



COIMBATORE INSTITUTE OF TECHNOLOGY, COIMBATORE – 641 014
(An Autonomous Institution affiliated to ANNA UNIVERSITY, CHENNAI)

DEPARTMENT OF CHEMICAL ENGINEERING
REGULATIONS 2023 CHOICE BASED CREDIT SYSTEM

B.TECH. CHEMICAL ENGINEERING

VISION

Create Chemical Engineers by nurturing innovation, critical thinking, and entrepreneurial spirit to offer solutions to the growing needs of the society.

MISSION

- To provide academic and research proficiency to pursue a successful career in the field of chemical engineering
- To nurture critical thinking among students and enable them to offer innovative solutions for a sustainable environment.
- To promote entrepreneurial spirit among the young minds.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO 1: Students will exhibit professional knowledge in understanding of chemical processes, design and development of chemical equipment's in process & chemical industries.

PEO 2: Students will be able to perform industrial solutions for engineering and handle problems of process industries relevance to society.

PEO 3: Students can adapt to changes in technologies through continuous education and will be able to contribute to national and global economic growth with socially responsible practices.

PROGRAM OUTCOMES (POs)

Twelve Graduate Attributes as given by NBA as per Washington Accord agreement should be considered for all the UG programmes without any change for POs.

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

- 2 **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7 **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- 8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 9 **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12 **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Understand and apply working knowledge of chemical engineering principles and applications

PSO2: Implement the inter-perceptual skills of individuals in chemical/allied engineering profession

MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES WITH PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC COUTCOMES (Where 1. Slight, 2. Moderate 3. Substantial)

PEOs	PROGRAMME OUTCOMES												PSOs	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
1	3	3	3	3									3	3
2				3		3	2			2				
3								3	3		3	3		



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DEPARTMENT OF CHEMICAL ENGINEERING
REGULATIONS 2023 - CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI

B.TECH. CHEMICAL ENGINEERING

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	23FYH111	Technical English	HSC	2	2	0	4	4
2.	23FYM116	Differential Calculus and Integral Calculus	BSC	3	1	0	4	4
3.	23FYP116	Physics for Chemical Engineers	BSC	3	0	0	3	3
4.	23FYC116	Physical Chemistry	BSC	3	0	0	3	3
5.	23CH111	Mechanics of Solids	ESC	3	0	0	3	3
6.	23CH112	Fundamentals of Computing	ESC	3	0	0	3	3
PRACTICALS								
7.	23CH121	Engineering Graphics	ESC	0	0	2	2	1
8.	23CH122	Computer Laboratory	ESC	0	0	2	2	1
MANDATORY COURSES								
9.	23FYH121	Heritage of Tamils	MC	15 Hours			-	1
10.	23MC101	Soft Skills	MC	15 Hours			-	-
11.	23MC102	Induction Programme	MC	15 Days			-	-
TOTAL				17	3	4	24	23

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	23FYM216	Matrices, Fourier Series and Transforms	BSC	3	1	0	4	4
2.	23FYP213	Material Science	BSC	3	0	0	3	3
3.	23FYC212	Organic Chemistry	BSC	3	0	0	3	3
4.	23CH211	Heat Power Engineering	ESC	3	0	0	3	3
5.	23CH212	Electrical Drives and Control	ESC	3	0	0	3	3
6.	23CH213	Introduction to Chemical Engineering	PCC	3	0	0	3	3
PRACTICALS								
7.	23FYH221	English Communication and Competency Laboratory	HSC	0	0	4	4	2
8.	23FPC221	Basic Sciences Laboratory	ESC	0	0	4	4	2
MANDATORY COURSES								
9.	23FYC221	Environmental Science & Engineering	MC	15 Hours			-	1
10.	23FYH222	Tamils and Technology	MC	15 Hours			-	1
11.	23CC	Co-curricular Activities	MC	15 Hours			-	1
TOTAL				18	1	8	27	26

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	23M316	Differential Equations and Boundary Value Problems	BSC	3	1	0	4	4
2.	23CH311	Biology for Chemical Engineers	BSC	3	0	0	3	3
3.	23CH312	Fluid Mechanics for Chemical Engineers	PCC	3	0	0	3	3
4.	23CH313	Process Instrumentation	PCC	3	0	0	3	3
5.	23CH314	Chemical Process Industries	PCC	3	0	0	3	3
6.	23CH315	Chemical Process Calculations	PCC	3	1	0	4	3
PRACTICALS								
7.	23CH321	Physical and Organic Chemistry Laboratory	ESC	0	0	3	3	1.5
8.	23CH322	Electrical Drive Laboratory	ESC	0	0	3	3	1.5
MANDATORY COURSES								
9.	23MC301	Induction Programme	MC	15 Hours			-	-
10.	23MC321	Human Values and Professional Ethics	OC	15 Hours			-	1
11.	23MC322	Design Thinking	EEC	15 Hours			-	1
TOTAL				18	2	6	26	25

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Probability and Statistics	BSC	3	1	0	4	4
2.		Mechanical Operations	PCC	3	0	0	3	3
3.		Heat Transfer	PCC	3	0	0	3	3
4.		Mass Transfer-I	PCC	3	0	0	3	3
5.		Chemical Engineering Thermodynamics	PCC	3	0	0	3	3
6.		Instrumental Methods of Analysis	PCC	3	0	0	3	3
PRACTICALS								
7.		Fluid Mechanics Laboratory	PCC	0	0	3	3	1.5
8.		Technical and Instrumental Analysis Laboratory	PCC	0	0	3	3	1.5
MANDATORY COURSES								
9.		Community Service Engineering	EEC	15 Hours			-	-
10.		Value added Courses-I	MC	15 Hours			-	-
TOTAL				18	1	6	25	22

SEMESTER V

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Numerical Methods in Chemical Engineering	PCC	3	0	0	3	3
2.		Mass Transfer-II	PCC	3	0	0	3	3
3.		Chemical Reaction Engineering-I	PCC	3	0	0	3	3
4.		Chemical Process Safety	PCC	3	0	0	3	3
5.		Elective-I	PEC	3	0	0	3	3
6.		Elective-II	PEC/OEC	3	0	0	3	3
PRACTICALS								
7.		Heat Transfer Laboratory	PCC	0	0	3	3	1.5
8.		Mechanical Operations Laboratory	PCC	0	0	3	3	1.5
INTERNSHIP			EEC	0	0	2	2	1
MANDATORY COURSES								
9.		Seminar and Technical Writing	MC	15 Hours			-	-
10.		Value added Course-II	EEC	15 Hours			-	1
TOTAL				18	2	6	26	23

SEMESTER VI

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Process Dynamics and Control	PCC	3	0	0	3	3
2.		Chemical Reaction Engineering-II	PCC	3	0	0	3	3
3.		Applied Mathematics in Chemical Engineering	PCC	3	0	0	3	3
4.		Biochemical Engineering	PCC	3	0	0	3	3
5.		Elective-III	PCC	3	0	0	3	3
6.		Elective-IV	PEC/OEC	3	0	0	3	3
PRACTICAL								
7.		Mass Transfer Laboratory	PCC	0	0	3	3	1.5
8.		Reaction Engineering Laboratory	PCC	0	0	3	3	1.5
MINI PROJECT			EEC	0	0	4	4	2
MANDATORY COURSE								
9.		Hackathon	EEC	0	0	2	2	1
TOTAL				18	0	12	30	24

SEMESTER VII

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Transport Phenomena	PCC	3	0	0	3	3
2.		Process Economics and Management	PCC	3	0	0	3	3
3.		Process Modeling and Simulation	PCC	3	0	0	3	3
4.		Process Plant Utilities	PCC	3	0	0	3	3
5.		Elective-V	PEC	3	0	0	3	3
6.		Elective-VI	PEC	3	0	0	3	3
PRACTICALS								
		Process Equipment Design and Drawing	PCC	0	0	3	3	1.5
		Process Control and Simulation Laboratory	PCC	0	0	3	3	1.5
TOTAL				18	0	6	24	21

SEMESTER VIII

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
		Elective-VII	PEC	3	0	0	3	3
		Elective-VIII	PEC	3	0	0	3	3
PRACTICALS								
		Project Work and Viva-Voce	EEC	0	0	12	12	6
							18	12

LIST OF PROFESSIONAL ELECTIVE COURSES

SI. No	COURSE CODE	COURSE TITLE	CATE GORY	L	T	P	CONTACT PERIODS	CREDITS
1.		Advanced Separation Processes	PE	3	0	0	3	3
2.		Carbon Capture	PE	3	0	0	3	3
3.		Colloid and Interfacial Engineering	PE	3	0	0	3	3
4.		Computer Aided Process Equipment Design	PE	3	0	0	3	3
5.		Drugs and Pharmaceuticals Technology	PE	3	0	0	3	3
6.		Energy Management in Chemical Industries	PE	3	0	0	3	3
7.		Fertilizer Technology	PE	3	0	0	3	3
8.		Fluidization Engineering	PE	3	0	0	3	3
9.		Food Technology	PE	3	0	0	3	3
10.		Integrated Design of Chemical Process	PE	3	0	0	3	3

11.		Technology of Composites	PE	3	0	0	3	3
12.		Mineral Processing Technology	PE	3	0	0	3	3
13.		Nanoscience and Nanotechnology for Chemical Engineering	PE	3	0	0	3	3
14.		Pilot Plant Scaleup Methods	PE	3	0	0	3	3
15.		Polymer Science and Engineering	PE	3	0	0	3	3
16.		Process Automation	PE	3	0	0	3	3
17.		Process Engineering	PE	3	0	0	3	3
18.		Pulp and Paper Technology	PE	3	0	0	3	3
19.		Sugar Technology	PE	3	0	0	3	3
20.		Surface Coating Technology	PE	3	0	0	3	3
21.		Total Quality Management	PE	3	0	0	3	3
<u>VERTICAL-I PETROLEUM PROCESS TECHNOLOGY</u>								
22.		Petroleum Chemistry	PE	3	0	0	3	3
23.		Primary Refining Technology	PE	3	0	0	3	3
24.		Secondary Refining Technology	PE	3	0	0	3	3
25.		Refinery advancements and regulations	PE	3	0	0	3	3
26.		Petroleum Equipment Design	PE	3	0	0	3	3
27.		Petrochemical Technology	PE	3	0	0	3	3
<u>VERTICAL-II ENERGY ENGINEERING</u>								
28.		Bio Energy	PE	3	0	0	3	3
29.		Renewable Energy	PE	3	0	0	3	3
30.		Hydrogen and Fuel Cell Technology	PE	3	0	0	3	3
31.		Power Plant Engineering	PE	3	0	0	3	3
32.		Non-renewable Energy sources	PE	3	0	0	3	3
33.		Sustainability Engineering	PE	3	0	0	3	3
<u>VERTICAL-III INDUSTRIAL BIOTECHNOLOGY</u>								
34.		Bio Chemistry	PE	3	0	0	3	3
35.		Bioprocess Technology	PE	3	0	0	3	3
36.		Fermentation & Bioprocessing	PE	3	0	0	3	3
37.		Bio Separation & Downstream processing	PE	3	0	0	3	3
38.		Enzyme Immobilisation	PE	3	0	0	3	3
39.		Bio Reactor Design	PE	3	0	0	3	3
<u>VERTICAL-IV ENVIRONMENTAL AND SAFETY ENGINEERING</u>								
40.		Air Pollution Engineering	PE	3	0	0	3	3
41.		Waste Water Treatment	PE	3	0	0	3	3
42.		Solid waste Management	PE	3	0	0	3	3
43.		Environmental Impact Assessment	PE	3	0	0	3	3
44.		Process Safety Management	PE	3	0	0	3	3
45.		Risk and Hazop Analysis	PE	3	0	0	3	3
<u>VERTICAL-V COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING</u>								
46.		Computational Techniques	PE	3	0	0	3	3
47.		Optimization of Chemical Processes	PE	3	0	0	3	3
48.		Pinch Analysis and Heat Exchanger networks	PE	3	0	0	3	3
49.		Chemical Process Flow sheeting	PE	3	0	0	3	3
50.		Computational Fluid Dynamics	PE	3	0	0	3	3
51.		Design and Analysis of experiments	PE	3	0	0	3	3

