	Develop process flow –sheets using Aspen Plus/DWSIM.

LIST OF EXPERIMENTS:

Sl. No.	Description
1	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/DWSIM.

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

Continuous internal assessment	60%
i) Day to day performance and Lab. files	30%
ii) Quiz -I	10%
iii) Viva	20%
Semester-End Examination	**40%**
i) Examination Experiment performance	30%
ii) Quiz-II	10%

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		1	2	3
CO 24404.1	1	1	3	3	3	3	1	1	3	1	1		3	3	3
CO 24404.2	3	3	3	1	1	3	1	1	3	3	1		3	3	3
CO 24404.3	1	3	3	1	3	3	3	1	1	3	1		3	3	3
CO 24404.4	1	1	1	3	3	3	1	1	3	3	1		3	3	3
CO 24404.5	1	1	1	1	1	3	1	1	1	3	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
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD6, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD6, CD8
CD3	Seminars	CO3	CD1, CD2, CD6, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD6, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, 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:	CL24381
Course title:	Multiphase flow
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L:03 T:01 P:00
Class schedule per week:	04
Class:	B. Tech.
Semester / Level:	V/III
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:

CO24381.1	Explain fundamental concepts, principles and application of multiphase flow.
CO24381.2	Describe different flow regimes of gas-liquid two phase flow.
CO24381.3	Solve analytical models to analyze the hydrodynamics of different flow regimes.
CO24381.4	Explain hydrodynamics of three phase flows.
CO24381.5	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 procedur

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Second quiz/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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	CL24383
Course title	Numerical Heat transfer and fluid flow
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	4
Class	B. TECH.
Semester / Level	V/3
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:

CO24383.1	Solve the Navier-Stokes equations
CO24383.2	Use Finite Difference and Finite Volume methods in CFD modeling.
CO24383.3	Generate and optimize the numerical mesh.
CO24383.4	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.
CO24383.5	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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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	CL24385
Course title	Molecular Simulation
Pre-requisite(s)	Chemistry, Physics, Calculus, Numerical Methods in Chemical Engineering
Co- requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	4
Class	B. TECH.
Semester / Level	VI/03
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.	Analyze the systems using molecular modelling packages.

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

CO24385.1	Apply the Density Functional Theory to Optimize the Geometry of Molecules.
CO24385.2	Explain the basic principles of molecular Simulation.
CO24385.3	Develop Simple Monte Carlo Simulation Code.
CO24385.4	Develop Simple Molecular Dynamics Code.
CO24385.5	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 Image Convention, 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 to Applications, 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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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	CL24387
Course title	Process Integration
Pre-requisite(s)	Basic knowledge of material and energy balances, fluid mechanics, heat and mass transfer, thermodynamics.
Co- requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	04
Class	B. TECH.
Semester / Level	VI/03
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:

CO24387.1	Explain the concept of Process Integration.
CO24387.2	Explain fundamentals of Pinch Technology.
CO24387.3	Apply Pinch Technology.
CO24387.4	Analyze Heat Exchanger Network using Composite Curves.
CO24387.5	Analyze Heat Integration of Distillation Column using Composite Curves.

SYLLABUS

MODULE	No. of Lecture Hours
Module 1: Introduction to process Intensification and Process Integration(PI), Areas of application and techniques available for PI, onion diagram, Process Integration in Chemical Industries ,Formulation of a Design Problem, Chemical Process Design and Integration, Hierarchy of Chemical Process Design and Integration, Continuous and Batch Processes, New Design and Retrofit, Approaches to Chemical Process Design and Integration, Process Control.	8
Module 2: Pinch Technology- Introduction, Basic concepts, how it is different from energy auditing, Roles of thermodynamic laws, problems addressed by Pinch Technology. Key steps of Pinch Technology: Concept of ΔT_{min}, Data Extraction, Targeting, Designing, Optimization-Super targeting.	8
Module 3: Basic Elements of Pinch Technology: Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.	8
Module 4: Targeting of Heat Exchanger Network, Designing of Heat Exchanger Networks, Hot Composite Curve, Cold Composite Curve, Problem Table Algorithm, Grand Composite Curve, Area Targeting by Uniform Bath formula and Unit Targeting by Euler’s formula, Heuristics for Pinch Design, Maximum Energy 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, Gulf Publishing 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/seminar/assignment/others	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**		**1**	**2**	**3**
CO1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3		1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3		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 24391**
Course title	**Introduction to Polymer Science**
Pre-requisite(s)	**PH24101,CH24101**
Co- requisite(s)	
Credits	L: 4 T: 0 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.	Define chemical structure of polymer, classification and isomerism
2.	Describe the different molecular weight measurement techniques
3.	Illustrate the types 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:

CO24391.1	Remembering:Show chemical structure of polymers,tell correlation between structure and properties,recall polymerization steps
CO24391.2	Understanding: Outline Polymerization processes and compare different steps of synthesis by various mechanisms,interpret polymer solubility in terms of thermodynamics
CO24391.3	Analyze:Given a set of polymers assess their suitability for specific use and application on the basis of chemical structure,solubility,degree of crystallinity
CO24391.4	Evaluate:Given a specific set of requirements of polymer application recommend and select the most cost effective polymerization technique for production
CO24391.5	Apply:Given a polymer, suggest the method of finding out molecular weight distribution,average molecular weight, degree of crystallinity

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module 1: Introduction & historical background, Macromolecular concept, structural feature of polymer, Classification of polymer, Functionality principle	8
Module 2: Types of polymerization, General theory of addition & condensation polymerization. Kinetics of chain & step growth polymerization, photo initiation, Radiation polymerization, concept of copolymerisation, Ionic & Coordination polymerization, Stereo regular polymerization, Living polymer	10
Module 3: Mol: wt & Mol: wt; distribution of polymer Determination of Molecular weight by viscometry, osmometry, light scattering, GPC, end group analysis & sedimentation method.	8
Module 4: Glass transition temp, Determination of glass transition, brittle temperature, melting temperature	6
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. Principle of Polymerization, G. Odian 2nd Ed. Wiley, Interscience. New york1981
2. Textbook of polymer science, Billmeyer. F. W. 3rd Ed, Wiley Interscience, 1984
3. Plastics Materials: Brydson J.A. 7th Ed.,Butter worth
4. Shreve's Chemical process Industries, George T. Sustin, Mc. Graw Hill.
5. Unit process in organic synthesis. Groggins P.H, Me. Grow Hill.
6. The role of additives in Plastics, Mascia, Edword Arnold 1974.

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/seminar/assignment/others	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		1	2	3
1	3	3	3	2	3	2	2	1	1	1	1		3	3	3
2	3	3	3	2	3	2	2	1	1	1	1		3	3	3
3	3	3	3	2	3	2	2	1	1	1	1		3	3	3
4	3	3	3	2	3	2	2	1	1	1	1		3	3	3
5	3	3	3	2	3	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	**CL24393**
Course title	**Polymer Technology - I**
Pre-requisite(s)	**CH24101, PH24101**
Co- requisite(s)	
Credits	L: 4 T: 0 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.	***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:

CO24393.1	**Remember:** Recall the preparation, properties and application of various commodity and engineering plastics
CO24393.2	**Understand:**Explain preparation, properties and application of commodity and engineering plastics.
CO24393.3	***Apply:*** Apply the importance of structure property relationship to choose the materials for various applications.
CO24393.4	***Analyze:*** Categorize the methods of the preparation, properties and application of specific copolymers.
C024393.5	***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. Societyofplastic&Industruy.Inc. 4thEdn.,Van Nostrand,N.Y. 1976
3. The Roll of Additives in Plastics, Mascia, L., Edward Arnold, 1974
5. Hand Bookof PlasticTestingTechnology, VishuShah, WileyInterScience.

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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO2	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO3	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO4	3	3	3	3	1	1	1	1	1	2	2		3	3	3
CO5	3	3	3	3	1	1	1	1	1	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: **CL24395**
Course title: **Polymer Process Technology**
Pre-requisite:
Credits: L: 03 T: 10 P: 00
Class schedule per week: **04**
Class: **B.Tech.**
Semester / Level: **06/3**
Branch: **Chemical Engineering**
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:

CO24 395.1	Remembering: Choose the corresponding process to be used to manufacture a specific product from suitable polymers.
CO24 395.2	Understanding: Compare the methods of different processing techniques for product manufacture with a given set of plastic materials for the specific use
CO24 395.3	Apply: Apply most modern technology to modify the process variables on the existing machine to manufacture a specific plastic/ rubber/composite product
CO 24395.4	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	Evaluate: Explain processing difficulties and estimate numerical problems related to polymer processing

24395.5	

Syllabus

MODULE	No. of Lecture Hours
Module1 Rheology of Polymer melts, Viscoelastic models. Extensional viscosity,. Compounding,. Dry blending, batch and continuous mixing process. Extrusion Process: general outline of screw theory, geometry of screw, The standard extruder screw and modification, pipe, tube, wire coating and sheet extrusion.	8
Module 2 Injection moulding process: Machine construction details, Shrinkage in injection moulding, Orientation arising in moulding, Injection moulding of thermosetting plastics. Troubleshooting in injection moulding.	8
Module3 Blow moulding: Extusion and Injection Blow moulding, Stretch blow moulding, Wall thickness and Parison thickness relationship, coextrution blow moulding. Thermoforming, Rotomoulding, Compression moulding,	8
Module4 Rubber compounding, Machineries used, Foams and foam processes: Foam processes, Expandable polystyrene foam, RIM foam moulding	8
Module 5 Processing of polymer composites: Open and close mould process. Filament winding, Vacuum bag moulding, DMC, SMC, Reaction Injection moulding, Resin transfer moulding, Pultrusion.	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/seminar/assignment/others/Assignment/Seminar/Other	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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	1	3	2	1		3	2	2
CO2	1	2	3	3	3	2	2	2	1	1	2		2	3	3
CO3	2	1	1	1	1	3	2	3	1	2	1		3	2	1
CO4	1	2	3	3	3	2	2	2	1	1	2		2	3	3
CO5	3	3	3	2	2	2	2	1	3	2	1		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: **CL24397**

Course title: Polymer Technology-II

Pre-requisite(s):

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

Credits: L: 04 T: 00 P: 00

Class schedule per week: **04**

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:

CO24397.1	Remembering:Relate properties of given thermoplastic and thermoset resins to chemical structures, recall industrial manufacturing processes of polymers suitable for different applications.
CO24397.2	Understanding: Summerize the mechanical, thermal etc. properties of engineering polymer and functional polymers
CO24397.3	Apply:Choose specific polymer for a given product application.
CO24397.4	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.
CO24397.5	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**.**	**8**
Module-V: Special application of polymers: conductive, magnetic, optical, photoresponsive polymers	**6**

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. Societyofplastic&Industruy.Inc. 4thEdn., 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 BookofPlasticTestingTechnology, VishuShah, WileyInterScience.