VERTICAL-VI CHEMICAL PLANT DESIGN								
52.		Chemical Plant Design	PE	3	0	0	3	3
53.		Plant Layout	PE	3	0	0	3	3
54.		Design Safety	PE	3	0	0	3	3
55.		Material Selection	PE	3	0	0	3	3
56.		Statutory Requirements & Customer Care	PE	3	0	0	3	3
57.		Piping and Instrumentation	PE	3	0	0	3	3

LIST OF OPEN ELECTIVE COURSES OFFERED FOR THE STUDENTS OF OTHER UG PROGRAMMES:

Sl. No	COURSE CODE	COURSE TITLE	CATEGORY	L	T	P	CONTACT PERIODS	C	UG PROGRAMME
1.		Industrial Safety Engineering	OE	3	0	0	3	3	ALL
2.		Risk Analysis and Hazop	OE	3	0	0	3	3	ALL
3.		Green Technology	OE	3	0	0	3	3	ALL
4.		Corrosion Science and Engineering	OE	3	0	0	3	3	ALL
5.		Nanomaterial Synthesis and Characterization Laboratory	OE	0	0	6	6	3	ALL
6.		Multivariate Statistics Laboratory	OE	0	0	6	6	3	ALL
VERTICAL - ENVIRONMENTAL AND SUSTAINABILITY ENGINEERING									
7.		Sustainable Infrastructure Development	OE	3	0	0	3	3	ALL
8.		Materials for Energy Sustainability	OE	3	0	0	3	3	ALL
9.		Environmental Quality Monitoring	OE	3	0	0	3	3	ALL

LIST OF VALUE-ADDED COURSES

S.NO	Name of the Course
1.	Critical Thinking
2.	Creativity & Innovation
3.	Leadership
4.	Emotional Intelligence
5.	Health and Lifestyle
6.	Psychology for Engineers
7.	Fundamentals of Nanoscience
8.	An Introduction to Environmental Ethics
9.	Corporate Social Responsibilities
10.	Energy Materials, Devices and Systems
11.	Surface Engineering of Nanomaterials
12.	Research Skills

SUMMARY

Category; BSC – Basic sciences, HSC– Humanities and Social Sciences, ESC–Engineering sciences, PCC –Professional Core, PEC- Professional Elective, OEC-Open Elective Course, EEC –Employability Enhancement Course, MC – Mandatory Course

B.E. CIVIL ENGINEERING										
Sl. No.	Subject Area	Credits per Semester								Credits Total
		I	II	III	IV	V	VI	VII	VIII	
1	HSC	4	2	-	-	-	-			6
2	BSC	10	10	7	4	-	-			31
3	ESC	8	8	3	-	-	-			19
4	PCC	-	3	13	18	15	15	15		79
5	PEC	-	-	-	-	3	3	6	6	18
6	OEC	-	-	-	-	3	3			6
7	EEC	-	-	0	-	2	2		6	10
8	MC	1	3	1	-	1	1			7
TOTAL CREDITS										176

SEMESTER-I

23FYH111	TECHNICAL ENGLISH	L	T	P	C
		2	2	0	4

MODULE I FOCUS ON LANGUAGE: GRAMMAR & VOCABULARY

6

Embedded Sentence – Numerical Adjectives - Subject Verb Agreement – If Conditionals – Active Passive Voice – Reported Speech - Idiomatic Expressions - Business- and Job-Related Vocabulary - Relative Clause – Pronouns – Adjectives - Degrees of Comparison - Technical Vocabulary – Avoidance of Jargon - Collocations - Formal and Informal Vocabulary – Verbal Analogy - Tenses - Prepositions – Articles – Homophones and Homonyms - One Word Substitutes –Linking Words.

MODULE II TECHNICAL COMMUNICATION

6

Importance of Technical Communication - Objective & Characteristics of Technical Communication – General and Technical Communication – Process of Communication - Levels of Communication – Flow of Communication –Visual Aids in Technical Communication - Barriers to Communication: Noise – Classification of Barriers –Non-verbal Communication: Kinesics – Proxemics- Chronemics.

MODULE III READING& LISTENING

6

Reading Comprehension Techniques: Understanding Technical Articles – Skimming and Scanning – Summarizing– - Intensive & Extensive Reading- Note Making – SQ3R Reading Technique - Meaning and Art of Listening-Importance of Listening & Empathy in Communication – Reasons for Poor Listening – Traits of a good listener – Listening to Technical Talks – Listening to TED/INK Talks

MODULE IV WRITING

6

Paragraph Writing – Interpreting Charts and Graphs – Instructions – Checklists – Recommendations – Describing a Process – Extended Definitions – Essay Writing – Report Writing – Minutes of the Meetings -Email Writing - Essay Writing - Job Application Letters.

MODULE V SPEAKING

6

Introducing Oneself- Asking for and Giving Directions – Seeking Clarification – Speaking about a Process – Introduction to Technical Presentation – Mechanics of Presentation – Achieving Confidence, Clarity & Fluency – Vocal Cues - Barriers to Speaking – Types of Speaking – Persuasive Speaking – Public Speaking.

Tutorials and Practical Sessions based on the above syllabus

30 Hours

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Apply the rules of the Grammar and construct grammatically correct sentences

CO2: Categorize the barriers to communication and formulate solutions.

CO3: Identify the nuances of Technical Communication.

CO4: Interpret texts using reading and listening strategies.

CO5: Demonstrate effective business writing and Presentation Skills.

CO6: Use effective LSRW strategies to communicate at workplace.

TOTAL : 60 PERIODS

TEXT BOOKS:

1. Praveen Sam D & Shoba K N, "A Course in Technical English" CUP, 2020.

2. Meenakshi Raman, Sangeeta Sharma, "Technical Communication – Principles and Practice", Oxford

University Press, New Delhi, 2015.

REFERENCES:

1. Sudharshana N. P & Savitha C, “English for Engineers”, CUP, 2018
2. Steve Hart, Aravind R. Nair & Veena Bhambhani, “Embark – English for Undergraduates”, CUP, 2016
3. Jack C Richerds, “Interchange - 2”, CUP, Fourth Edition, Chennai, 2015.
4. Lourdes Joavani Rayen & Shoba K N, “Communicative English”, CUP, 2018.

ONLINE SOURCES

1. Technical English for Engineers - NPTEL course.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1									2	3		1		
2									2	3		1		
3									2	3		1		
4									2	3		1		
5									2	3		1		
Avg.									2	3		1		

1-low, 2-medium, 3-high

23FYM116	DIFFERENTIAL CALCULUS AND INTEGRAL CALCULUS	L	T	P	C
		3	1	0	4

MODULE I DIFFERENTIAL CALCULUS 9

Representation of functions – Basic concepts – Limit, Continuity, Differentiation – Indeterminate forms - L'Hospital's rule- Functions of one variable - Rolle's theorem - Mean value theorem- Taylor's and Maclaurin's series - Maxima and minima.

MODULE II INTEGRAL CALCULUS 9

Definite integrals – Techniques of Integration – Substitution rule – Integration by parts – Improper integrals- Beta and Gamma functions - Properties –Simple problems.

MODULE III FUNCTIONS OF SEVERAL VARIABLES 9

Partial derivatives- Total derivative - Taylor's series- Maxima and minima of functions of two variables– Lagrange's method of undetermined multipliers.

MODULE IV MULTIPLE INTEGRALS 9

Double integrals – Change of order of integration – Jacobians -Evaluation in polar coordinates – Area enclosed by plane curves – Triple integrals in Cartesian coordinates– Volume of solids.

MODULE V VECTOR CALCULUS 9

Vector differentiation – Gradient, divergence and curl - Directional derivative – Solenoidal and Irrotational vector fields - Vector integration – Line, surface and volume integrals - Green's, Gauss and Stoke's theorems (without proof) –Simple applications involving cube and rectangular parallelepiped.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Assimilate ideas of limits and continuity, understand the concepts of Rolle's and mean value theorems on differentiable functions

CO2: Choose appropriate techniques to evaluate definite and improper integrals

CO3: Compute partial derivatives of multivariable functions and determine maxima and minima of functions of two or three variables

CO4: Evaluate double and triple integrals and find the area of regions and volume of solids

CO5: Assimilate ideas of vector differentiation, evaluate line, surface and volume integrals along with the classical theorems involving them

TUTORIAL: 15 PERIODS

TOTAL: 60 PERIODS

TEXT BOOKS:

1. B.S. Grewal, "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, 2021
2. B.V. Ramana, "Higher Engineering Mathematics", 1st Edition, McGraw Hill Education, 2017

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2014
2. P. Sivaramakrishnanadas, E. Rukmangadachari, "Engineering Mathematics", 2nd Edition,

Pearson, Delhi, 2013.

3. T. Veerrajan, "Engineering Mathematics (For First Year)", McGraw Hill Education, 2006

4. Joel R.Hass, Christopher E.Heil, Maurice D.Weir, "Thomos Calculus", 14th Edition, Pearson, 2018.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2		1									1	
2	3	2		1									1	
3	3	2		1									1	
4	3	2		1									1	
5	3	2		1									1	
Avg.	3	2		1									1	

1-low, 2-medium, 3-high

23CH311	PHYSICS FOR CHEMICAL ENGINEERS	L	T	P	C
		3	0	0	3

MODULE I LASERS

8

Absorption and emission – Spontaneous emission – Stimulated emission – Population inversion- Sources of excitation- Active medium – Resonant cavity- Einstein's theory of stimulated emission- Nd-YAG laser- CO₂ laser- Semi Conductor laser- Applications- 3D profiling, laser drilling and welding.

MODULE II FIBRE OPTICS

9

Optical Fibre – Advantages of optical fibre as wave guide and propagation of light in optical fibres- Numerical aperture and acceptance angle- Structure of optical fibre – Fibre optical materials – Types of optical fibres – Single and multimode fibres – Step index and graded index fibres- Applications – Fibre optic communication system, Fibre endoscope.

MODULE III QUANTUM PHYSICS

9

Compton effect - Expression for Compton shift - Concept of matter waves - Physical significance of wave, function - Schrodinger's wave equation - Time independent and time dependent equation - Eigen values and eigen function - Particle in a box (one dimension)- Scanning electron microscope (SEM)-Transmission electron microscope (TEM).

MODULE IV CRYSTAL STRUCTURE

10

Crystal structure -Space lattice- Unit cell - Bravais Lattices- Miller Indices-d-spacing in cubic lattice. Coordination number, packing factor for simple cubic, body centered cubic, face centered cubic and hexagonal close packed structures, Crystal imperfections- Point and Line defects.

MODULE V NANO TECHNOLOGY AND NEW ENGINEERING MATERIALS

(9)

Nano materials- Preparation of nano materials- Physical vapour deposition - sol gel methods, properties of nano particles – applications- Shape memory alloys - characteristics and application Liquid crystal properties and applications.

TOTAL: 45 PERIODS

COURSE OUTCOME

Upon successful completion of course, students will be able to

- CO1:** Acquire working knowledge about lasers & optical fibres and their applications.
- CO2:** Develop conceptual understanding about quantum mechanics.
- CO3:** Demonstrate competency and understanding about the arrangement of atoms in crystals and basics of nano technology.
- CO4:** Solve problems in laser, fibre optics, quantum mechanics and crystal structure
- CO5:** Illustrate the structure, materials, types of optical fibre and their applications.

TEXT BOOKS

1. Avadhanulu M.N, Kshirsagar P.G, Arun Murthy T.V.S, A Text book of Engineering Physics, S.Chand& Company Ltd., New Delhi, 2018.

2. Rajendran..V, Engineering Physics, Tata McGraw Hill Publishing company, New Delhi, 2017.

REFERENCES

Gaur R K and Gupta S L, Engineering Physics, Dhanpat Rai Publications PVt Ltd, New Delhi, 2017.

CO PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1		1										
2	2	1		1										
3	2	1		1										
4	2	1		1										
5	2	1		1										
Avg.	2	1		1										

1-LOW, 2-MEDIUM, 3-HIGH

23FYC116	PHYSICAL CHEMISTRY	L	T	P	C
		3	0	0	3

MODULE I SURFACE CHEMISTRY AND CATALYSIS 9

Adsorption: Introduction, Types of adsorptions - adsorption of gases on solids – adsorption of solute from solutions (Gibbs Adsorption) - adsorption isotherms - Freundlich's adsorption isotherm - Langmuir adsorption isotherm. Catalysis: Catalyst - types of catalysis - criteria - auto catalysis - catalytic poisoning and catalytic promoters - acid base catalysis - enzyme catalysis - Michaelis-Menten equation.