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/seminar/assignment/others	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		1	2	3
CO1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3		1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3		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	CL24251
Course title	Unit Operation-I
Pre-requisite(s)	
Co- requisite(s)	
Credits	L: 3 T: 1 P: 0
Class schedule per week	4
Class	B. TECH.
Semester / Level	V/02
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:

CO24251.1	Estimate mass balance over various unit processes.
CO24251.2	Estimate energy balance over various unit processes.
CO24251.3	Explain/Estimate various characterization of solid particles.
CO24251.4	Explain various solid handling Equipments.
CO24251.5	Classify various solid-solid/solid-fluid separation processes.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module-1: Introductory concepts of units, Mole Concept, Basis of 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/seminar/assignment/others	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		1	2	3
CO1	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO2	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO3	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO4	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO5	3	2	2	3	1	3	2	3	3	2	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
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:	CL24253
Course title:	Unit Operation II
Pre-requisite(s):	
Co- requisite(s):	
Credits:	L:3 T:1 P:0
Class schedule per week:	4
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:

CO24253.1	Identify and describe the fluid static mechanisms, concept of pressure, pressure measuring device, flow rate measuring device.
CO24253.2	Apply mass and momentum balance equation to solve various engineering problems.
CO24253.3	Describe fluidization and its applications.
CO24253.4	Explain the basic principles of heat transfer: Conduction, Convection and Radiation.
CO24253.5	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: Reynolds transport theorem, Integral balances - mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Differential analysis:	12
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:

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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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**
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/CD9	Self- learning such as use of NPTEL materials and internets/Simulations		

Course Information Sheet

Course code:	CL24255
Course title:	Fundamentals of Chemical Reaction Engineering
Pre-requisite(s):	CL204 Chemical Process Calculations
Co- requisite(s):	
Credits:	3 (L: 3 T: 1 P: 0)
Class schedule per week:	4
Class:	B. Tech.
Semester / Level:	VI/ second
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.	Analyze 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:

CO24255.1	Explain the concepts of Kinetics and Rate Laws.
CO24255.2	Analyze ideal Reactors for homogeneous reactions.
CO24255.3	Determine rate constant, reaction order and reactor volume using the kinetic data.
CO24255.4	Analyze the characteristics of non-isothermal and heterogeneous reactions
CO24255.5	Analyze the non-ideality of real reactors.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module-1:	8
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.	

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-PrenticeHall.
2. Levenspiel O., "Chemical Reaction Engineering", 3rdEd., John Wiley andSons.
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 UniversityPress.

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/seminar/assignment/others	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1. Student Feedback on Course Outcome
2.

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		1	2	3
CO1	3	3	3	2	2	2	1	1	1	2	1		3	2	2
CO2	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO3	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO4	3	3	3	2	2	2	2	1	2	2	1		3	2	2
CO5	3	3	3	2	2	2	2	1	3	2	1		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: CL24399
Course title: Unit Operation III
Pre-requisite(s):
Co- requisite(s): NIL
Credits: **4 (**L: 3 T: 1 P: 0)
Class schedule per week: 04
Class: B. TECH.
Semester / Level: VII/03
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:

CO24399.1	Understand the basic principles of mass transfer operation.
CO24399.2	Design separation unit for the gas-liquid and gas-solid operations.
CO24399.3	Solve engineering problems related to distillation, drying and humidification.
CO24399.4	Identify suitable solvent/sorbent for particular liquid-liquid or solid-liquid extraction operation and solve related problems.
CO24399.5	Theoretical and analytical knowledge on crystallization and membrane separation processes and their engineering applications.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1:	8
Basic Principles: Principles of molecular diffusion and diffusion between phases, Fick's Law, Diffusivity, equation of continuity, Diffusion in solids. Concept of Mass transfer coefficient, correlation of mass transfer coefficients, Theories of Mass Transfer, mass transfer across interfaces, Analogy between momentum, heat and mass transfer.	
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-Thiele method, importance of reflux ratio. **(B) Humidification** Humidification and dehumidification operations, Psychometric chart, 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 of solvents, 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 rate of 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. (B) Membrane Separation Introduction to membrane separation, classification of membrane, characterization of membrane. Membrane modules, pressure-driven and concentration driven membrane separation processes.	8

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/seminar/assignment/others	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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	1	3	2	1		3	2	2
CO2	1	2	3	3	3	2	2	2	1	1	2		2	3	3
CO3	2	1	1	1	1	3	2	3	1	2	1		3	2	1
CO4	1	2	3	3	3	2	2	2	1	1	2		2	3	3
CO5	3	3	3	2	2	2	2	1	3	2	1		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	CL24231
Course title	Energy Engineering
Pre-requisite(s)	**CL24207, CL24205**
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. TECH.
Semester / Level	IV/Two
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 24231.1	Explain various energy sources, their availability, importance of energy conservation & audit and available energy conservation technologies.
CO 24231.2	Describe fundamental concepts of conversion technologies of conventional energy resources such as coal, petroleum and gaseous fuels and their utilization.
CO 24231.3	Explain principles and technologies of conversion of renewable energy resources to various other energy forms.
CO 24231.4	Acquire the knowledge of modern energy conversion technologies.
CO 24231.5	Assess major energy issues and challenges of the 21st 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** **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	8
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

Mid Semester Examination	25
Second quiz/seminar/assignment/others	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		1	2	3
CO1	3	3	3	3	3	3	3	3	3	3	1		3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	1		3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	1		3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	1		3	3	3
CO5	3	1	3	3	3	3	3	3	3	3	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
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 24233**
Course title	**Macromolecular Science**
Pre-requisite(s):	**PH24101, CH24101**
Co- requisite(s):	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	IV / Two
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:

CO**24233**.1	Remembering: Show chemical structure of polymers, correlation between structure and properties, recall polymerization steps
CO**24233**.2	Understanding: Outline Polymerization processes and compare different steps of synthesis by various mechanisms, interpret polymer solubility by thermodynamics
CO**24233**.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
CO**24233**.4	Evaluate: Given a specific set of requirements of polymer application recommend and select the most cost effective polymerization technique for production
CO**24233**.5	Apply: Given a polymer, suggest the method of finding out molecular weight distribution, 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, 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-growth (condensation) polymerization. Mechanism of stepwise polymerization. Kinetics and statistics of linear stepwise polymerization. Polyfunctional step-reaction polymerization.	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 and kinetics of ionic chain growth polymerization. Mechanism of co-ordination polymerization. Mechanism ring opening polymerization. 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. 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. 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:

Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. McGraw Hill, 1998.

1. The Element of Polymer Science & Engineering: Rudin.
2. Structural Investigation of Polymer: Bodor G., 1st Ed., Ellis Harwood Ltd., 1991.
3. 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 as there is no scope of laboratory course in the programme

POs met through Gaps in the Syllabus:

PO11,PO9,PO2

Topics beyond syllabus/Advanced topics/Design

Details of manufacturing process of conducting 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/seminar/assignment/others	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment –

1.Student Feedback on the attainment of 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		1	2	3
CO**24233**.1	3	3	3	2	3	2	2	1	1	1	1		3	3	3
CO**24233**.2	3	3	3	2	3	2	2	1	1	1	1		3	3	3
CO**24233**.3	3	3	3	2	3	2	2	1	1	1	1		3	3	3
CO**24233**.4	3	3	3	2	3	2	2	1	1	1	1		3	3	3
CO**24233**.5	3	3	3	2	3	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:	CL24235
Course title:	Computer Aided Process Engineering
Pre-requisite(s):	**MA24201, CL24201, CL24203**
Co- requisite(s):	Chemical reaction engineering-I CL24213
Credits:	3 (L:3 T:0 P:0)
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	IV / Two
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 the 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:

CO24235.1	Adapt the basic flowsheet in a chemical process plant.
CO24235.2	Formulate the conservation equations for a continuous process from the concept of chemical engineering to evaluate and examine steady state operating conditions.
CO24235.3	Formulate the conservation equations for a continuous process from the concept of chemical engineering to evaluate and examine unsteady state process with transient analysis.
CO24235.4	Formulate the Vapor-liquid equilibrium and liquid-liquid equilibrium data in a chemical process to analyze the yield, quality of a chemical process.
CO24235.5	Make use of different commercial softwares 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 units with and without chemical reaction, energy conservation equation of multiple units 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/seminar/assignment/others	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		1	2	3
CO1	3	3	1	1	1	2	1	1	2	1	1		3	2	3
CO2	3	3	1	3	3	1	1	1	3	2	1		3	3	3
CO3	3	3	1	3	3	1	1	1	2	2	1		3	3	2
CO4	3	3	2	2	3	1	1	1	3	3	1		3	3	3
CO 5	3	3	2	2	3	1	1	1	3	3	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
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	CL 24237
Course title	Waste Management
Pre-requisite(s)	**CH24101, PH24101**
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	IV / 02
Branch	Chemical Engineering
Name of Teacher	

Course Objectives

This course enables the students to:

1.	Learn about the problem of waste generation and its impact on the environment and human health.
2.	Familiarize with the existing legislation, knowledge and practices regarding waste management in the country.
3.	Familiarize with the waste conversion/treatment processes.
4.	Understand engineering, financial and technical options for waste management.
5.	Develop an ability to manage the solid waste effectively.