MODULE II CHEMICAL KINETICS 9

Rate of reaction - Definition of order and molecularity. Derivation of rate constants for first, second, third and zero order reactions and examples. Derivation for time half change. Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy. Collision theory of reaction rates.

MODULE III THERMODYNAMICS 9

The first law of thermodynamics - statement, definition of internal energy and enthalpy. Heat capacities and their relationship. Joule-Thomson effect - coefficient. Calculation of work done for the expansion of perfect gas under isothermal and adiabatic conditions for reversible processes. State and path function. Kirchoff's equation. Second law of thermodynamics. Different Statements of the law. Concept of entropy, entropy as a state function, entropy changes in reversible and irreversible processes.

MODULE IV DILUTE SOLUTIONS 9

Colligative properties. Raoult's law, relative lowering of vapour pressure, its relation to molecular weight of non-volatile solute. Elevation of boiling point and depression of freezing point. Derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods of determination. Osmosis, osmotic pressure, experimental determination. Theory of dilute solutions. Determination of molecular weight of non-volatile solute from osmotic pressure. Abnormal Colligative properties - Van't Hoff factor

MODULE V PHASE RULE AND ELECTROCHEMISTRY 9

Phase rule: Introduction, definition of terms with examples, one component system – water system – reduced phase rule – thermal analysis and cooling curves – two component systems – lead-silver system. Electrochemistry: Specific conductance and equivalent conductance. Variation of equivalent conductance with dilution. Migration of ions, Kohlrausch's law. Arrhenius theory of electrolyte dissociation and its limitations. Ostwald's dilution law.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Understand the basic concepts of adsorption, isotherms and catalytic phenomena of a reaction.

CO2: Analyze the rate of reaction, concepts of activation energy, collision theory and absolute reaction rates.

CO3: Understand the laws of thermodynamics, isothermal and adiabatic conditions, reversible and irreversible processes.

CO4: Calculate the work done for the expansion of gases under different processes and understand the various thermodynamic concepts.

CO5: Apply the basic concepts of phase rule of one and two component system, thermal analysis and cooling curves of the system

TOTAL : 45 PERIODS

TEXT BOOKS:

1. M B.R.Puri, L.R.Sharma and M.S.Pathania, "Principles of Physical Chemistry" Forty Seventh Edition, Vishal Publishing Company, 2017.
2. P.C.Jain and Monica Jain, "Engineering Chemistry" Sixteenth Edition, Dhanpatrai publication, 2015.

REFERENCES:

1. Robert.W.Kelsall, IanW.Hamley and Mark Geoghegan, "Nano Scale Science and Technology", John Wiley& Sons Ltd-UK. 2005.
2. PL Soni, OP Dharmarha, Un Dash, "A Text Book of Physical Chemistry", Sultan Chand and Sons, 2016.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1	2	2		2							2	2
2	2	1	1	1		2							2	2
3	2	1	1	1		1							2	2
4	2	1	1	1		1							2	2
5	2	2	2	1		1							2	2
Avg.	2	1.2	1.4	1.2		1.4							2	2

1-low, 2-medium, 3-high

23CH111	MECHANICS OF SOLIDS	L	T	P	C
		3	0	0	3

MODULE I CONCEPT OF STRESS AND STRAIN 9

Simple stresses and strains at a point -Normal and shear Stresses - Hook's Law - Young's modulus - Bars subjected to axial Forces - simple problems. Thermal stresses - Simple statically indeterminate problems like compound bars - Elastic constants - modulus of rigidity - Bulk modulus - Relationships.

MODULE II TRANSVERSE LOADING ON BEAMS 9

Beams - support conditions - types of beams - transverse loading on beams - shear force and bending moment in beams - analysis of cantilevers, simply supported beams and over hanging beams - relationships between loading, S.F and B.M. in beams and their applications -S.F and B.M. diagrams.

MODULE III STRESSES IN BEAMS 9

Theory of simple bending - assumptions and derivation of bending equation - analysis of stresses in beams - loads carrying capacity of beams - proportioning of beam sections - leaf springs - flitched beams - shear stress distribution in beams - determination of shear stress in rectangular beams.

MODULE IV TORSIONS 9

Torsion of solid and hollow circular shafts - Power transmitted through shafts - closed coiled helical springs - springs constants - springs in series and springs in parallel.

MODULE V COLUMNS AND PLANE TRUSSES 9

Axially loaded short columns - columns of unsymmetrical sections - Euler's theory of long columns - critical loads of prismatic columns with different end conditions - Rankine's empirical theory. Analysis of statically determinate plane trusses - Method of Joints and method of sections.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Compute stresses due to axial forces, thermal stresses, complex stresses and stresses due to suddenly applied loads and impact loads.

CO2: Illustrate Bending moment and Shear Force diagram for determinate beams.

CO3: Calculate stress related to bending, shear and torsion.

CO4: Calculate member forces for trusses.

CO5: Estimate the location of maximum bending stress in beam.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Bansal R.K., Strength of Materials, Fifth Edition, Laxmi Publications Pvt. Ltd, New Delhi, 2012.
2. Sadhu Singh, Strength of Materials, Tenth Edition, Khanna Publications, New Delhi, 2012.

REFERENCES:

1. Khurmi R.S., Strength of Materials, Third Edition Reprint, S.Chand and Company Ltd, 2015.
2. Singh J.P., Mechanics of Solids, Fourth Edition, Khanna Publications, New Delhi, 2005.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1	2	2		2							2	
2	2	1	1	1		2							2	
3	2	1	1	1		1							2	
4	2	1	1	1		1							2	
5	2	2	2	1		1							2	
Avg.	2	1.2	1.4	1.2		1.4							2	

1-low, 2-medium, 3-high

23CH112	FUNDAMENTALS OF COMPUTING	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION TO PROGRAMMING 9

Fundamentals of programming- Flow charts – Components of flow charts- Construction of flow charts for simple problems such as Simple interest, Compound interest calculations. Construction of flowcharts for if, else if constructs.

MODULE II INTRODUCTION TO C 9

C Data types – C Compilation and execution – Operators: Hierarchy of Operators, Associativity of Operators – Expressions – Single Dimensional Arrays – Console I/O functions: Formatted I/O: scanf(), printf(), getchar(), putchar().

MODULE III CONTROL STATEMENTS 9

If Statements: If-else statement, Nested if statements, ternary Operators- while do loop- while loop, for loop- break statement – Continue statement- switch case statement-go to statement and statement labels.

MODULE IV FUNCTIONS 9

Function declaration and prototypes – Parameter Passing – Recursion – Command line arguments – Simple examples on Functions.

MODULE V POINTERS AND ARRAYS 9

Array of pointers – Multidimensional arrays- Pointers and Strings- Standard String Library functions: strlen(), strcpy(), strcat() and strcmp(). Dynamic memory allocation and Deallocation.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1:exhibit fundamental knowledge in problem solving, designing algorithms and representation through flow charts.

CO2: Develop simple programs using decision making statements and looping constructs.

CO3: Handle series of data items through arrays and pointers.

CO4: Practice modularization of the given problem using functions.

CO5: To solve real world problems involving collection of data items through structures and files.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Byron S.Gottfried," Programming with C" Fourth Edition, Tata McGraw Hill, New Delhi, 2018.

REFERENCES:

1. Brian W.Kernigham and Dennis M.Ritchie, "The C Programming Language", Second Edition, Prentice Hall of India, New Delhi, Reprint 2016.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1	2	2		2							2	2
2	2	1	1	1		2							2	2
3	2	1	1	1		1							2	2
4	2	1	1	1		1							2	2
5	2	2	2	1		1							2	2
Avg.	2	1.2	1.4	1.2		1.4							2	2

1-low, 2-medium, 3-high

23CH121	ENGINEERING GRAPHICS	L	T	P	C
		0	0	2	1

INTRODUCTION TO ENGINEERING DRAWING

Principles of Engineering Graphics and their significance, usage of drawing instruments and lettering, dimensioning and scales.

ORTHOGRAPHIC PROJECTIONS

Principles of orthographic Projections – Conventions – Projections of Points and lines inclined to both planes; Projection of Planes. Projections of Solids inclined to both the Planes – Draw simple annotation.

SECTION OF SOLIDS AND DEVELOPMENT OF SURFACES

Sections – Prism, Cylinder, Pyramid and Cone; Development of Surfaces of Right Regular Solids- Prism, Pyramids Cylinder and Cone.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able

CO1: Understand the importance of BIS ISO standards in Engineering Drafting.

CO2: Imagine and Visualize the geometric details of engineering objects.

CO3: Communicate ideas through technical drawings

CO4: Use computer aided drafting in their respective engineering field

CO5: Interpret orthographic and isometric views of objects.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3											1	1	1
2		3										1	1	1
3	3											1	1	1
4												1	1	1
5		3			2							1	1	1
Avg.	3	3			2							1	1	1

1-low, 2-medium, 3-high

23CH122	COMPUTER LABORATORY	L	T	P	C
		0	0	3	1.5

LIST OF EXPERIMENTS

LIST OF EXPERIMENTS

Using EXCEL

1. Solving linear and non-linear equations using Goal seek method
2. Programming on visual basic applications
3. Linear and non-linear regression using solver
4. Solving ordinary differential equations

Using MATLAB

1. Introduction and overview of MATLAB programming
Array operations, evaluating functions, plotting output and arithmetic operations
2. Solving linear equations using matrix algebra
3. Solving ordinary differential equations – IVP and BVP
4. Solving partial differential equations
5. Least square regression analysis
6. Solving Integral and differential equations using SIMULINK
7. Experiments on formulation and solution to real world problem using first principles.

TOTAL: 30 PERIODS

Students will able to

CO1: To solve ordinary differential equation and algebraic equation using solver and goal seek in Excel.

CO2: To create function in VBA and develop programming codes to solve user-defined calculations in Excel.

CO3: To perform mathematical operations and develop script file to solve algebraic equations using MATLAB.

CO4: To apply and familiarize in-built functions of MATLAB for solving ordinary and partial differential equations

CO5: Apply ethical principles while doing experiments.

REFERENCES

1. Victor J Law, Numerical Methods for Chemical Engineers Using Excel, VBA & MATLAB, Taylor & Francis group, 2013.
2. Finlayson B. A, Introduction to Chemical Engineering Computing, John Wiley and Sons, 2006.
3. Cleve Moler, Experiments with MATLAB, math works, 2011.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3											1		
2		3											1	1
3	3												1	
4													1	
5		3			2								1	
Avg.	3	3			2								1	1

1-low, 2-medium, 3-high

23FYM216	MATRICES, FOURIER SERIES AND TRANSFORMS	L	T	P	C
		3	1	0	4

MODULE I MATRICES **9**

Eigenvalues and Eigenvectors - Cayley Hamilton theorem (statement only) - Applications to find the inverse and higher power of a matrix – Diagonalization by an orthogonal transformation – Transformation of quadratic forms to canonical forms

MODULE II FOURIER SERIES **9**

Dirichlet's conditions - Full range series - Half range series - Complex form of Fourier series - Parseval's identity - Harmonic analysis.

MODULE III LAPLACE TRANSFORMS **9**

Transform of elementary functions - Transform of unit step, Dirac delta and periodic functions - Initial and final value theorems – Inverse Laplace transforms -Convolution Theorem-Solution of linear second and higher order ordinary differential equations with constant coefficients.

MODULE IV FOURIER TRANSFORMS **9**

Fourier integral theorem (without proof) - Infinite Fourier transforms - Properties(without proof) - Convolution theorem - Infinite Fourier sine and cosine transforms-Parseval's identity - Finite Fourier sine and cosine transforms.

MODULE V Z – TRANSFORMS **9**

Introduction to Z-transforms – Properties – Simple Problems - Inverse Z-transforms - Convolution theorem – Definition of difference equation - Solution of difference equations with constant coefficients.