Course Outcomes

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

CO 24237 .1	Present an overview of the steps of SWM from waste generation to final step and select the most suitable SWM option.
CO 24237 .2	Explain plastic waste related terms and various management practices.
CO 24237 .3	Explain E-waste related terms and various management practices.
CO 24237 .4	Explain food waste related terms and various management processes.
CO 24237 .5	Explain Biomedical Waste Management, treatment and disposal processes.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1:Overview, MSW and its management, Generation of MSW, Management practices of MSW in developing countries, Solid waste management rules (India) 2016, Technologies for municipal solid waste management, Kinetics of waste degradation.	8
Module 2: Plastics – What it is? Types, Uses and Global Statistics, Plastic Waste – Sources, Production, Global and Indian Context, Plastic Waste Management Rules 2016/2018/2022 (India) and Global Rules and Regulations, Impact of Plastics on Marine Life, Effect on Wildlife, Human Health and Environment, Plastic Waste Management Practices – Use of Plastic waste in roads, chemical routes for recycling, conversion of plastic waste to fuel, Possible Alternate Materials to Plastics - Greener Alternatives, Plastics Resource Recovery and Circular Economy.	8
Module 3: E-Waste, E-waste management, Environmental and public health issues, E-waste health risk assessment, Recovery of materials from E-Waste, E-Waste Management Rules of India (2016 and 2018 Rules), E-waste Management: Case Studies and Unique Initiatives from around the World.	8
Module 4: Introduction: sources and characterization of food waste and food industry wastes, Valorization of food waste for bioethanol, biobutanol, biodiesel and organic acids production, State of the art of food waste management in various countries.	8
Module 5: Bio-medical waste, type of waste, classification, sources, health risks, environmental impact, treatment, processing, disposal, Bio-medical waste management rules 2016, BMW management during a pandemic.	8

Textbooks:

1. Municipal solid waste management in developing countries, Sunil kumar, CRC press.
2. https://onlinecourses.swayam2.ac.in/ugc19_bt18/preview.
3. Plastic Waste and Recycling Environmental Impact, Societal Issues, Prevention, and Solutions, 1st Edition - March 10, 2020, Editor: Trevor Letcher.
4. Datta P, Mohi GK, Chander J. Biomedical waste management in India: Critical appraisal. J Lab Physicians. 2018 Jan-Mar;10(1):6-14. doi: 10.4103/JLP.JLP_89_17. PMID: 29403196; PMCID: PMC5784295.

Reference books:

1. The Escalating Biomedical Waste Management To Control the Environmental Transmission of COVID-19 Pandemic: A Perspective from Two South Asian Countries, Environ. Sci. Technol. 2021, 55, 7, 4087–4093.

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/seminar/assignment/others	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		1	2	3
CO 1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO 2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO 3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO 4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO 5	3	3	1	2	3	2	2	1	1	2	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
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:	CL 24239
Course title:	Safety and hazards in process industries
Pre-requisite(s):	**CH24101, PH24101**
Co- requisite(s):	
Credits:	**3 (**L: 3 T: 0 P: 0)
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	IV/02
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 24239.1	Understand the importance of plant safety and safety regulations, personal protective equipment's, principles and procedures of safety audit.
CO 24239.2	Identify and mitigate different types of toxic chemical hazards
CO 24239.3	Implement various safety aspect of fire and explosion in a chemical plant
CO 24239.4	Assess and mitigate different hazards due to storage and transportation of chemicals, plant operations.
CO 24239.5	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	8
Limiting Values, Exposure Thresholds, Airborne Contaminants, Confined Spaces Hazards, Respiratory Protection, Prevention and Control	
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. Chemical ProcessSafety: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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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		
D8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

PROGRAMME ELECTIVE 2 (PE-2)

COURSE INFORMATION SHEET

Course code	CL24331
Course title	Petroleum Refinery Engineering
Pre-requisite(s)	**CL24207**, CL24211, CL24301, CH24101
Co- requisite(s)	
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	B. Tech.
Semester / Level	V/03
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 and products of petroleum refinery.
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 24331 .1	Describe importance of refinery industries, methods for evaluation of crude & fractions, their inter-convertibility.
CO 24331 .2	Describe the principles of operation of atmospheric and vacuum distillation processes.
CO 24331 .3	Describe the different refining processes such as reforming, isomerization, hydrogen production, acid gas processing, sulfur recovery , alkylation etc.
CO24331 .4	Describe the different cracking and treating processes such as Visbreaking, coking, FCC, hydrotreating and hydrocracking.
CO 24331 .5	Calculate various properties of blended product such as Reid Vapour Pressure blending, flash point blending etc.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Refining processes: Physical separation processes, chemical catalytic conversion processes, thermal chemical conversion processes. Refinery configuration, Composition of crude oils and products. Physical property characterization data: True boiling point distillation, ASTM distillation, conversion between ASTM and TBP distillation, API gravity, Pour point, Aniline point, flash point, octane number, cetane number, smoke point, reid vapor pressure.	8
Module 2 Crude distillation: Introduction, Process description, Operation of crude distillation units, Crude oil desalting. Vacuum distillation - Process description, steam ejectors. Catalytic reforming: Reformer feed characterization, role of reformer in the refinery, Reforming reactions, Thermodynamics of reforming reactions, Reaction kinetics and catalysts, Process technology. Isomerization of light naphtha: Thermodynamics of isomerization, Isomerization reactions, Isomerization catalysts, Isomerization yields.	8
Module 3 Visbreaking: Feed sources, Visbreaking reactions, Visbreaking severity, kinetics of Visbreaking, product yield and properties, process description (coil Visbreaking, soaker visbreaker). Delayed coking: Role of delayed coker, process description, types of coke and their properties, coking and decoking operation, Hydrotreating – Objectives, role of hydrotreating, chemistry of hydrotreating, Hydrotreating catalysts, thermodynamics of hydrotreating, reaction kinetics, hydrotreating processes (Naphtha hydrotreating, middle distillates hydrotreating, atmospheric residue desulphurization), make-up hydrogen, operating conditions.	8
Module 4 Hydrocracking: Role of hydrocracking in the refinery, feeds and products, hydrocracking chemistry, hydrocracking catalysts, thermodynamics and kinetics of hydrocracking, hydrocracking processes, process configuration, catalytic dewaxing. Fluidised catalytic cracking: Introduction, role of FCC in the refinery, feedstock and products, FCC reactions, FCC catalyst, FCC configuration, process description.	8

Module 5 Alkylation processes, Hydrogen production: Steam reforming, reactions, operating variables, product purification. Acid gas processing, Sulfur recovery, Mercaptans removal. Product blending: Reid Vapour Pressure blending, flash point blending, pour point blending, cloud point blending, aniline point blending, smoke point blending, viscosity blending, octane number blending.	8

Text books:

1. Fundamentals of Petroleum Refining, Mohamed Fahim, Taher Al-Sahhaf, Amal Elkilani, 1st Edition 2009, Elsevier Science.
2. Petroleum refining 3: Conversion processes, Edited by Pierre Leprince, Technip.
3. Handbook of petroleum refining processes, 3rd edition, Robert A. Mayers, Mcgraw-Hill.
4. Petroleum refining vol 1. Edited by Jean-Pierre Wauquier, Technip.

Reference books:

1. Advanced Petroleum Refining: G. N. Sarkar
2. Petroleum Refining Technology – Ramprasad
3. Petroleum Refining Engineering: W.L. Nelson
4. Petrochemicals Technology: B.K.B. Rao
5. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwork

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/seminar/assignment/others	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		1	2	3
CO1	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO2	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO3	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO4	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO5	3	2	2	3	1	3	2	3	3	2	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
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:	CL24333
Course title:	Polymer Technology
Pre-requisite:	CH24101, CL24233
Co- requisite(s):	
Credits:	**3 (**L: 3 T: 0 P: 0)
Class schedule per week:	03
Class:	B. Tech
Semester / Level:	05/03
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:

CO24333 .1	Remember: Recall the preparation, properties and application of various commodity polymers, usefulness of additives of plastics
CO24333 3.2	Understand: Explain the methods of preparation, properties and application of commodity thermoplastics/thermosets.
CO24333 .3	Apply: Apply the importance of structure property relationship to choose the materials for various applications.
CO24333 .4	Analyze: Categorize the methods of the preparation, properties and application of specific copolymers.
CO24333 .5	Evaluate: Select polymers for the preparation of blends for specific application

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module1: Additives for Plastics: Definition,classification, mechanism of action: fillers, coupling agents, plasticizer, cross linking agents,stabilizer, blowing agents	8
Module 2: Polyethylene,(LDPE, HDPE, LLDPE, XLPE, UHMHDEP), Polytetrafluoroethylene, Polypropylene, Polystyrene, Polyvinyl chloride, Polyvinyl alcohol, Acrylics, nylon 6,nylon66-preparation, structure property relation, application, limitations	10
Module 3: Phenol-formaldehyde resins, alkyl & aryl epoxies, polyurethanes, silicones, Unsaturated Polyester-preparation, structure property relation, application, limitations	7
Module 4: Polymer Blends, Interpenetrating Networks, Thermodynamics of Polymer blending, Classification of blends, Method of blending, Properties of blends: mechanical, thermal, optical and rheological, Commercial blends and their applications	8
Module 5: Definition of composite, classification of composite, types of reinforcement and matrix-Manufacturing of polymer composite by SMC, DMC, Pultrusion, filament winding, Reaction Injection moulding, Application of polymer composites	7

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/seminar/assignment/others	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		1	2	3
CO24333.1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO24333.2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO24333.3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO24333.4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO24333.5	3	3	1	2	3	2	2	1	1	2	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
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	CL24335
Course title	Fluid-Solid Operation
Pre-requisite(s)	**CL24203**, CL24209
Co- requisite(s)	
Credits	**3 (**L: 3 T: 0 P: 0)
Class schedule per week	3
Class	B. TECH.
Semester / Level	V/03
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:

CO24335.1	Explain the Flow around immersed bodies.
CO24335.2	Estimate drag force and terminal settling velocity for single particles.
CO24335.3	Estimate Pressure drop in fixed and fluidized beds.
CO24335.4	Classify various solid-solid/solid-fluid separation processes.
CO24335.5	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, 2nd 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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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 24337
Course title	Fertilizer Technology
Pre-requisite(s)	CL24201, CL24205, CL24211, CL24207
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.	Understand the plant nutrients and different types of inorganic chemical fertilizers and organic manures.
2.	Learn the concepts of production technology of nitrogenous, phosphatic, potash, NPK fertilizers.
3.	Apply the knowledge of various fertilizer application methods and recent advances in fertilizer technology.
4.	Analyze the physical and chemical properties of various fertilizers.
5.	Describe the most recent fertilizer production technologies.

Course Outcomes

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

CO24337.1	Describe the basic concept of fertilizer industries.
CO24337.2	Explain the principles and technology of production of fertilizers.
CO24337.3	Analyze fertilizers on the basis of different properties.
CO24337.4	Choose appropriate fertilizer and application methods.
CO24337.5	Describe the concepts of nano fertilizers and biofertilizers.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Introduction to Chemical inorganic Fertilizers and Organic manures. plant nutrients; Introduction to important types of fertilizers: nitrogenous, phosphate, potassium, NPK, Mixed, complex, compound and others.	8
Module 2: Nitrogenous fertilizers: Feedstock for production of Ammonia, methods of production, Characteristics; Production of ammonium sulphate, ammonium chloride; ammonium nitrate, Urea, calcium ammonium nitrate;	8
Module 3: Phosphatic fertilizers: Raw materials; Methods of production of single super phosphate, triple super phosphate; specifications, storage and applications; Potassium fertilizers: Methods of production, Characteristics, Specification and storage of potassium chloride, potassium sulphate and potassium nitrate.	8
Module 4: Ammonuim phosphate fertilizers: Production, Characteristics, Specification and storage of MAP, DAP, Urea ammonium phosphate; NPK fertilizers: Types, production and storage.	8
Module 5: Secondary nutrients, Micro nutrients; Recent advances: Fluid fertilizers, Controlled release fertilizers; nanofertilizers, biofertilizers and others; Fertilizer application methods; Fertilizer Industry in India.	8

Textbooks:

1. Francis T. Nielsson, Manual for Fertilizer Processing, CRC press, 1986.
2. Collings, G.H., Commercial Fertilizers, 5th Edn., McGraw Hill, New York, 2001.

Reference books:

1. Handbook of fertilizer technology, The Fertilizer Association of India, New Delhi, 2002.
2. Slacks, A.V., Chemistry and Technology of Fertilizers, Interscience, New York, 1966.

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

Formulation and compounding of fertilizers with specific plant and soil requirements

POs met through Gaps in the Syllabus

PO2, PO3, PO4, PO7 and PO8

Topics beyond syllabus/Advanced topics/Design

More detailed concepts and recent advances of natural organic fertilizers, Studies on special fertilizer application methods, formulating fertilizers for specific plant and soil requirements

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/seminar/assignment/others	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**		**1**	**2**	**3**
CO 1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO 2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO 3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO 4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO 5	3	3	1	2	3	2	2	1	1	2	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
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:	CL24339
Course title:	Biomaterials
Pre-requisite:	**CL24233, PH24101,CH24101**
Co- requisite(s):	
Credits:	**3 (**L: 3 T: 0 P: 0)
Class schedule per week:	3
Class:	B. Tech
Semester / Level:	07/04
Branch:	Chemical Engineering
Name of Teacher:	

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.24339 .1	Analyze : Justify the selection of a specific biomaterial for a specific biomedical application on the basis of specific characteristic features
CO.24339 .2	Apply: Explain the suitability of polymeric biomaterials over the others on the basis of experimental evidences
CO24339 .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
CO24339 .4	Remember: Different types of materials used in biomedical application, classify these and compare properties
CO24339 .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, Polyurethane, PVC, Polyester Structure, properties and application of biological materials-proteins, polysaccharides, Mineralized tissues, Collagen	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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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:	CL24341
Course title:	Analytical Instrumental Methods
Pre-requisite(s):	**CH24101, PH24101**
Co- requisite(s):	
Credits:	**3 (**L: 3 T: 0 P: 0)
Class schedule per week:	3
Class:	B. TECH.
Semester / Level:	05/03
Branch:	Chemical Engineering
Name of Teacher:	

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 24341.1	Remember: Describe the different spectroscopic techniques for chemical structure determination
CO 24341.2	Understand: Discuss the different chromatographic techniques for organic compounds
CO 24341.3	Apply: Given a sample assess the physical and chemical characteristics.
CO243417 .4	Analyze: Outline the working principles of various microscopy.
CO 24341.5	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 Chromatography and High Performance Thin Layer Chromatography, Gas Chromatography, Affinity Chromatography, Pyrolysis Gas Chromatograph. Electrochemical analysis.	8
Module 3: Optical microscopy, 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:

1 SKOOG, D. A., HOLLER, F. J., CROUCH, S. R. (2007). Principles of instrumental Analysis, 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 Text book of polymer Science: Billimeyer F.W., 3rd Edn., Wiley Interscience, 1984
5 Principles of Polymer Systems, Rodriguez, F, Taylor& Francis, 4th Edn., 1996

REFERENCE:

1. Fundamentals of Polymer Science: Kumar Anil & Gupta R.K. Mc Graw Hill, 1998.
2. Structural Investigation of Polymer: Bodor G., 1st Ed., Ellis Harwood Ltd., 1991.
3. 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/seminar/assignment/others	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**		**1**	**2**	**3**
CO1	3	3	2	2	3	2	1	1	3	3	1		3	3	3
CO2	3	3	2	2	3	2	1	1	3	3	1		3	3	3
CO3	3	3	2	2	3	2	1	1	3	3	1		3	3	3
CO4	3	3	1	1	3	1	1	1	3	3	1		3	1	3
CO5	3	3	1	1	3	1	1	1	3	3	1		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		

PROGRAMME ELECTIVES 3 (PE-3)

COURSE INFORMATION SHEET

Course code: **CL24351**
Course title: **Polymer Processing**
Pre-requisite: **CL24233, CL24333**
Credits: **3** (L: 3 T: 0 P: 0)
Class schedule per week: **3**
Class: **B.Tech.**
Semester / Level: **06/3**
Branch: **Chemical Engineering**
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 **24351**.1	Remembering: Choose the corresponding process to be used to manufacture a specific product from suitable polymers.
CO **24351**.2	Understanding: Compare the methods of different processing techniques for product manufacture with a given set of plastic materials for the specific use
CO **24351**.3	Apply: Apply most modern technology to modify the process variables on the existing machine to manufacture a specific plastic/ rubber/composite product
CO**24351**.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 **24351**.5	Evaluate: Explain processing difficulties and estimate numerical problems related to polymer processing

Syllabus

MODULE	No. of Lecture Hours
Module 1 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
Module 2 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
Module 3 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
Module 4 Classification, Machinery, process details, analysis, defects, remedies: Blow Moulding, Thermoforming, Calendaring.	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/seminar/assignment/others/Assignment/Seminar/Other	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		1	2	3
CO **24351**.1	3	3	3	2	2	2	2	1	3	2	1		3	2	2
CO **24351**.2	1	2	3	3	3	2	2	2	1	1	2		2	3	3
CO **24351**.3	2	1	1	1	1	3	2	3	1	2	1		3	2	1
CO**24351**.4	1	2	3	3	3	2	2	2	1	1	2		2	3	3
CO **24351**.5	3	3	3	2	2	2	2	1	3	2	1		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:	CL**24353**
Course title:	Design and Analysis of Experiments
Pre-requisite:	**CH24101, PH24101**
Co- requisite(s):	
Credits:	**3 (**L: 3 T: 0 P: 0)
Class schedule per week:	3
Class:	B. Tech
Semester / Level:	06/03
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Explain the fundamentals of experiments and its uses.
2.	Learn the basic statistics including ANOVA and regression.
3.	Learn the experimental designs such factorial and fractional factorial designs.
4.	Apply statistical models in analyzing experimental data.
5.	Apply RSM to optimize response of interest from an experiment.

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

CO**24353**.1	Explain basics of design of experiments and basic statistical concepts.
CO**24353**.2	Apply methods for the design and analysis of single factor experiments.
CO**24353**.3	Apply factorial design for experiments.
CO**24353**.4	Apply 2^k and Two-level fractional factorial designs for experiments.
CO**24353**.5	Apply Linear Regression models.