COURSE OUTCOME

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

- CO1:** Make use of computational techniques and algebraic skills in the study of eigenvalues and eigenvectors, diagonalization and quadratic forms
- CO2:** Calculate both real and complex forms of Fourier series.
- CO3:** Solve initial value problems in ordinary differential equations using Laplace transforms
- CO4:** Calculate Fourier transform and inverse transform of functions and apply them in follow-up courses in engineering.
- CO5:** Apply Z-transforms to solve the difference equations

TUTORIAL:15 PERIODS

TOTAL: 60 PERIODS

TEXT BOOKS

1. B.S. Grewal, "Higher Engineering Mathematics", 42nd Edition (2012), Khanna Publishers
2. B.V. Ramana, "Higher Engineering Mathematics", 1st Edition(2017), McGraw Hill Education

REFERENCES

1. T. Veerrajan, "Transforms and Partial Differential Equations", (2016), McGraw Hill Education
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 9th Edition (2011), John Wiley & Sons
3. P. Sivaramakrishnadas, C. Vijayakumari, "Engineering Mathematics", 1st Edition (2017), Pearson Education
4. T. Veerrajan, "Engineering Mathematics (For First Year)", (2006), McGraw Hill Education

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2		1								1		
2	3	2		1								1		
3	3	2		1								1		
4	3	2		1								1		
5	3	2		1								1		
Avg.	3	2		1								1		

1-low, 2-medium, 3-high

23FYP213	MATERIAL SCIENCE	L	T	P	C
		3	0	0	3

MODULE I MECHANICAL PROPERTIES

10

Tensile testing – Elastic and Plastic deformation – Mechanism of Slip – Cold and Hot working Recovery, Recrystallization and Grain Growth – Ductile and Brittle Fractures. - Creep – Creep test- Creep resistant materials – Fatigue – Measurement Fatigue Strength.

MODULE II ELECTRICAL PROPERTIES

9

Free electron Theory- Classical and Quantum – Fermi energy – Band theory of solids (basic concepts only) – Super conductors - Properties of super conductors, electrical resistance and diamagnetic properties – Effect of magnetic field, heavy current and pressure- Josephson's effect- Isotope effect – Type I and Type II super conductors- Applications - cryotron and magnetic levitation.

MODULE III SEMICONDUCTING PROPERTIES

9

Intrinsic and Extrinsic semiconductors – Direct bandgap and Indirect bandgap semiconductors - Fermi level – Variation of Fermi Level with temperature in intrinsic semiconductor - Variation of Fermi level with temperature and impurity concentration in extrinsic semiconductor (no derivation) – Expression for conductivity in intrinsic semiconductor – Determination of Band Gap energy of intrinsic semiconductor – Hall effect – Determination of Hall Co-efficient.

MODULE IV NUCLEAR ENGINEERING MATERIALS

9

Nuclear power generation – Nuclear Fission – Nuclear versus Thermal Power – Nuclear Reaction Cross reaction – Nuclear Fuel – Fuel cladding – Moderators- control materials - Coolants – Shielding Materials.

MODULE V MODERN TECHNIQUES OF MATERIAL STUDIES

8

Spectroscopy- Chemical analysis using Atomic absorption spectroscopy – Photo electron Spectroscopy – X- ray Fluorescence – Magnetic resonance: NMR – Basic principle – instrumentation- application and ESR – Basic principles – instrumentation – application.

COURSE OUTCOME

Upon successful completion of course, students will be able to

CO1: Infer the mechanical properties of materials.

CO2: demonstrate basic knowledge about electrical properties of conductors.

CO3: Explain the types of semiconductors and their variation of Fermi level.

CO4: Interpret the properties of super conductors for various applications.

CO5: Develop the knowledge about nuclear reactors.

TOTAL:45 PERIODS

TEXT BOOKS

1. Arumugam M., Material Science, Anuradha publications.
2. Raghavan.V, "Material Science and Engineering" Prentice Hall of India, New Delhi.

REFERENCES:

1. Pillai S.O, Solid State physics, New age International Publishers, 7th Edition, 2016.
2. William D.Callister, David G.Rethwisch, Material Science and Engineering, Wiley Eastern Publications, 2016.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1		1									2	
2	2	1		1									2	
3	2	1		1									2	
4	2	1		1									2	
5	2	1		1									2	
Avg.	2	1		1									2	

1-low, 2-medium, 3-high

23FYC212	ORGANIC CHEMISTRY	L	T	P	C
		3	0	0	3

MODULE I CHEMICAL BONDING AND ORGANIC MOLECULES REACTIVITY 9

Introduction to Organic Chemistry. Covalent Bonding – Geometry of atomic orbitals. Atomic orbital theory applied to chemical bonding – Types of Covalent bonding. Hybridisation – The structure of methane, ethane and acetylene. Hydrogen bonding in organic compounds. Electron displacements in organic compound, Inductive effect, Electromeric effect Mesomeric Effect, Hyper Junction. Acids and Bases – effect of solvation on acidity. Homolytic and Heterolytic cleavage of a covalent bond – Formation of reaction bonds.

MODULE II REACTION MECHANISM 9

Substitution reactions – Nucleophilic substitution reaction mechanism (SN1 & SN2). Electrophilic substitutions in Aromatic Hydrocarbons. Elimination Reaction Mechanism – E1 and E2. Factors influencing the types of reaction mechanisms. Role Solvents. Aldol Condensation, Perkin Reaction, Cannizaro Reaction, Riemer-Tiemenn Reaction and Benzoin Condensation.

MODULE III SYNTHETIC ORGANIC CHEMISTRY 9

Reagents – Preparation, Properties and uses Aluminium Propoxide, Crown Ethers, Lithium aluminium hydrides, N- Bromosuccinimides, Ziegler Nata Catalyst, Acetoacetic ester and Malonic ester. Preparation, properties and uses of Furan, Thiophene and Pyrrole.

MODULE IV CARBOHYDRATES, AMINO ACIDS AND PROTEINS 9

Introduction – mono, disaccharides and polysaccharides. Structural elucidation of Starch and Cellulose – Derivatives of cellulose – Carboxymethyl cellulose. Amino acid – Preparation (Strecker, Skraup, Gabriel phthalimide) and properties. Composition and classification of proteins. Structure of proteins – Tests for proteins – Properties and relations of proteins – Hydrolysis of proteins.

MODULE V DYES 9

Classification, colour and constitution; Mordant and Vat dyes; Chemistry of dyeing. Synthesis and applications of: Azo dyes – Methyl orange and Congo red (mechanism of Diazo Coupling); Triphenylmethane dyes - Malachite Green, and crystal violet; Phthalein dyes – Phenolphthalein and Fluorescein.

Course outcome

After completion of the course, students are able to

CO1: Understand the basic concepts of molecular structure and chemical bonding to identify the structural arrangements of the developed product.

CO2: Infer the electron displacement reaction, various effects and reactivity of organic molecules.

CO3: Interpret the reaction mechanisms of different types of organic reactions to understand the rate of reaction and thermodynamic parameters to develop a product.

CO4: Analyze the appropriate reagents and finding the specific reaction conditions for organic synthesis.

CO5: Deduce the preparation techniques, properties and applications of organic compounds.

TEXT BOOKS

1. B.S.Bhal and Arun Bhal, "A Text Book of Organic Chemistry", 22nd Edition, S.Chand & Co. New Delhi, 2017.
2. K.S. Tiwari, N.K.Vishoni and C.N.Mehrotra, "A Text Book of Organic chemistry", Vikas Publishing House, 2nd Edition, New Delhi, 2006.

REFERENCES

1. R.T.Morrison and R.N. Boyd "Organic Chemistry", 7th Edition, Prentice Hall Inc. USA, 2010.
2. I.L. Finar, "Organic Chemistry" ELBS (1994).

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2											1	
2	3	2											1	
3	3	2											1	
4	3	2											1	
5	3	2											1	
Avg.	3	2											1	

23CH211	HEAT POWER ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I INTERNAL COMBUSTION (IC) ENGINE 12

Classification - working of four stroke and two stroke engines - Petrol and Diesel engines - Ignition systems - working of simple carburetor - cooling and lubrication systems - Testing of IC Engines - various efficiencies - Heat balance test.

MODULE II AIR POWER CYCLES AND JET PROPULSION 9

Otto cycles, Diesel cycle, Dual cycle, comparison. Mean Effective Pressure (MEP) - Brayton cycle - Simple problems, Turbo jet - thrust - thrust power - propulsion efficiency - Rocket propulsion.

MODULE III GAS AND STEAM TURBINES 10

Open and closed cycle gas turbine system - practical gas turbines – Regeneration Intercooling and Reheating - Simple Problems, Principle of impulse and reaction turbines - compounding of turbines.

MODULE IV STEAM POWER CYCLE AND BOILERS 8

Ranking cycle, Properties of steam - steam tables and charts, Study of boilers - fire tube, water tube boilers- Mounting - Accessories.

MODULE V REFRIGERATION AND AIR CONDITIONING 6

Vapour compression refrigeration cycle on p-h diagram - COP - heat pump, Psychrometry - Air-Conditioning processes – application.

COURSE OUTCOME

After completion of the course, students are able to

CO1: Classify IC engines, discuss their working and analyze their performance.

CO2: Analyze - Air standard Otto, Diesel, Dual and Brayton Cycles; and performances of Jet and Rocket engines, using process diagrams.

CO3: Analyze Gas Turbine cycles, using process diagrams.

CO4: Explain steam generators, steam turbines, and analyze Rankine cycle using steam tables and Mollier diagram.

CO5: Evaluate performances of vapor compression refrigeration and heat pump systems, and compute property changes in simple calculations in air-conditioning processes, using psychrometric chart.

TOTAL:45 PERIODS

TEXT BOOKS

1. Rudramoorthy. R, Thermal Engineering, Fifteenth Edition, Tata McGraw Hill, New Delhi, 2012.
2. Kothandaraman C.P., Domkundwar S., Engineering Thermodynamics, Second Edition, Dhanpath Rai and Sons, New Delhi, 2003.

REFERENCES

1. Rajput.R .K., Thermal Engineering, Ninenth Edition, Laxmi Publication Pvt. Ltd, New Delhi ,2013.
2. Ballaney.P.L., *Thermal Engineering, Fifth Edition, Khanna publishers, New Delhi, 2010.*

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1		1									2	
2	2	1		1									2	
3	2	1		1									2	
4	2	1		1									2	
5	2	1		1									2	
Avg.	2	1		1									2	

1-low, 2-medium, 3-high

23CH212	ELECTRICAL DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

MODULE I DC MACHINES

9

Review - basics on electricals, D.C Generator: Constructional details-EMF equations-types and characteristics-D.C motors: Principle of operation- torque equation types and characteristics -speed control-applications.

MODULE II TRANSFORMERS

9

Transformers: Construction and principle of operation -EMF equation - equivalent circuit -OC and SC test-regulation and efficiency-auto transformer.

MODULE III AC MACHINES

9

Alternator: types of construction-operation-EMF equation-regulation by load test-synchronous motor: Principles of operation starting -applications. Three phase induction motor: types of construction - principle of operation-torque-slip characteristics speed control-applications. Single phase induction motor: Capacitor start and run, shaded pole induction motor-universal motor.

MODULE IV INDUSTRIAL DRIVES AND CONTROL (Qualitative Treatment)

9

Characteristics of electric drives and loads-selection of motor rating-solid state DC drive-solid state AC drive (Qualitative treatment)- V/F control. Selection of drives for chemical industries: paper mills, process control industries, cement mills, printing press.

MODULE V INSTRUMENTATION

9

Strain gauges, linear variable differential transformers, piezo-electric transducers, digital displacement transducers, sound level meter, electromagnetic flow meters, thermocouples, thermistors, resistance potentiometers, capacitive transducers, speed measurement.

COURSE OUTCOME

After completion of the course, students are able to

- CO1:** Explain the basic concepts and working principles of DC machines and transformer.
- CO2:** Describe the construction, working principle and applications of AC machines.
- CO3:** List the various characteristics of AC/DC drives and identify the suitable drives needed for chemical industries.
- CO4:** Understand the concepts of various transducers.
- CO5:** Interface external devices with ARM processor.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Arvind Mittal, Mittal, V.N., Basic Electrical Engineering, Second Edition, Tata McGraw Hill, New Delhi, 2005.

2. Dubey, G.K , Fundamentals of Electrical Drives, Second Edition, Narosa Publishing House, New Delhi, 2002.
3. Sawhney A.K, PuneetSawhney, A Course in Electrical and Electronics Measurements, Twentieth Edition, DhanpatRai and Sons, New Delhi, 2012.
4. Steve B. Furber, Stephen B. Furber, ARM System-on-Chip Architecture, Second Edition, Addison Wesley Longman Limited, 2000.