SYLLABUS

MODULE	**NO. OF LECTURE HOURS**
MODULE- I Introduction: Strategy of Experimentation, Applications of Experimental design, Basic Principles, Guidelines for designing experiments. Simple Comparative Experiments: Introduction, Basic Statistical Concepts, Sampling and Sampling distributions.	8

MODULE II: Experiments with a single factor: The Analysis of Variance, Analysis of the fixed effects model, Model adequacy checking, Practical interpretation of results, The regression approach to the analysis of variance, The randomized complete block design.	8
MODULE-III Introduction to factorial designs: Basic definitions and principles, The advantage of factorials, The two-factor factorial design, The general factorial design. The 2^k factorial design: Introduction, the 2^2 design, the 2^3 design, the general 2^k design.	8
MODULE - IV Blocking and confounding in the 2^k factorial design: Introduction, blocking a replicated 2^k factorial design, confounding in the 2^k factorial design, confounding the 2^k factorial design in two blocks, confounding the 2^k factorial design in four blocks, partial confounding. Two-level fractional factorial designs: Introduction, one-half fraction of the 2^k design.	8
MODULE V Fitting Regression models: Introduction, Linear Regression models, estimation of the parameters in linear regression models. Introduction to Response surface methods and designs.	8

Text Books:

1. Design and Analysis of Experiments, Douglas C Montgomery, Eighth edition, Wiley, 2017.
2. Design and Analysis of Experiment, R Panneerselvam, PHI Learning Pvt Ltd, 2012.

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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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**24355**
Course title:	Pollution control and equipment design
Pre-requisite(s):	CH24101, PH24101, MA24101
Co- requisite(s):	
Credits:	3 (L:3 T:0 P:0)
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	06/03
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**24355** .1	Explain legislative aspects including water act, Air Act and effluent standards.
CO**24355** .2	Explain air pollution sources, air pollutants & their effects, working principle of Air pollution control equipments and their design.
CO **24355** .3	Describe water pollution sources, water pollutants & their effect, terms related with water pollution and working principle of primary equipments and their design.
CO **24355** .4	Explain conventional and advanced methods for waste water treatment.
CO **24355** .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/seminar/assignment/others	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		1	2	3
CO1	3	1	1	1	1	3	3	3	3	3	1		3	3	3
CO2	3	3	3	3	3	3	3	3	3	1	2		3	3	3
CO3	3	3	3	3	3	3	3	3	3	1	2		3	3	3
CO4	3	3	3	3	3	3	3	3	3	1	2		3	3	3
CO5	3	3	3	3	3	3	3	3	3	1	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	CL24357
Course title	Petrochemicals Technology
Pre-requisite(s)	**CH24101, CL24331**
Co- requisite(s)	
Credits	**3** (L: 3 T: 0 P: 0)
Class schedule per week	3
Class	B. Tech.
Semester / Level	VI/03
Branch	Chemical Engineering
Name of Teacher	

Course Objectives:

This course enables the students to:

1.	Acquire knowledge of petrochemical complex and petrochemical configurations.
2.	Learn all the techniques/processes of petrochemical complex encompassing selection of the mass/heat transfer devices, their operation and basic design.
3.	Understand feed stocks and products of petrochemical complex.
4.	Examine how processes work in petrochemical complex.
5.	Draw a flow sheet to explain processes involved in petrochemical complex.

Course Outcomes:

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

CO 24357 .5	Describe different chemical production processes from ethylene and propylene.
CO 24357 .4	Explain synthesis gas production, chemicals production from synthesis gas route, and steam cracking of hydrocarbons.
CO 24357 .3	Describe the production processes for chemicals production from aromatics.
CO 24357 .2	Explain the different processes involved in the recovery of aromatics.
CO 24357 .1	Describe importance of petrochemical complex, petrochemical configurations, and Naphtha/natural gas steam cracking process.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1 Definitions of petrochemicals, Feedstocks, Intermediates, Finished products, petrochemical configurations, Naphtha cracking, history and growth of petrochemical industry in India, overview of petrochemical industry in India.	8

Module 2 Aromatics complexes: Introduction, configurations, process description; UOP sulfolane process, UOP Isomar process, UOP parex process, UOP tatoray process,	8
BP-UOP cyclar process, UOP thermal hydrodealkylation process, UOP oleflex process for light olefin production, UOP pacol dehydrogenation process.	
Module 3 Chemicals based on benzene, ethylbenzene production, styrene production, cumene production, phenol and acetone from cumene, linear alkyl benzene, aniline from phenol, caprolactam production, benzoic acid to phenol, p-xylene to dimethyl terephthalate, phenol from toluene oxidation, phthalic anhydride from o-xylene, maleic anhydride from benzene, DDT manufacture from benzene, hydrodealkylation of toluene.	8
Module 4 Steam reforming of natural gas (synthesis gas), Methanol from synthesis gas route, formaldehyde from methanol, chloromethanes from methane, ethylene and acetylene production via steam cracking of hydrocarbons, vinyl chloride from ethylene using two-step process.	8
Module 5 Ethanolamine from ethylene, Isopropanol from propylene, cumene from propylene, acrylonitrile from propylene, Oxo process for converting olefins and synthesis gas to aldehydes and alcohols, butadiene from butane.	8

Text books:

1. Handbook of petroleum refining processes, 3rd edition, Robert A. Mayers, McGraw-Hill.
2. Chemistry of petrochemical processes, 2nd edition, Sami Matar and Lewis F. Hatch, Gulf Publishing Company.

Reference books:

1. Petrochemicals Technology: B.K.B. Rao
2. Petroleum Refining Technology & Economics: J.H. Gary & G.E. Handwork

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/seminar/assignment/others	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		1	2	3
CO1	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO2	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO3	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO4	3	2	2	3	1	3	2	3	3	2	1		3	3	3
CO5	3	2	2	3	1	3	2	3	3	2	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
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 24359
Course title:	Nanotechnology
Pre-requisite(s):	CH24101, PH24101
Co- requisite(s):	
Credits:	3 (L:3 T:0 P:0)
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	06/03
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Gain foundational knowledge of the Nanoscience and related fields.
2.	Acquire an understanding the Nanoscience and Applications.
3.	Understand the synthesis of nanomaterials.
4.	Explain the properties of nanomaterials.
5.	Learn the applications of nanomaterials.

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

CO 24359.1	Explain nanotechnology, nanomaterials and various manufacturing approaches.
CO24359.2	Describe chemical, electronic, magnetic, optical, thermal and mechanical properties.
CO24359.3	Explain synthesis and properties of dendrimers, Fullerenes and Carbon Nanotube.
CO24359.4	Describe conducting polymers, Charge transfer polymers, Ionically conducting polymers, Stimuli responsive Polymers and Conductively filled polymers.
CO 24359.5	Describe principles of molecular self-assembly and Self-assembled monolayers.

SYLLABUS

MODULE	NO. OF LECTURE HOURS
Module 1: Nanotechnology and definition, classification of nanomaterials. Top-down versus bottom up approach in manufacturing.	8
Module 2: Novel physics and chemistry of nano dimensions. Unique chemical, electronic, magnetic, optical, thermal and mechanical properties. Metals, ceramics & semiconductors.	8

Module 3: Dendrimers – synthesis, properties & structure Fullerenes – synthesis, properties & structure Carbon Nanotube - synthesis, properties & structure.	8
Module 4: Conducting polymers – synthesis & properties of Polyacetylenes, Polyanilines, polyphenylene, polythiophene & poly pyrrole. Charge transfer polymers, Ionically conducting polymers, Conductively filled polymers Polymer dopant interaction. Diffusion of dopants, chemistry of doping. Doping level. Morphology of pristine polymers, doped polymers. Mechanism of conduction, Applications.	8
Module 5: Stimuli responsive Polymers – Solvent, Temperature, pH responsive, Ions, Electrical energy, Photons – Applications. Principles of molecular self- assembly and self-organization, surfactant solutions, polymers. Self-assembled monolayers, thiol and silane monolayers, Langmuir – Blodgett films, Topological substrate Patterning. Polymer surfaces and interfaces, structure and properties.	8

Text books:

1. Nanotechnology, T. Pradeep.
2. Peter. J.F Harris, Carbon Nanotube Science: Synthesis, Properties and Applications, Cambridge University Press, 2011.
3. Jamie H. Warner, Franziska Schaffel, Mark Rummeli, Alicja Bachmatiuk, Graphene: Fundamentals and Emergent Applications, Elseiver, 2013.
4. G.A. Ozin and A.C. Arsenault, Nanochemistry: A chemical approach to nanomaterials, Royal Society of Chemistry, 2009.
5. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods,John Wiley & Sons, 2013.

Reference books:

1. Bharat Bhushan, Handbook of Nanotechnology, Springer, 2005.
2. Hari Singh Nalwa, Handbook Of Nanostructured Biomaterials And Their Applications In Nanobiotechnology, Journal of Nanoscience and Nanotechnology, 2005.
3. R.W. Cahn, E.M. Lifshitz, Concise Encyclopedia of Materials Characterization: Advances in Materials Sciences and Engineering,Elsevier, 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/seminar/assignment/others	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		1	2	3
CO1	3	1	1	1	1	3	3	3	3	3	1		3	3	3
CO2	3	3	3	3	3	3	3	3	3	1	2		3	3	3
CO3	3	3	3	3	3	3	3	3	3	1	2		3	3	3
CO4	3	3	3	3	3	3	3	3	3	1	2		3	3	3
CO5	3	3	3	3	3	3	3	3	3	1	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		

PROGRAMME ELECTIVE – 4 (PE-4)

COURSE INFORMATION SHEET0

Course code	CL24371
Course title	Membrane Science and Technology
Pre-requisite(s)	**CL24203, CL24201, CL24211**
Co- requisite(s)	
Credits	**3 (**L: 3 T: 0 P: 0)
Class schedule per week	3
Class	B. Tech.
Semester / Level	VI/04
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:

CO24371.1	Explain Membrane Processes and Types of Membranes.
CO24371.2	Explain the Membrane Preparation Methods and Membrane Characterization Techniques.
CO24371.3	Explain the Principles and application of different Membrane processes and their characteristics.
CO24371.4	Develop skills to choose appropriate membrane process for a specific application.
CO24371.5	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	8
Areas of Application. Types of Synthetic Membranes- Micro porous (Isotropic and Anisotropic), Asymmetric, Thin film composite, Electrically Charged, 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/seminar/assignment/others	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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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**
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:	CL24373
Course title:	Reservoir Engineering
Pre-requisite(s):	**MA24101, CH24101, CL24201**
Co- requisite(s):	**CL24309**
Credits:	**3 (**L: 3 T: 0 P: 0)
Class schedule per week:	3
Class:	B. TECH.
Semester / Level:	VI/03
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:

CO24373.1	Understand basic characteristics of various reservoir and reservoir fluids
CO24373.2	Analyze the multiphase flow behaviour through porous media
CO24373.3	Understand mechanics of oil production (natural reservoir energies & expulsion of fluids)
CO24373.4	Learn basic concepts of reservoir engineering and technologies for oil recovery.
CO24373.5	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	8
Reservoir Fluids: Reservoir fluid characteristics, reservoir fluid sampling, PVT properties determination, different correlations and laboratory measurements. Phase behaviour of hydrocarbon system.	
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/seminar/assignment/others	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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	0	1	2	0		3	3	3
CO2	3	2	1	2	3	0	1	0	1	2	0		3	3	3
CO3	3	1	1	1	1	0	0	0	1	1	0		3	3	3
CO4	3	3	2	2	3	1	2	0	1	2	0		3	3	3
CO5	3	3	1	2	3	2	2	0	1	2	0		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:	CL24375
Course title:	COLLOID AND INTERFACIAL SCIENCE
Pre-requisite(s):	**CH24101, PH24101, CL24201**
Credits:	**3 (**L:3 T:0 P:0)
Class schedule per week:	3
Class:	B. TECH.
Semester / Level:	06/03
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.	Analyze: Analyze 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:

CL24375.1	Remember: Define the preparation and properties of colloidal system
CL24375.2	Understanding: Illustrate the different intermolecular forces in colloidal system.
CL24375.3	Applying: Identify the method of measurement for given colloidal system.
CL24375.4	Analyzing: Illustrate the stability of the given colloidal system.
CL24375.5	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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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	CL24377
Course title	Computational Fluid Dynamics
Pre-requisite(s)	**CL24203, CL24207, MA24201**
Co- requisite(s)	
Credits	**3 (**L: 3 T: 0 P: 0)
Class schedule per week	3
Class	B. TECH.
Semester / Level	06/03
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:

CO24377.1	Solve the Navier-Stokes equations
CO24377.2	Use Finite Difference and Finite Volume methods in CFD modeling.
CO24377.3	Generate and optimize the numerical mesh.
CO24377.4	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.
CO24377.5	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/seminar/assignment/others	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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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 24379

Course title: Environment and Plastics

Pre-requisite(s): **CL24333, CL24351**

Co- requisite(s):

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

Class schedule per week: 3

Class: B. Tech

Semester / Level: 06/03

Branch: Chemical Engineering

Name of Teacher:

Course Objectives

This course enables the students:

1.	Understand major environment issues and their relationship with the polymer industry.
2.	Understand of the stability of the polymeric materials in the environment.
3.	Learn the various methods employed for recycling of polymers.
4.	Explore the significance of recycling of plastics and rubber waste management.
5.	Analyze various recycled polymer for specific applications.

Course Outcomes

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

CO24379 .1	Receive the knowledge about diverse plastics and rubber waste recycling technologies.
CO 24379 .2	Understand the recycling potential of plastics used in various industries.
CO 24379 .3	Understand recycling methods of various waste plastics.
CO24379 .4	Use recycled polymers for various applications.
CO 24379 .5	Analyze various recycled polymer modification for specific applications.

Syllabus

MODULE	No. of Lecture Hours

Module 1 Environmental wastes and its disposal problems and solutions. Plastics production and consumption. Plastic wastes: Composition, quantities and disposal, alternative types of recycle methods. Sorting and segregation of plastic wastes.	7
Module 2 Steps in mechanical recycling of polymer waste: Collection, washing & drying, sorting & separation, size reduction, and melt reprocessing. Equipment for mechanical recycling. Mechanical Recycling of different plastic wastes: Polyolefins, polyamide, poly (ethylene terephthalate), PVC, polystyrene, polyurethanes, and mixed polymer waste. Problem encountered in mechanical recycling of plastic wastes.	10
Module 3 Chemical recycling/feedstock recycling process for recovery of oil, monomer and energy. Depolymerization of polyamides, PMMA, PET, Polyamides, PVC, and polyoxymethylene. Feedstock recycling: Degradative Extrusion, Pyrolytic techniques, Hydrogenation, Gasification, and reduction in blast furnace.	10
Module 4 Energy recovery from plastic in a waste incineration plant. Waste Rubber Recycling. Biodegradable plastics: an overview. Environmental issues, policies and legislation in India. Few case studies on life cycle analysis: Household plastics packaging (PE, PP, PVC), PET bottles, tyres. Applications of different recycled polymers	8
Module 5 Toxicity of plastics: Commodity plastics, toxicity of additives used in plastics Toxicity due to plastics combustion, rules and regulation of plastic toxicity	5

Text books:

1. Bandrup, Dr. J. Ed. Recycling of plastics‖ Carl Hanser Verlag 1995.
2. Raymond D. Harbison Ed. ― Hamilton &Hardy_s Industrial Toxicology‖ 5th edition. Mosby Publisher, 1998.

Reference books:

1. Rene Lefaux: ―Practical Toxicology of plastics‖, CRC press, Cleveland, Ohio 1968.

2. R.J.Ehrig, Plastics Recycling, Products and Processes, Hanser Publishers, New York, 1992

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/seminar/assignment/others	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		1	2	3
CO1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3		1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3		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, 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 - 5
(PE-5)

COURSE INFORMATION SHEET

Course code: **CL24431**
Course title: **FIBRE SCIENCE AND TECHNOLOGY**
Pre-requisite(s): **CL24333, CL24351, CH24101**
Co- requisite(s):
Credits: **3** (L: 3 T: 0 P: 0)
Class schedule per week: **3**
Class: **B. Tech.**
Semester / Level: **07/04**
Branch: Chemical Engineering,
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:

CO24431.1	Remembering: Choose & relate the suitable fibres for a specific application.
CO24431.2	Understanding: Classify & compare the different fibres, can outline the process involved in the manufacture of fabrics
CO24431.3	Applying: Utilize the knowledge of different types of fibre manufacture process.
CO24431.4	Analyzing: Examine the performance of basic fibre properties using empirical relations.
CO24431.5	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 plant and animal fibres. Conventional man-made fibres: Rayon, Polyethylene terephthalate, Nylon 6 and nylon 66, Acrylic fibres, Polyolefins. High performance fibres: Aramid - Nomex and Kevlar, 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/seminar/assignment/others	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**		**1**	**2**	**3**
CO24431.1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO24431.2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO24431.3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO24431.4	2	2	1	1	1	1	1	1	1	2	3		1	1	1
CO24431.5	2	2	1	1	1	1	1	1	1	2	3		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	CL24433
Course title	Introduction to Microelectronics Fabrication
Pre-requisite(s)	**EE24101, EC24101**
Co- requisite(s)	
Credits	**3** (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:

CO24433.1	Understand the theoretical principles of all processes involved in microelectronics fabrication.
CO24433.2	Identify, formulate, and solve problems relating to microelectronics manufacturing.
CO24433.3	Select a fabrication process or sequence of processes suitable for production of a microelectronic device.
CO24433.4	Design micro-machines by using fundamental skills learned in this course.
CO24433.5	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/seminar/assignment/others	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		1	2	3
CO1	3	3	2	2	3	2	1	1	3	3	1		3	3	3
CO2	3	3	2	2	3	2	1	1	3	3	1		3	3	3
CO3	3	3	2	2	3	2	1	1	3	3	1		3	3	3
CO4	3	3	1	1	3	1	1	1	3	3	1		3	1	3
CO5	3	3	1	1	3	1	1	1	3	3	1		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: CL24435
Course title: Microfluidics
Pre-requisite(s): **CL24203**
Co- requisite(s):
Credits: **3 (**L:3 T:0 P:0)
Class schedule per week: 3
Class: B. Tech.
Semester / Level: **07/04**
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:

CO24435.1	Explain the theory and physical principles of fluid mechanics on the microscale.
CO24435.2	Solve problems related to surface tension and interfacial energy in microfluidic systems.
CO24435.3	Describe the electrohydrodynamics fundamentals and solve related problems for microfluidic systems.
CO24435.4	Mathematically model microfluidic devices and systems.
CO24435.5	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, Taylor-Aris dispersion, Two-phase flows, Flow through deformable channel.	8
Module 2: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect, lubrication theory, thin film.	8
Module 3: Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electroosmotic flow, Ideal EOF with back pressure, EOF of power-law fluids. Electrophoresis, Dielectrophoresis, Diffusiophoresis, Thermophoresis.	8
Module 4: Fabrication methods in microfluidics, Materials, Clean room, photolithography-mask, spin coating, exposure and development, Wafer bonding. Polymer microfabrication, PMMA/COC/PDMS substrates, micromolding, fluidic interconnections.	8
Module 5: Dynamics of particles and droplets, Droplet spreading, Droplet deformation, Electrowetting, Droplet generators, T-junction and Cross-junction, Droplet formation, breakup and transport.	8
Few applications of microfluidics: Drug delivery, Diagnostics, Bio-sensing.	