REFERENCES

1. Robert L. Boylesteadd and Louis Nashelsky, Electronic Devices and Circuit Theory, Eleventh Edition, Pearson Education Asia, United States, 2012.
2. Ian G.Warnock, Programmable Controllers Operation and Application, Prentice Hall International, UK, 1992.
3. Singh, S.K, Industrial Instrumentation and Control, Third Edition, Tata McGraw Hill Publishers, New Delhi, 2009.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1		1									2	
2	2	1		1									2	
3	2	1		1									2	
4	2	1		1									2	
5	2	1		1									2	
Avg.	2	1		1									2	

1-low, 2-medium, 3-high

23CH213	INTRODUCTION TO CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I OVERVIEW OF CHEMICAL ENGINEERING 9

Introduction to Unit Operations and Unit Processes, Basic Laws, Basic Mathematical principles: Units and Dimensions, Conversion Factors, Problems on Unit Conversion, Principles of Dimensional Homogeneity, Unit Conversion in Equation, Fundamentals of symbols used in process flowsheets.

MODULE II MATERIAL AND ENERGY BALANCE CALCULATIONS 12

Basic Chemical Principles: gram atom, gram mole and gram equivalent, calculations on solid mixture and solution. Material Balance: Guidelines and Step-by-Step procedure. Material Balance for simple systems. Material Balance for system involving reaction. Energy Balance on simple systems.

MODULE III FLUID FLOW OPERATIONS 7

Nature and Properties of Fluids, Types of Fluids, Newton's law of viscosity, Flow of a fluid past a solid surface. Equation of Continuity and Simple problems. Agitation and mixing.

MODULE IV HEAT TRANSFER OPERATIONS 9

Review of conduction, resistance concept, extended surfaces, Introduction to Convection, natural and forced convection, correlations; Radiation; Heat exchangers- Fundamental principles and classification of heat exchangers, Evaporators.

MODULE V MASS TRANSFER OPERATIONS 8

Diffusion – Basic laws with simple problems, Principles on Adsorption, Absorption, Distillation, Drying, Extraction, Membrane separation. Industrial Equipment for Drying, Adsorption and Extraction.

COURS OUTCOMES

After completion of the course, students are able to

- CO1:** Express the fundamentals of chemical engineering and to solve problems.
- CO2:** Develop basic fluid concepts, transfer and separation operations.
- CO3:** Apply basic transport laws to solve simple problems.
- CO4:** Apply material and Energy balance to precisely calculate material required for a process.
- CO5:** Apply steady state balances to develop process flow sheets.

TOTAL: 45 PERIODS

TEXT BOOKS

- S K Ghosal, S K Sanyal and S Dutta, Introduction to Chemical Engineering, Tata McGraw-Hill publishing company Ltd, New Delhi, 1993.
- W.L. McCabe, J.C. Smith and P. Harriott, Unit Operations of Chemical Engineering, 6th Edition, McGraw Hill, 2001.

REFERENCES

- G.T. Austin, R.N. Shreve, Chemical Process Industries, 5th Ed., McGraw Hill, 1984.
- R. M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd Ed., John Wiley, New York, 2004.

3. L.B. Anderson and L.A. Wenzel, Introduction to Chemical Engineering, McGraw Hill, 1961

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	
2	3	3	3										3	
3	3	3	3										3	
4	3	3	3										3	
5	3	3	3										3	
Avg.	3	3	3										3	

1-low, 2-medium, 3-high

23FYH221	ENGLISH COMMUNICATION AND COMPETENCY LABORATORY	L	T	P	C
		0	0	4	2

Verbal Aptitude

Alphabet test – Alphabet Order, Alphabet Series - Letter Word Problem, Word Formation and Scramble - Series Completion –Para Jumbles- Synonyms and Antonyms - Sentence Completion - Logical Sequence of Words - Word Power Exercises - Common Errors in English - Sentence Correction

Speaking and Writing

Self-Introduction- Greeting - Thanking – Apologizing - Congratulating -Complaining - Giving Instructions - Advising and Sympathizing – Requesting and warning people - Introduction to Phonetics – Consonants and Vowels - Extempore - Just a Minute - Book Reviews - Describing an object -- Story Building – Creative Writing – Describing a Picture – Dialogue Writing – Paraphrasing

Reading and Listening

Reading Comprehension- Skimming and Scanning - Reading Prose – Bacon’s Essays (Speaking Activity based on the essays) - Listening to Short Conversations – Listening to Monologues – Listening and Gap Filling.

Career Development Skills

Technical Presentation -Applications of MS Power Point- Group Discussion – Interview Skills – Telephoning Skills

LIST OF EXPERIMENTS

S.NO.	TOPICS
1.	Speech Sounds
2.	Vocabulary
3.	Reading Comprehension
4.	Listening Practice - I
5.	Dialogue Writing
6.	Conversational Exercise - I
7.	Focus on Language
8.	Creative Writing
9.	Conversational Exercise –II
10.	Listening Practice - II
11.	Greeting & Thanking
12.	Complaining, Apologizing & Congratulating

13. Asking & Giving Directions
14. Alphabet Series & Letter Series Word Formation
15. Para Jumbles
16. Synonyms and Antonyms
17. Sentence Completion & Correction
18. Presentation Skills
19. Group Discussion
20. Interview Skills

COURSE OUTCOME

Upon completion of this course the students will be able to

CO1: Solve timed objective questions on logical reasoning and verbal ability.

CO2: Use appropriate functional expression and converse effectively.

CO3: Assimilate meaning and comprehend text.

CO4: Perceive the nuances of Presentation, Interview and Group Discussion skills.

CO5: Generate language structures accurately and speak fluently.

REFERENCES:

1. Michael Mccarthy et al., "Touchstone – Level 2" Second Edition, CUP, 2014

CO-PO & PSO MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
1									2	3			1		
2									2	3			1		
3									2	3			1		
4									2	3			1		
5									2	3			1		
Avg.									2	3			1		

1-low, 2-medium, 3-high

23FPC221	BASIC SCIENCES LABORATORY	L	T	P	C
		0	0	4	2

Physics Laboratory

LIST OF EXPERIMENTS

1. Torsional Pendulum – Rigidity Modulus.
2. Determination of Band gap of a semi-conductor
3. Calibration of Voltmeter and Ammeter.
4. Figure of Merit of Galvanometer.
5. Implementation of basic Logic Gates using Universal Logic Gates.
6. Study of I-V characteristics of Solar cell
7. LASER- Determination of wave length
8. Young's Modulus- cantilever.

COURSE OUTCOME

Upon completion of this course the students will be able to

CO1: Determine the rigidity modulus of the material of the wire using torsional pendulum and determine the band gap of semiconductor by studying the I-V characteristics.

CO2: Calibrate the given voltmeter and ammeter and determine the figure of merit of a table galvanometer.

CO3: To construct and verify the basic logic gates.

CO4: Find the efficiency of a silicon solar cell and determine the wavelength of LASER .

CO5: Determine the Young's modulus of the material by cantilever method.

Chemistry Laboratory

LIST OF EXPERIMENTS

1. Determination of strength of given HCl using NaOH by pH measurement.
2. Determination of Alkalinity of water.
3. Determination of equivalent conductance of a strong electrolyte.
4. Estimation of Dissolved Oxygen in water sample.
5. Determination of sodium in water sample by flame photometry.
6. Estimation of iron in water sample by spectrophotometry.
7. Determination of corrosion rate of steel in acid media by weight loss method.
8. Estimation of ferrous ion by potentiometric titration.

COURSE OUTCOME

Upon completion of this course the students will be able to

CO1: Gain a fundamental understanding of the apparatus used in experiments.

CO2: Recognize how observation, experiment and theory go together.

CO3: Apply the knowledge of detecting dissolved oxygen, alkalinity and metal ions in water sample

CO4: Implement different types of elemental analysis through titrations like volumetric,

potentiometric and conductometric.

CO5: Handle analytical tools such as spectrophotometer, flame photometer, and potentiometer.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2		2	1									2	
2	2		2	1									2	
3	2		2	1									2	
4	2		2	1									2	
5	2		2	1									2	
Avg.	2		2	1									2	

23M316	DIFFERENTIAL EQUATIONS AND BOUNDARY VALUE PROBLEMS	L	T	P	C
		3	1	0	4

MODULE I ORDINARY DIFFERENTIAL EQUATIONS 9

Second and higher order linear differential equations with constant coefficients - Legendre linear homogenous ordinary differential equations - Method of variation of parameters - System of simultaneous linear differential equations with constant coefficients.

MODULE II NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS 9

Numerical solution of first order ordinary differential equation: Taylor's Series Method –Picard's Method - Euler's method -Modified Euler's method- Fourth order Runge- Kutta method - Milne's predictor corrector method.

Module III PARTIAL DIFFERENTIAL EQUATIONS 9

Formation of partial differential equations – Solutions of first order non-linear partial differential equations (standard types) - Lagrange's linear equation –Second and higher order homogeneous linear equations with constant coefficients.

Module IV BOUNDARY VALUE PROBLEMS 9

Method of separation of variables - One dimensional heat flow equations with steady state and unsteady state solutions – Two-dimensional steady state heat equation in Cartesian coordinates

MODULE V NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS 9

Difference Quotients – Graphical Representation of Partial quotients – Classification –One dimensional heat equation: Explicit method - Bender Schmidt recurrence formula – Implicit Method - Crank Nicholson Difference Formula - Elliptic Equations by Liebmann's Iteration Process.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Understand the concepts of ordinary differential equations in modelling and solving physical problems

CO2: Demonstrate accurate and efficient use of numerical solutions of ordinary differential equations and their role in modern mathematics and applied contexts

CO3: Formulate concrete problems and find the solutions of partial differential equations

CO4: Solve the boundary value problems relevant to one dimensional and two-dimensional heat equations.

CO5: Familiarize finite difference approximation to get numerical solutions of partial differential equations

TUTORIAL : 15 PERIODS

TOTAL : 60 PERIODS

TEXT BOOKS:

1. B.S. Grewal, "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, 2021

2. B.V. Ramana, "Higher Engineering Mathematics", 1st Edition, McGraw Hill Education, 2017

REFERENCES:

1. Srimanta Pal and Suboth. C. Bhunia, Engineering Mathematics, Oxford University Press, New Delhi, 2015.
2. Brian Bradie, "A Friendly Introduction to Numerical Analysis", Pearson Education, Asia, New Delhi, 2007.
3. S.S. Sastry, "Introductory Methods of Numerical Analysis", 5th Edition, Prentice Hall India Learning Private Limited, 2012.
4. T. Veerajan, "Transforms and Partial Differential Equations", 3rd Edition, McGraw Hill Education, 2016
5. T. Veerajan and T. Ramachandran, "Numerical Methods: With Programs in C", McGraw-Hill Science Engineering, 2008

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2		1	1							1		
2	3	2		1	1							1		
3	3	2		1	1							1		
4	3	2		1	1							1		
5	3	2		1	1							1		
Avg.	3	2		1	1							1		

1-low, 2-medium, 3-high

23CH311	BIOLOGY FOR CHEMICAL ENGINEERS	L	T	P	C
		3	0	0	3

MODULE I BASICS

9

Diversity of life - Genetic diversity, Species diversity & Ecosystem diversity. Prokaryotic and Eukaryotic cells - Constituents and organelles present in prokaryotic and eukaryotic cells. Similarities and differences between prokaryotic and eukaryotic cells. Macromolecules present in cells

MODULE II BIOCHEMISTRY AND METABOLISM

9

(Anabolism and Catabolism) Carbohydrate metabolism - Glycolysis and TCA cycle. Lipid metabolism - Beta oxidation of saturated fatty acids. Synthesis of saturated fatty acids. Protein metabolism - General breakdown of proteins - Deamination, Transamination & Urea cycle. Bioenergetics - Oxidative phosphorylation.

MODULE III GENETICS AND MOLECULAR BIOLOGY

9

Mendelian laws of inheritance. Structure and types of DNA and RNA. Basic features of prokaryotic and eukaryotic genome organization. DNA replication - Basic principles and mechanism of DNA replication - k model of DNA replication. Transcription - Synthesis of RNA and Post-transcriptional modifications. Translation - Genetic code - General features of the genetic code. Mechanism of protein synthesis and post translational modifications. Regulation of gene expression - Operon concept with specific reference to lac operon.

MODULE IV CELL BIOLOGY

9

Cytoskeleton -functions of microfilaments and microtubules. Membrane systems - Structure and organization of biological membranes. Fluid Mosaic Model. Membrane proteins. Transport of molecules across membranes -Transport of small molecules - Passive transport, Active transport (Sodium-Potassium pump) and Facilitated diffusion. Transport of large molecules - exocytosis and endocytosis. Cell division-Mitosis and Meiosis. Signal transduction - Intracellular and Intercellular signalling. Role of cyclic AMP.

MODULE V INDUSTRIAL APPLICATIONS

9

Broad classification and Characteristics of microorganisms; Types of culture media; Growth kinetics; Corona virus; Applications of Microbiology in food and pharmaceutical industries. Enzymes - Classification, Properties and Kinetics; Applications of industrial enzymes

COURSE OUTCOME

At the end of the course, students will be able to

CO1: Demonstrate biodiversity and identify cell constituents.

CO2: Categorize biomolecules and construct specific metabolic pathways.

CO3: Deduct genotypes using Mendelian laws

CO4: Illustrate the phases of the cell cycle and cell division

CO5: Classify microorganisms and evaluate enzyme kinetic parameters.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Suraishkumar, G. K. Biology for Engineers, Johny wiley 1st Edition, 2018.
2. Verma, P. S., and V. K. Agarwal. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand and Company Limited, 2019.
3. Nelson, D.L. and Cox, M.M. (2017). Lehninger Principles of Biochemistry, 17th edition, W.H. Freeman and Company, New York.

REFERENCES:

1. Ananthanarayanan and Paniker's (2017). Textbook of Microbiology, 10th edition, Orient Longman Pvt. Ltd., Hyderabad.
2. Victor W. Rodwell, David A. Bender, Kathleen M. Botham, Peter J. Kennelly and P. Anthony Weil. Harpers Illustrated Biochemistry, 31st edition, McGraw-Hill Education, 2018.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						2							
2	3				1				1			1		
3	3		1											
4	3		2											
5	3	3	3	2	1	3	2	1	2	1	1	1	3	1
Avg.	3	3	2	2	1	3	2	1	1.5	1	1	1	3	1

1-low, 2-medium, 3-high

23CH312	FLUID MECHANICS FOR CHEMICAL ENGINEERS	L	T	P	C
		3	0	0	3

MODULE I BASIC CONCEPTS

11

Definition of a fluid - Shear stress in a moving fluid - difference between liquids and gases - compressible and incompressible fluids - Newtonian and non-Newtonian fluids - continuum concept of a fluid - properties of fluids - viscosity - compressibility - bulk modulus. Dimensional analysis and its applications in fluid flow. Statics of fluid systems-pressure - variation of pressure vertically in a fluid under gravity -General equation for the variation of pressure due to gravity in a static fluid - manometers: U-tube, differential and inclined manometers.

MODULE II FLUID DYNAMICS

9

Fluid flow - basic concepts - Reynolds experiment - laminar and turbulent flows - nature of turbulence. Basic concepts of Boundary layer. Equation of continuity and its applications -momentum equations - Euler's equation of motion -Bernoulli's theorem and its applications.

MODULE III INCOMPRESSIBLE FLUID FLOW

9

Flow in conduits -Shear stress distribution in a cylindrical tube -Friction factor-Fanning's equation - Applications -Laminar flow in pipes -Hagen Poiseuille equation -Velocity distribution for laminar and turbulent flows -Losses due to sudden expansion and sudden contraction -Losses in pipe fittings.

MODULE IV PIPES, PUMPS & FLOW METERS

7

Pumps, Fans, Compressors and Blowers - Positive displacement pumps - Centrifugal pumps - NPSH and cavitation - Pump calculations - Constant and variable head flow meters. Pipes, Fittings and valves.

MODULE V FLUIDISED AND PACKED BEDS

9

Flow through packed beds - Ergun equation and Kozeny - Carman equation. Equation for one dimensional motion – Fluidisation Mechanism of fluidisation - Types of fluidisation-Pressure drop in fluidised beds - Minimum fluidisation velocity.

COURSE OUTCOME

At the end of the course, students will be able to

CO1: Classify fluid types, static behaviour and their applications in pressure, density measurements

CO2: Apply the basic concepts of fluid mechanics and find solution by dimensional analysis

CO3: Solve problems related to mass, momentum and energy balances in fluid flow.

CO4: Design fluid flow system and Identify losses due to friction & pipe fittings

CO5: Estimate the pump efficiency, head developed and pressure drop.

TOTAL : 45 PERIODS

TEXT BOOKS:

- McCabe. W.L., Smith. J C., Harriot. P., Unit operations of Chemical Engineering, McGraw Hill, Seventh Edition, 2014
- Douglas.J.F.,Gasiorek. J.M., Swaffielf. J.A., FLUID MECHANICS, Prentice Hall, Sixth Edition, 2011.

3. Noel de Nevers, Fluid Mechanics for Chemical Engineers, McGraw Hill, Fourth Edition, 2021

REFERENCES:

1. Hughes. F., John A Brighton and Nicholas Winowich, Schaum's Outline of Fluid Dynamics, Third Edition 1999.
2. Ranald.V.Giles, Cheng Liu and Jack Evett, Schaum's outline of Fluid Mechanics and Hydraulics, Fourth Edition 2010.
3. Christie John Geankoplis, A.Allen Hersel and Daniel H.Lepek, ' Transport Processes and Separation Process Principles' Prentice Hall India. Inc, Fifth Edition, 2017.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	1	3	1	1					2	3	2	1
2	3	2	2	3	2	3					2	3	2	2
3	3	2	3	3		3		1				3	2	3
4	3	2	1	3	2	2					1	3	2	1
5	3	2	1	3	1	2					1	3	2	1
Avg.	3	2	1.6	3	1.5	2.2		1			1.5	3	2	1.6

1-low, 2-medium, 3-high

23CH313	PROCESS INSTRUMENTATION	L	T	P	C
		3	0	0	3

MODULE I PRINCIPLES OF MEASUREMENT 9

Analysis: Measurement of Force, Strain and Torque- Use of strain gauges. Transducers - Resistive, capacitive, Inductive and piezoelectric pickups. Static and Dynamic response of Instruments. Errors in measurements.

MODULE II TEMPERATURE MEASUREMENT 9

Liquid filled, Gas filled and Vapour pressure Thermometers. Bimetallic and Resistance thermometers. Thermocouples and Thermistors. Optical and Radiation pyrometers.

MODULE III PRESSURE MEASUREMENT 9

Manometers, Bourdon gauge and Bellow gauge. Measurement of pressure and Vacuum. Use of Transducers.

MODULE IV FLOW, DENSITY AND LEVEL MEASUREMENTS 9

Variable head flow meters. Area flow meters. Positive displacement meters. Pressure Probes. Level measurements - Direct and Inertial types. Measurement of density and specific gravity. Instruments for weighing and feeding.

MODULE V MISCELLANEOUS MEASUREMENTS 9

Analysis of gas mixtures. Thermal conductivity, Viscosity and Electrical conductivity. Supporting instrumentation - Standard cells, Balancing circuits and Terminating devices. Principles of Telemetry. P and I diagrams.

COURSE OUTCOME

At the end of the course, students will be able to

CO1: Explain the basic principles of various measuring instruments and its static, dynamic response and errors in the measurements

CO2: Demonstrate the various instruments utilized to measure the temperature and calculate the temperature using thermometer, thermistor, radiation pyrometer.

CO3: Calculate the pressure using manometer and demonstrate the basic fundamentals of pressure measuring devices.

CO4: Demonstrate the fundamentals of variable head meter, area flow meter, direct, inertial type level meter and density measurement devices.

CO5: Select suitable measuring device for gas mixture analysis, thermal, electrical conductivity, viscosity and construct piping and instrumentation diagram.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Eckman, D.P, Automatic Process Control, Wiley Eastern, New Delhi, 2006.
2. Jain, R.K, Mechanical and Industrial Measurements, Twelfth Edition Khanna Publishers, New Delhi 2015.

REFERENCES:

1. Perry, R.H., Green, D.W., Perry's Chemical Engineer's Handbook, Eighth Edition, McGraw Hill

(ISE), 2007.

2. Considine, D.N., Process Instruments and Controls Handbook, Fifth Edition, McGraw Hill. New York, 1999.
3. Benedict, R.P, Fundamentals of temperature, Pressure and Flow measurements, Third Edition, John Wiley, New York. 1984.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3			1	1							1	
2	3	1			1	1							2	1
3	3	3	1		2	2							3	2
4	1	2	1		1	1							1	1
5	3	3	1	1	2	1							3	1
Avg.	2.4	2.4	1	1	1.4	1.2							2	1.25

1-low, 2-medium, 3-high

23CH314	CHEMICAL PROCESS INDUSTRIES	L	T	P	C
		3	0	0	3

MODULE I NITROGEN, PHOSPHOROUS AND SULPHUR BASED INDUSTRIES 11

Nitrogen, Ammonium nitrate, Ammonium sulphate and Urea. Phosphorus, Phosphoric acid, Ammonium phosphates, Sodium phosphates, Nitro phosphate & Phosphate esters. Mixed fertilizers (NPK Mixtures). Manufacture of Sulphur and Sulphuric acid. Materials for handling, storage and transportation.

MODULE II OIL AND ALLIED INDUSTRIES 7

Vegetable oil extraction methods, Refining of vegetable oils, Hydrogenation of Oils. Soaps and Candle, Detergents and Glycerine, Materials for handling, storage and transportation.

MODULE III CARBOHYDRATES AND FERMENTATION INDUSTRIES 9

Manufacture of Starch, Dextrin, Glucose and sucrose and manufacture of Ethyl alcohol, Acetic acid, Citric acid, Oxalic acid and Antibiotics (Penicillin). Materials for handling, storage and transportation.

MODULE IV PULP AND LEATHER INDUSTRIES 9

Production of Pulp, Conversion to paper, Production of Viscose, Cuprammonium rayons and Cellulose acetate, Production of Dimethyl sulphite and Dimethyl sulphoxide from wood liquor, Manufacture of leather from hides and skins. Manufacture of Glue and Gelatin, Materials for handling, storage and transportation.

MODULE V SURFACE COATING, CEMENT AND GLASS INDUSTRIES 9

Constituents of paints & varnishes and their functions. Paint mixing process. Manufacture of pigments such as White lead, Zinc oxide and Titanium dioxide. Cements: Introduction, types of cements, properties and applications. Manufacture of Portland cement. Beneficiation & Production of Hydrated lime. Raw materials for Glass Industries, Production of glass by tank furnace - shaping and forming of articles from glass.

COURSE OUTCOME

At the end of the course, students will be able to

CO1: Understand the basic concepts of unit operations and process concepts involved in it.

CO2: Identify the raw materials and deduce the chemical reactions for the product development.

CO3: Analyse the various steps of chemical processes and process instrumentation.

CO4: Design the flow sheets for manufacturing process with the contemporary innovations.

CO5: Evaluate the product efficiency, economics, handling process, storage and adapting to new technological advancements.

TOTAL : 45 PERIODS

TEXT BOOKS:

- Gopala Rao, M. & Marshall Sittig.: Dryden's Outlines of Chemical Technology, (3rd Ed.), Affiliated East-West Press, New Delhi, (2004).
- Austin, G.T.: Shreve's Chemical Process Industries, (5th Ed.), McGraw Hill (ISE), (1984).
- Shukla, S.D. Pandey, G.N.: A Text Book of Chemical Technology, Vol. I, Vikas, New Delhi, (1994)

REFERENCES:

- Venkateswaralu, D., Upadrashta, K.R. & Chandrasekaran, K.D. (Editors): CHEMTECH - I, S. Chand & Co., New Delhi, (1975).

2. CHEMTECH - II, Chemical Engineering Education Development Centre, I.I.T., Madras, (1977).
3. Kent, A.J. : Riegel's Handbook of Industrial Chemistry, Van Nostrand - Reinhold, New York, ninth Edition (1974).