Text Books:

1. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
2. Nguyen, N. T., Werely, S. T., Fundamentals and applications of Microfluidics, Artech house Inc., 2002.
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/seminar/assignment/others	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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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: **CL24437**
Course title: **Plastic Packaging Technology**
Pre-requisite(s): **CH24101, PH24101**
Co- requisite(s):
Credits: **3** (L:3 T:0 P:0)
Class schedule per week: **3**
Class: **B.Tech**
Semester / Level: **06/4**
Branch: **Chemical Engineering**
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 **24437**.1	Remember: Effectively observe and compare the different package forms
CO **24437**.2	Understand: Describe the importance of compatibility studies and their associated parameters.
CO **24437**.3	Apply: Select the suitable types of packaging material for a particular application(s).
CO**24437**.4	Analyze: Analyze the various hazards & environmental issues, aesthetics of a package and the differentiating factors.
CO**24437**.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/seminar/assignment/others	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**		**1**	**2**	**3**
CO1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3		1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3		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:	CL**24439**
Course title:	Chemical Process Intensification
Pre-requisite(s):	**CL24207, CL24211, CL24301**
Co- requisite(s):	
Credits:	**3 (**L: 3 T: 0 P: 0)
Class schedule per week:	3
Class:	B. Tech.
Semester / Level:	**06/4**
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 **24439**.1	Explain process intensification and mechanisms involved in the process intensification.
CO**24439**.2	Explain role of process intensification in sustainable development and design techniques in process intensification.
CO**24439**.3	Explain mechanism of cavitation-based process intensification.
CO**24439**.4	Explain Process Intensification by monolith reactor and membrane.
CO**24439**.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. David Reay, Colin Ramshaw, and Adam Harvey, Process Intensification: Engineering for efficiency, sustainability and flexibility, IchemE, 2nd edition, 2013, Elsevier.
2. 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.
3. Juan¬Gabriel¬Segovia-Hernández¬ Adrián¬Bonilla-Petriciolet Editors, Process Intensi cation in Chemical Engineering Design Optimization and Control, Springer, 2016.

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/seminar/assignment/others	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		1	2	3
CO 1	3	3	1	1	1	2	1	1	2	1	1		3	2	3
CO 2	3	3	1	3	3	1	1	1	3	2	1		3	3	3
CO3	3	3	1	3	3	1	1	1	2	2	1		3	3	2
CO4	3	3	2	2	3	1	1	1	3	3	1		3	3	3
CO4	3	3	2	2	3	1	1	1	3	3	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
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		

PROGRAMME ELECTIVE - 6
(PE-6)

COURSE INFORMATION SHEET

Course code: CL24459
Course title: Biorefinery
Pre-requisite(s):
Co- requisite(s):
Credits: **3 (**L: 3 T: 0 P: 0)
Class schedule per week: 3
Class: B. Tech.
Semester / Level: VII/04
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Acquire knowledge of various fuels and chemicals production from biomass.
2.	Gain knowledge of biomass conversion technologies.
3.	Realize the emerging concepts of biorefinery.
4.	Explain biomass hydrothermal processing.
5.	Explain biodiesel production processes.

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

CO 24441.1	Explain the fundamentals of biorefinery, biomass and its processing.
CO24441.2	Explain biomass pyrolysis and gasification technology.
CO24441.3	Explain biomass pre-treatment and conversion of cellulose to sugars.
CO 24441.4	Explain biomass hydrothermal processing.
CO 24441.5	Explain biodiesel production processes.

Syllabus

Module 1 Biorefinery concepts: Introduction, definition for biorefinery, economic value of biomass using biorefining, classification of biorefineries, conventional biorefineries, advanced biorefineries, whole crop biorefinery, oleochemical biorefinery, lignocellulosic feedstock biorefinery, syngas platform biorefinery, next generation hydrocarbon biorefinery, green biorefinery, marine biorefinery, chain development, biorefinery concepts in comparison to petrochemical refineries, biorefinery complexity index, SWOT analysis on biorefineries.	8
Module 2 Fast pyrolysis of biomass for energy and fuels: Introduction, thermal conversion processes, fast pyrolysis, reactors, bio-oil, bio-oil upgrading – Physical, chemical and catalytic upgrading, applications of bio-oil, chemicals in bio-oil.	8
Module 3 Biomass gasification: Gasification chemistry and reaction stages, gasification processes, practical issues of gasification, producer gas conditioning, Syngas derived from biomass gasification for use in Fischer-Tropsch synthesis, Syngas to alcohols, catalyst types.	8
Module 4 Hydrothermal processing of biomass: hydrothermal liquefaction, hydrothermal gasification. Biomass pre-treatment, conversion of cellulose to sugars, conversion of carbohydrates to liquid fuels.	8
Module 5 Biodiesel production: Introduction, Biodiesel chemistry, processing technology, biodiesel fuel properties, catalysts for biodiesel production, conversion of glycerol to valuable commodity chemicals.	8

Textbooks:

1. Thermochemical conversion of biomass to liquid fuels and chemicals, RSC Energy and Environment series, Mark Crocker, 2010.

2. Thermochemical Processing of biomass – conversion into fuels, chemicals and power, 2nd edition, Robert C. Brown, Wiley, 2011.

3. Recent advances in thermochemical conversion of biomass, Elsevier 2015.

4. Industrial biorefineries and white biotechnology, Elsevier, 2015.

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/seminar/assignment/others	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		1	2	3
CO 1	3	3	1	1	1	2	1	1	2	1	1		3	2	3
CO 2	3	3	1	3	3	1	1	1	3	2	1		3	3	3
CO3	3	3	1	3	3	1	1	1	2	2	1		3	3	2
CO4	3	3	2	2	3	1	1	1	3	3	1		3	3	3
CO4	3	3	2	2	3	1	1	1	3	3	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
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: **CL24451**
Course title: Polymer Composite
Pre-requisite(s): CH24101, PH24101, MA24101
Co- requisite(s):
Credits: **3** (L: 3 T: 0 P: 0)
Class schedule per week: **3**
Class: **B. Tech**
Semester / Level: 06/4
Branch: **Chemical Engineering**
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**24451**.1	Remember: Classify the different type of polymeric composites and its applications.
CO**24451**.2	Understanding: Ability to select the process for fabrication of polymer composites.
CO**24451**.3	Applying: Select different types of matrix and reinforcement materials.
CO **24451**.4	Analysing: Relate theoretical knowledge with typical products and its stress –strain behavior.
CO **24451**.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 -, hand lay up spray up, vacuum bag moulding, pressure bag moulding, autoclave moulding, 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 short fibre composites. Deformation behaviour of single ply and laminates. Creep, Fatigue Impact. Electrical,and thermal properties.	8

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/seminar/assignment/others	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		1	2	3
CO1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3		1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3		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:	**CL24453**
Course title:	Elastomer Technology
Pre-requisite(s):	CH24101
Co- requisite(s):	
Credits:	**3** (L: 3 T: 0 P: 0)
Class schedule per week:	**3**
Class:	**B. Tech**
Semester / Level:	**07/04**
Branch:	**Chemical Engineering**

Name of Teacher:

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**24453**.1	***Remembering: List*** *the* synthesis procedure and characteristics of industrially available elastomers
CO**24453**.2	***Understanding: Explain the*** compounding recipe with given chemical additives and infer appropriate raw rubber materials for a given application
CO**24453**.3	***Applying: Select*** the elastomer processing operations depending on the materials characteristics and final product requirements
CO**24453**.4	***Analyzing: Examine*** the rubber compound formula, list suitable processing parameters and conditions of rubber processing with a given equipment and material
CO **24453**.5	***Evaluating: Recommend 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 vulcanized 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, sulfur etc. Theory and technology of reinforcement. Mechanism of sulfur 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/seminar/assignment/others	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		1	2	3
CO1	3	2	2	1	1	2	3	2	1	2	2		3	1	3
CO2	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO3	3	2	2	1	1	2	3	1	1	2	2		3	1	3
CO4	2	2	1	1	1	1	1	1	1	2	3		1	1	1
CO5	2	2	1	1	1	1	1	1	1	2	3		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: CL 24455
Course title: Natural Gas Engineering
Pre-requisite(s):
Co- requisite(s):
Credits: **3 (**L: 3 T: 0 P: 0)
Class schedule per week: 3
Class: B. Tech.
Semester / Level: **06/4**
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

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

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

CO 24455.1	Calculate the Properties of Natural gas.
CO 24455.2	Evaluate Gas Reservoir Deliverability, Choke Performance and wellbore performance.
CO 24455.3	Explain Gas Treating, disposal and Sulfur recovery processes.
CO 24455.4	Describe Gas Dehydration, Hydrocarbon Recovery, Nitrogen Rejection Processes, Trace component recovery or removal, Transportation and Storage.
CO 24455.5	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.	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/seminar/assignment/others	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		1	2	3
CO 24455.1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO 24455.2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO 24455.3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO 24455.4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO 24455.5	3	3	1	2	3	2	2	1	1	2	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
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: CL24457
Course title: Paints and Surface Coating Technology
Pre-requisite(s): **CH24101, Ph24101**
Co- requisite(s):
Credits: **3 (**L:3 T:0 P:0)
Class schedule per week: 3
Class: B. TECH.
Semester / Level: 06/04
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:

CL24457.1	Remembering: Define paints, lacquers, varnish, surface coating
CL24457.2	Understanding: Describe the properties of binder, pigments, solvents and other additives
CL24457.3	Applying: Basic understanding of designing paint formulation considering various ingredients .
CL24457.4	Analyze: Given a type of paint defects examine the cause of failure and provide the necessary corrective actions.
CL24457.5	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 the paint system. Toxicity and Environment Pollution. Solvent selection.	6
Module 2:	
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.	5
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

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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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		

VOCATIONAL COURSES

COURSE INFORMATION SHEET

Course code:	CL24102
Course title:	**Introduction to Chemical Engineering**
Pre-requisite(s):	**CH24101, Ph24101**
Co- requisite(s):	
Credits:	**3 (**L:1 T:0 P:4)
Class schedule per week:	5
Class:	B. TECH.
Semester / Level:	2/01
Branch:	Chemical Engineering
Name of Teacher:	

Course Objectives:
This course enables the students to:

1.	Remembering: Overview of Chemical Engg., Introduction to Reaction Engg.
2.	Understanding: Types of chemical reaction pathways
3.	Understanding: Unit processes eg. Oxidation, nitration, halogenation etc.
4.	Perform experiments related to Fuels & energy engineering
5.	Perform experiments based on Reaction Engg. & chemical technology

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

CL24102.1	Understanding the importance of unit operations and unit processes
CL24102.2	Understanding the mechanisms of chemical reactions
CL24102.3	Applying the knowledge of chemical processes for industrial applications
CL24102.4	Analyzing properties of fuels by experiment and characterization
CL24102.5	Analyze saponification reaction and kinetic data in batch reactors

SYLLABUS - Theory

MODULE	NO. OF LECTURE HOURS
Module 1: Overview of chemical engineering, Classification of reactions, Variables affecting rate, Definition of reaction rate, single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction,	8

Reaction pathways, Arrhenius law, Activation energy, Reversible and irreversible reactions, Reaction equilibrium.	
Module 2 Unit Processes: Oxidation: Oxidizing agents, Liquid phase oxidation with oxidizing agents and oxygen; Nitration: nitration agents and nitration with reference to explosives; Halogenation: importance of halogenations; Hydrogenation: Industrial hydrogenation of fat and oil, Hydrolysis: Industrial Hydrolysis of fat, hydrolysis of carbohydrates, starch to dextrose; Polymerization: polymerization reactions, classifications of polymers, methods.	8

SYLLABUS- Practical

List of experiments

1. Flash point
2. Fire point
3. Viscometer
4. Junker's calorimeter
5. Acid-base titration
6. Batch reactor
7. Saponification reaction
8. Soap & detergent manufacturing

Text Books:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.

Reference books:

1. Don W. Green, Marylee Z., **Perry's Chemical Engineering Handbook, 9th Edition,** McGraw-Hill, 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:

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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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: CL24104
Course title: **Basics of Process Calculations and Mechanical Operations**
Pre-requisite(s): **MA24101, PH24101**
Co- requisite(s):
Credits: **3 (**L:1 T:0 P:4)
Class schedule per week: 5
Class: B. TECH.
Semester / Level: 2/01
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understanding the importance Material Balance calculations
2.	Understanding the importance Energy Balance calculations
3.	Understanding mechanism of size reduction devices
4.	Perform experiments related to Mechanical Operations
5.	Perform experiments based on Fluid flow

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

CL24102.1	Apply concept of material balance for various unit operations & processes
CL24102.2	Apply concept of Energy balance for various unit operations & processes
CL24102.3	Evaluating the performance of size reduction equipment
CL24102.4	Analyzing the experiment related to size reduction & screening
CL24102.5	Analyzing the experiment related to Fluid flow

SYLLABUS - Theory

MODULE	**NO. OF LECTURE HOURS**
Module 1: Introduction to material balances, material balances without chemical reaction, stoichiometry and terminology for reaction systems, species mole balances, element material balances, material balances for combustion systems, Material balance involving recycles, bypass and purge systems, Combined material & energy balances	8

for single stage processes, Material and Energy balance calculations for industrial processes.	
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.	8

SYLLABUS- Practical

List of experiments

1. Screening
2. Ball mill
3. Filtration
4. Sedimentation
5. Reynolds experiment
6. Centrifugal pump
7. Notches
8. Venturi meter, orifice meter, rotameter

Text Books:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
2. Haugen, P.A. Watson, K.M., Ragatz R.A Chemical Process Principles Part - I
3. Himmelblau, D.M Basic Principles and Calculation in chemical engineering, Prentice Hall

Reference books:

1. Don W. Green, Marylee Z., **Perry's Chemical Engineering Handbook, 9th Edition,** McGraw-Hill, 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:

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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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: CL24252
Course title: **Introduction to Industrial Chemical Processes**
Pre-requisite(s): **CH24101**
Co- requisite(s):
Credits: **3** (L:1 T:0 P:4)
Class schedule per week: 5
Class: B. TECH.
Semester / Level: 2/02
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understanding the manufacturing process of commodity chemicals
2.	Understanding the manufacturing process of fertilizers
3.	Understanding the basics of petroleum refining
4.	Perform experiments related to materials testing
5.	Perform experiments on preparation of paper & biodiesel

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

CL24102.1	Apply the principles of various unit operations in chemical manufacturing processes
CL24102.2	Apply the principles of various unit operations in fertilizer manufacturing processes
CL24102.3	Apply the principle of unit operations in refining petroleum crude
CL24102.4	Analyzing and characterizing the properties of materials
CL24102.5	Analyzing and characterizing the properties of biodiesel and paper

SYLLABUS - Theory

MODULE	**NO. OF LECTURE HOURS**
Module 1: Alkalies and Acids: Chloro-alkali Industries: Manufacture of Soda ash, Manufacture of caustic soda and chlorine - common salt. Sulphur and Sulphuric acid: Mining of sulphur and manufacture of sulphuric acid. Manufacture of hydrochloric acid. Cement Gases:	8

Types and Manufacture of Portland cement. Fertilisers: Nitrogen Fertilisers; Synthetic ammonia, nitric acid, Urea, Phosphorous Fertilisers: Phosphate rock, phosphoric acid, super phosphate and Triple Super phosphate.	
Module 2 Introduction & primary processing: Origin & formation of crude oil, Classification of crude, Characterization of crude, Distillation-Atmospheric distillation, Vacuum distillation.	8

SYLLABUS- Practical

List of experiments

1. Biodiesel production
2. Viscosity measurement of Crude Oil
3. Fractional Distillation of Synthetic Crude Oil
4. Preparation of Sodium Hydroxide via electrolysis
5. Determination of Urea fertilizer in Laboratory Scale
6. Purity of Common salt using Mohr Method
7. Cement Hardening and Setting Time Experiment

Text Books:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
2. Dryden's Outlines of Chemical Technology, M. Gopala Rao, M. Sittig, 3rd Edition, East West Press.

Reference books:

1. Don W. Green, Marylee Z., **Perry's Chemical Engineering Handbook, 9th Edition,** McGraw-Hill, 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:

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		1	2	3
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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: CL24254
Course title: **Fundamentals of Process control and separation processes**
Pre-requisite(s):
Co- requisite(s):
Credits: **3** (L:1 T:0 P:4)
Class schedule per week: 5
Class: B. TECH.
Semester / Level: 2/02
Branch: Chemical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	Understanding the key concepts of process control & instrumentation
2.	Understanding the concept of various separation processes
3.	Understanding the psychrometric chart, solubility curves, drying curve etc.
4.	Perform experiments related to mass transfer operations
5.	Perform experiments related to process control

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

CL24102.1	Apply the principles of process control to chemical processes
CL24102.2	Apply the principles of various mass transfer operations to solve problems
CL24102.3	Apply the various characteristic graphs to solve problems
CL24102.4	Analyzing the experimental parameters related to mass transfer operations
CL24102.5	Analyzing the experimental parameters related to process control

SYLLABUS - Theory

MODULE	NO. OF LECTURE HOURS
Module 1: Dynamic behaviour of systems - derivation of transfer functions for first and second order systems, liquid level, temperature, pressure, flow and concentration control processes, linearization of nonlinear systems, interacting and non-interacting systems	8

Module 2 Humidification Theory, Psychometric Chart, Adiabatic Saturator, Wet Bulb Theory, Methods of Humidification and dehumidification, Cooling towers. Drying Theory and Mechanism, Drying Characteristics, Estimation of Drying time, drying rate curve, Classification of Driers, Description and Application of Driers, Continuous driers. Crystallization, Solubility curve, Types of crystals, Principles of Crystallization, Supersaturation Theory, Factors governing nucleation and crystal growth. Theory of crystallization, Classification of crystallizers and their applications	8

SYLLABUS- Practical

List of experiments

1. Crystallization
2. Tray dryer
3. Distillation
4. Mass transfer coefficient
5. Diffusivity
6. Shell & Tube heat exchanger
7. Pressure controller
8. Temperature controller

Text Books:

1. McCabe, W.L., Smith J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill, Inc.
2. Mass Transfer Operations: R.E. Treybal Mc Graw Hill, 1981

Reference books:

1. Don W. Green, Marylee Z., **Perry's Chemical Engineering Handbook, 9th Edition,** McGraw-Hill, 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:

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**		**1**	**2**	**3**
CO1	3	3	3	2	2	2	2	1	1	2	1		3	3	3
CO2	3	2	1	2	3	1	1	1	1	2	1		3	3	3
CO3	3	1	1	1	1	1	1	1	1	1	1		3	3	3
CO4	3	3	2	2	3	1	2	1	1	2	1		3	3	3
CO5	3	3	1	2	3	2	2	1	1	2	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
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		