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3			1	1							1	
2	3	1			1	1							2	1
3	3	3	1		2	2							3	2
4	1	2	1		1	1							1	1
5	3	3	1	1	2	1							3	1
Avg.	2.4	2.4	1	1	1.4	1.2							2	1.25

1-low, 2-medium, 3-high

23CH315	CHEMICAL PROCESS CALCULATIONS	L	T	P	C
		3	1	0	4

MODULE I CALCULATIONS ON GAS AND GAS MIXTURES 9

Basic Chemical Principles- Solid, Liquid and Gas, Calculations on solid, liquid and gas mixtures using Ideal gas laws. Mole fractions and partial pressures - Application of Dalton's and Amagat's law.

MODULE II HUMIDITY AND SATURATION 9

Calculations involving change in mass of gas mixture, Concept of Vapour pressure, Raoult's law and its applications, Calculation on Vapor-Liquid mixture, Concepts of gas-vapour mixture, Humidity and Saturation, relative and percentage saturation, Dew point - humid heat, Numerical examples using Humidity Charts.

MODULE III MATERIAL BALANCE -SYSTEM WITHOUT CHEMICAL REACTIONS 9

Material balance in systems without chemical reactions, Material balance in systems- Distillation, Evaporation, Mixing, Extraction (LLE & Leaching), Absorption, Drying and Crystallization with concept of solubility. Material Balance - Recycle, Bypass and Purge.

MODULE IV MATERIAL BALANCE-SYSTEM WITH CHEMICAL REACTIONS 9

Combustions Reaction, Concept of ToD, Excess air, Calculations on Orsat Analysis, Flue gas analysis, Calculations on conversion, yield. Concepts of tie elements, Material Balance system involving reactions with recycle, by-pass and purge.

MODULE V ENERGY BALANCE 9

Definition of Heat capacity and Specific heat, Heat capacity of gases as a function of temperature, Mean heat capacity, heat capacity of mixture of gases. Heat capacities of solids and liquids - Kopp's rule. Standard heat of reaction, formation and combustion, Hess's law of heat summation and its application to determine heat of reaction, heat of neutralization, integral heat of solution, heat of mixing. Effect of pressure and temperature on heat of reaction. Theoretical and actual flame temperature in combustion calculations.

COURSE OUTCOME

At the end of the course, students will be able to

CO1: Apply the principles of dimensional homogeneity to convert one form of unit to other equivalent forms in CGS, FPS. MKS and SI unit systems and apply fundamental gas laws to solve ideal gas problems.

CO2: Calculate the composition of a mixture in terms of mole fractions from a given composition expressed in terms of mass fractions or vice versa.

CO3: Compute the concentration, degree of saturation and dew point of vapour -gas mixture at the given temperature and pressure using humidity chart.

CO4: Formulate steady state material balance for the unit operations such as distillation, evaporation, mixing, extraction, drying and crystallization processes with recycle, by-pass and purge.

CO5: Practice the combined steady state material and Energy balance for simple processes like distillation, evaporation and combustion.

TUTORIAL:15 PERIODS

TOTAL : 60 PERIODS

TEXT BOOKS:

1. Bhatt, B.I. and Vora, S.M., Stoichiometry, Fifth Edition, Tata-McGraw Hill, New Delhi, 2013.
2. Narayanan. K.V. and Lakshmikutty.B., Stoichiometry and Process Calculations, Second Edition, Prentice- Hall of India, New Delhi, 2006.
3. Venkataramani.V, Anantharaman.N, Meera SheriffaBegum.K.M, Process Calculations, Second Edition, PHI Learning Private Limited, 2011.

REFERENCES:

1. David M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Eighth Edition, Prentice -Hall of India, New Delhi, 2012.
2. Richard.M.Felder, Ronald.W.Rousseau, Elementary Principles of Chemical Processes, Third Edition, John Wiley and sons, 2005
3. Hougen, O.A., Watson, R.M. and Ragatz, R.A., Chemical Process Principles - Part I, Second Edition, John Wiley (ISE), 1976

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3		2						2		2	2	
2	3													
3	3	3	3	3		2							3	
4	3	3	3	2		1							2	
5	3	3	3	2		1							2	
Avg.	3	3	3	2.25		1.33				2		2	2.25	

1-low, 2-medium, 3-high

23CH321	PHYSICAL AND ORGANIC CHEMISTRY LABORATORY	L	T	P	C
		0	0	3	1.5

List of Experiments in Physical Chemistry Lab:

1. Determination of Critical Solution Temperature for Phenol-Water system
2. Determination of Transition point of Salt Hydrate
3. Determination of Heat of Solution of Ammonium Chloride
4. Determination of effect of impurity on Critical Solution Temperature of Phenol-Water System.
5. Determination of Velocity Constant of Acid Hydrolysis of Methyl Acetate
6. Construction of Binodal Curve for Water, Nitrobenzene and Acetic acid system

List of Experiments in Organic chemistry Lab:

Qualitative analysis of Organic compounds

7. Identification of aliphatic/aromatic nature
8. Identification of Saturated/unsaturated type
9. Identification of the presence of special elements, Like Nitrogen, Sulphur, Halogens
10. Identification of various functional groups like Carbohydrates, amides, Aldehyde, Ketone, Carboxylic acids, phenols and amines

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able

CO1: estimate the composition of various constituents in the solid or liquid mixture with help of quantitative or qualitative analysis.

CO2: attain skills in analysing various samples and handling of instruments.

CO3: assess practical knowledge to carry out meaningful interpretation of data from analytical chemical measurements.

CO4: Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5: perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3											1		
2		3										1		1
3	3											1		
4												1		
5		3			2							1		
Avg.	3	3			2							1		1

1-low, 2-medium, 3-high

23CH322	ELECTRICAL DRIVES LABORATORY	L	T	P	C
		0	0	3	1.5

LIST OF EXPERIMENTS

1. Calibration of Ammeter, Voltmeter and Wattmeter
2. Calibration of Single-Phase Energy meter
3. Swinburne's Test
4. No load Speed Control of DC Shunt Motor
5. Open Circuit Characteristics of a separately excited DC generator
6. Critical speed of DC shunt generator
7. Load Test on DC shunt Motor
8. Load Test on DC shunt Generator
9. Open circuit and short circuit test on single phase Transformer
10. Predetermination of efficiency and regulation characteristics of single-phase transformer
11. Load test on single phase transformer
12. Load test on three phase squirrel cage induction motor
13. Load test on slip ring induction motor
14. Load test on single phase capacitor start induction motor
15. Load test on single phase Alternator
16. Study of capacitive transducers
17. Study of inductive transducers
18. Speed torque characteristics of single-phase Fan motor
19. Simple programs in ARM
20. Interfacing programs in ARM.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students will be able

CO1: measure the electrical quantities accurately and analyse the performance of DC and AC machines.

CO2: implement the proper speed control techniques to DC and AC motors with proper selection of power rating and corresponding drive system using power electronic controller for industry process applications.

CO3: assess practical knowledge to carry out meaningful interpretation of data from analytical electrical measurements.

CO4: Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5: perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3											1		
2		3										1		1
3	3											1		
4												1		
5		3			2							1		
Avg.	3	3			2							1		1

1-low, 2-medium, 3-high

	PROBABILITY AND STATISTICS	L	T	P	C
		3	1	0	4

MODULE I PROBABILITY AND RANDOM VARIABLE 9

Probability – The axioms of probability – Conditional probability – Baye’s theorem – Discrete and continuous random variable – Moments – Moment generating functions of Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions

MODULE II TWO – DIMENSIONAL RANDOM VARIABLES 9

Joint distributions (Discrete & Continuous) – Marginal and conditional distributions – Covariance – Correlation and linear regression.

MODULE III SAMPLING THEORY – I 9

Sampling distributions – Statistical hypothesis – Large samples - Testing of hypothesis about significance difference between proportions - difference between means and population mean - difference between sample means - difference between standard deviations.

MODULE IV SAMPLING THEORY – II 9

Small Samples – Student’s t-test- Testing of hypothesis about significance difference between sample mean and population mean – difference between two sample means – F-test – Testing of hypothesis for equality of variance – Chi-square test – Test for Goodness of fit – Independence of Attributes.

MODULE V DESIGN OF EXPERIMENT 9

Analysis of variance - One way and Two-way classifications – Completely randomized design – Randomized block design – Latin square design.

TUTORIAL:15 PERIODS

TOTAL:60 PERIODS

COURSE OUTCOME:

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

CO1: Assimilate ideas of basic concepts of probability and one dimensional random variable

CO2: Understand the concepts of two dimensional random variables with correlation and regression

CO3: Apply the concepts of testing of hypothesis for large samples which plays an important role in real life problems

CO4: Apply the concepts of testing of hypothesis for small samples which plays an important role in real life problems

CO5: Familiarize basic concepts of classifications of design of experiments which plays very important roles in the analysis of variance

TEXTBOOKS

1. E. Walpol, R. H. Mayers, S. L. Mayers and K. Ye, “Probability and Statistics for Engineers and Scientists”, 8th Edition, Pearson Education, (2007).
2. Sheldon M. Ross, “Introduction to Probability and Statistics for Engineers and Scientists”, 4th Edition, Academic Foundation, (2011).
3. T. Veerarajan, “Probability Statistics and Random Process”, Tata McGraw Hill Publishing Company, 2017.

REFERENCES

1. Douglas C. Montgomery, “Applied Statistics and Probability for Engineers,”5th Edition, , Wiley India, ISBN: 978-8-126-53719-8, (2012).

2. Spiegel, M. R., Schiller, J. and Srinivasan, R. A., "Probability & Statistics", 3rd Edition, Tata McGraw Hill, (2010).
3. Gupta.S.C., and Kapoor, V.K., "Fundamentals of Mathematical Statistics", 12th Edition, Sultan Chand and Sons, 2020.
4. Jay L. Devore, "Probability and statistics for Engineering and the Sciences", 9th Edition, Cengage Learning, 2020.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2		1								1		
2	3	2		1								1		
3	3	2		1								1		
4	3	2		1								1		
5	3	2		1								1		
Avg.	3	2		1								1		

1-low, 2-medium, 3-high

	MECHANICAL OPERATIONS	L	T	P	C
		3	0	0	3

MODULE I PROPERTIES OF PARTICULATE SOLID AND SIZE REDUCTION 9

Forces employed for size reduction of solids. Types of crushers, grinders and disintegrators for coarse, intermediate, fine and ultrafine grinding. Cutting machines. Size reduction operation - Power requirements, Laws of comminution. Open and closed-circuit grinding. Shape factor of particulate solids. Standard sieves and sieve scales. Differential and cumulative analysis - Specific surface determination - Calculation of particle size from sieve analysis data. Size distribution of fine particles. Industrial screening equipments. Screen effectiveness.

MODULE II STORAGE, TRANSPORTATION AND RECOVERY OF FINE PARTICLES 9

Storage of solids - Angle of repose and angle of internal friction. Pressures in bins - Janssen equation. Mechanical and pneumatic conveying equipments. Gas cleaning methods - Cyclone separators, Bag filters, Scrubbers and electrostatic precipitators. Magnetic separation. Dense Media Separation (DMS), Flotation process.

Module III MIXING AND AGITATION 9

Agitation equipment, classification and types of impellers- applications, power requirement in agitation. Scale up of agitator design. Types of Mixers and mixing equipments for liquids, pastes, rubber and plastic materials and for dry powders. Criteria for mixing of Solids - Mixing Index.

Module IV SIZE SEPARATION BY SETTLING AND SEDIMENTATION METHODS 9

Drag on spherical and non-spherical particles, Terminal settling velocity under laminar and turbulent conditions (Stokes' law and Newton's law). Size separation by settling methods - Free settling and Hindered settling. Equipments - Settling chambers, classifiers, jigging and Tabling. Theory of Sedimentation. Types of Thickeners - Batch and Continuous. Applications of batch sedimentation tests for design of continuous thickeners.

MODULE V FILTRATION AND CENTRIFUGAL SEPARATION 9

Principles and Theory of filtration and washing. Filter media and Filter aids. Compressibility of filter cakes. Batch and continuous filtration equipments. Principles of centrifugal filtration- industrial centrifuges, Membrane filtration

TOTAL:45 PERIODS

COURSE OUTCOME:

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

CO1: Select the appropriate size reduction equipment and analyze the particle size distribution in the feed and product.

CO2: Identify suitable storage, transportation and recovery methods for various types of solids.

CO3: Design the different type of agitators and mixers used in chemical industries and compare the

same.

CO4: Apply the basic principles of settling and sedimentation for the separation of different type of solid particles.

CO5: Estimate cake, filter medium resistance and filtration, washing time

TEXTBOOKS

1. McCabe. W. L., Smith. J. C., Harriot. P., Unit Operations of Chemical Engineering, Seventh Edition, McGraw-Hill, New York, 2005.
2. Badger. W.L., Banchero. J.T., Introduction to Chemical Engineering, McGraw Hill (ISE), 1997.

REFERENCES

1. Perry. R. H., Green. D. W., Perry's Chemical Engineer's Handbook, Eighth Edition, McGraw-Hill, New York, 2007.
2. Narayanan. C.M., Bhattacharyya. B.C., Mechanical Operation for Chemical Engineers (Incorporating Computer Aided Analysis), Khanna Publisher, Third Edition, 2005.
3. Rhodes, M. J., Introduction to Particle Technology, 2nd edition, John Wiley, Chichester ; New York, 2008.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2				1							3	
2	2	3	2			2							2	
3	3	1				1							1	
4	2	2	2			1							3	1
5	1	2	2			1							2	1
Avg.	2.2	2	2			1.2							2.2	1

1-low, 2-medium, 3-high

	HEAT TRANSFER	L	T	P	C
		3	0	0	3

MODULE I CONDUCTION

12

Importance of heat transfer in Chemical Engineering operations - Modes of heat transfer - Fourier's law of heat conduction - one dimensional steady state heat conduction equation for flat plate, hollow cylinder and sphere - Heat conduction through a series of resistances - effect of temperature on thermal conductivity; Combined Conduction- Convection Heat transfer, Critical radius of insulation, Heat transfer in extended surfaces, Unsteady state heat transfer.

MODULE II CONVECTION

9

Concepts of heat transfer by convection - Natural and forced convection, Dimensional analysis in heat transfer, Correlations for the calculation of heat transfer coefficients, heat transfer coefficient for flow through a pipe, flow through a non-circular conduit, Concepts of thermal boundary layer, Von Karman Integral & energy Equation for flow past flat plate, Heat transfer by natural convection.

MODULE III RADIATION

6

Radiation heat transfer - Emissive power, Black body radiation, Emissivity, Stefan - Boltzmann law, Planck's law Kirchoff's Law and radiation between surfaces.

MODULE IV CONDENSATION AND BOILING

7

Heat transfer to fluids with phase change - heat transfer from condensing vapours, drop wise and film wise condensation, Nusselt equation for vertical and horizontal tubes, condensation of superheated vapours, effect of non-condensable gases on rate of condensation. Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling.

MODULE V HEAT EXCHANGERS AND EVAPORATORS

11

Parallel and counter flow heat exchangers - Log mean temperature difference - Single pass and multipass heat exchangers; plate heat exchangers; use of correction factor charts; heat exchangers effectiveness; number of transfer unit - Chart for different configurations - Fouling factors. Theory of evaporation - single effect and multiple effect evaporation - Types of Evaporators - Design calculation for single and multiple effect evaporation.

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1: Solve one-dimensional steady state heat conduction problems for the rectangular, cylindrical and spherical Co-ordinate systems.

CO2: Analyze the convection heat-transfer problems for laminar and turbulent flows in internal and external configurations by understanding the basics of the boundary layer theory.

CO3: Estimate heat exchanger design parameters like heat transfer area and overall heat transfer coefficient using LMTD and effectiveness - NTU method.

CO4: Estimate the heat transfer co-efficient for phase change operations using empirical correlations.

CO5: Apply fundamental laws of radiation to determine the heat transfer rate between surfaces and apply the principles of evaporation to precisely calculate the energy requirement for single and multiple effect evaporators.

TEXTBOOKS

1. Binay K. Dutta., Heat Transfer: Principles and Applications, Fifth Printing, Prentice Hall of India Private Limited, 2006.
2. Holman, J. P., Heat Transfer, Tenth Edition, McGraw Hill, USA, 2010.
3. Ghajar A.J., Cengel Y.A., Heat and Mass Transfer: A Practical Approach, 5th edition., McGraw-Hill, USA, 2014.

REFERENCES

1. McCabe W.L., Smith J.C., Harriott. P., Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill International Student Edition, 2005.
2. Frank Kreith, Raj M Manglik, Principles of Heat Transfer, 8th edition., Cengage Learning, USA, 2016.
3. Kern, D.Q., Process Heat Transfer, McGraw-Hill, 1999.
4. Coulson, J.M. and Richardson, J.F., Chemical Engineering, Vol-1, Fourth Edition, Asian Books Private Limited, India, 1998.
5. Christie John Geankoplis, A.Allen Hersel and Daniel H.Leppek, ' Transport Processes and Separation Process Principles' Prentice Hall India. Inc, Fifth Edition, 2017.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	1	2							1	2		3	
2	3	3	2	2						1	1		3	
3	3	3	3	1						1	2		3	
4	3	3	3	1						1	2		3	
5	3	3	3	1						1	2		3	
Avg.	3	2.6	2.6	1.0						1	1.8		3	

1-low, 2-medium, 3-high

	MASS TRANSFER-I	L	T	P	C
		3	0	0	3

MODULE I DIFFUSION IN FLUIDS

9

Molecular diffusion and eddy diffusion. Steady state molecular diffusion in fluids at rest and in laminar flow. Molecular diffusion in gases, Steady state diffusion of gas A through non-diffusing gas B, steady state equimolar counter diffusion. Steady state diffusion in multicomponent mixtures - Effective diffusivity, Molecular diffusion in liquids. Diffusivity prediction in gases and liquids.

MODULE II INTERPHASE MASS TRANSFER

9

Mass transfer coefficients, F and K type mass transfer coefficients, Relation between mass transfer coefficients, Film theory, Penetration theory, Danckwerts surface renewal theory. Two film theory. Wetted wall towers. Equilibrium stage modelling: equilibrium curve and operating line. Analogy between momentum, heat and mass transfer.

MODULE III HUMIDIFICATION

9

Humidification operation, Properties of air-water vapour system, Psychrometric chart, Methods of humidification and dehumidification, Lewis relation, Theory and principles of cooling towers, Types of cooling towers. Design of cooling tower.

MODULE IV DRYING

9

Theory and mechanism of drying. Batch drying test, drying rate curve, time of drying. Mechanism of moisture movement, drying rate during constant rate period, unsaturated surface drying, drying with internal diffusion. Methods of drying- Classification of dryers, Continuous drying operations and equipment. Application of dryers in process industries.

MODULE V CRYSTALLIZATION

9

Theory of crystallization, methods of supersaturation, nucleation and crystal growth, Batch and continuous crystallizers. Performance and applications of industrial crystallizers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Estimate the mass transfer flux for molecular diffusion in fluids and measurement of diffusivity.

CO2: Analyze mass transfer theories to predict the mass transfer coefficients, develop the analogy between momentum, heat and mass transfer.

CO3: Determine the properties of air-water system using psychrometric chart and review the operational features of cooling towers.

CO4: Analyse the applications of dryers and calculate the time of drying from rate of drying curve.

CO5: Compute the yield of crystals and select the crystallizer by revising the working features.

TEXTBOOKS

1. Treybal R.E., Mass Transfer Operations, Third Edition, McGraw Education (India) Private Limited, 1980.
2. Binay.K.Dutta., Principles of Mass Transfer and Separation Process, PHI Learning Pvt.Ltd, 2013.
3. N.Anantharaman, K.M.Meera Sheriffa Begum, Mass Transfer :Theory and Practice, Prentice Hall India Pvt Ltd, 2017.

REFERENCES

1. K.V.Narayanan, B.Lakshmi kutty, Mass Transfer: Theory and Applications, CBS Publishers and Distributors, 2017.
2. McCabe W. L., Smith J.C., and Harriott P., Unit Operations of chemical Engineering, seventh Edition, McGraw Hill Education (India) Private Limited, 2014.
3. Coulson J.M., Richardson J.F., Backhurst J.R Harker J.M., Coulson and Richardson's., Chemical Engineering, Vol II, 6th Edition, Butter Worth Heinemann, Oxford, 2002.
4. Alan S. Foust, Leonard A Wenzel, Curlis W.Clump, Louis Maus, L.Bryce Andersen., Principles of Unit operations, second ed, John Wiley and Sons, 2008.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3											1	
2	3	1											2	1
3	3	3	1										3	2
4	1	2	1										1	1
5	3	3	1	1									3	1
Avg.	2.4	2.4	1	1									2.0	1.0

1-low, 2-medium, 3-high

	CHEMICAL ENGINEERING THERMODYNAMICS	L	T	P	C
		3	0	0	3

MODULE I BASIC CONCEPTS AND LAWS OF THERMODYNAMICS 9

Preliminary Concepts - The language of Thermodynamics - Measured Thermodynamic Properties - The first law of thermodynamics for closed and open systems -Reversible and Irreversible Process - Thermochemical Data for U and H -PVT behaviour of pure substances - Entropy and The second law of thermodynamics, The second law of thermodynamics for closed and open systems, Calculation of entropy for ideal gases.

MODULE II EQUATION OF STATE AND THERMODYNAMICS PROPERTY RELATIONSHIP 9

Intermolecular forces-Principles of corresponding states - Equation state generalized compressibility charts - Thermodynamic property relations - calculation of change in entropy, internal energy and enthalpy - Departure functions.

MODULE III PHASE EQUILIBRIA - PROBLEM FORMATION AND FUGACITY 9

Introduction - Pure Species Phase Equilibrium- - Thermodynamics of Mixtures -Multicomponent Phase Equilibria - The Fugacity - Fugacity in the Vapor Phase - Fugacity in the Liquid Phase.

MODULE IV PHASE EQUILIBRIA- PHASE DIAGRAMS 9

Vapor Liquid Equilibrium- Ideal Gas and Ideal Solution- Non-ideal Solution - Azeotropes - Fitting Activity Coefficient Models with VLE data – Solubility of Gases in Liquids.

MODULE V CHEMICAL REACTION EQUILIBRIA 9

Thermodynamics and Kinetics - Chemical Reaction and Gibbs Energy - Equilibrium for a Single Reaction - Calculation of K From Thermochemical Data - Relationship Between the Equilibrium Constant and the Concentrations of Reacting Species.

TOTAL:45 PERIODS

COURSE OUTCOME:

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

CO1: Apply mass and energy balances to closed and open systems and predict the feasibility of process

CO2: Predict the thermodynamic properties of fluids.

CO3: Formulate phase equilibria problem and explain the concepts of fugacity.

CO4: Construct the phase diagrams for different systems.

CO5: Examine the chemical reaction equilibria problem

TEXTBOOKS

1. Koretsky, Milo D. Engineering and chemical thermodynamics. John Wiley & Sons, 2012.
2. J.M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th edition, McGraw-Hill International Edition,2005.
3. Rao, Y. V. C. Chemical engineering thermodynamics. Universities Press, 1997.

REFERENCES

1. Narayanan, K. V. "Chemical Engineering Thermodynamics." Prentice Hall India Learning Private Limited; 2nd Revised edition edition (2013).
2. M J Moran, H N Shapiro, D D Boettner and M B Bailey, Principles of Engineering Thermodynamics, 8th Edition, Willey.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2	2	1	2	1					2	3	
2	3	1	1	2	3	2	1					2	3	
3	3	1	1	2	1	2	1					2	3	
4	3	3	3	3	3	3	1					3	3	
5	3	3	3	3	3	3	1					3	3	
Avg.	3	2.2	1.0	2.4	2.2	2.4	1					2.4	3	

1-low, 2-medium, 3-high

	INSTRUMENTAL METHODS OF ANALYSIS	L	T	P	C
		3	0	0	3

MODULE I UV-VISIBLE SPECTROSCOPY AND NMR SPECTROSCOPY 9

Electromagnetic radiation - Characteristics - Wave length, wave number, frequency, energy. Lamberts and Beer-Lambert's laws - Theory of electronic spectroscopy - Chromophores - Auxochrome - Types of absorption bands - Absorption and intensity shifts -Instrumentation -Applications. NMR - Theory - Chemical shift – Factors influencing chemical shift – Spin-Spin coupling -Instrumentation.

MODULE II IR SPECTROSCOPY AND MASS SPECTROSCOPY 9

Theory of IR spectroscopy, Various molecular vibrations - stretching, bending and its types -various ranges of IR (Near, Mid, Finger print and Far). Fundamental Vibrational frequency & overtones - Number of vibrational modes for diatomic and triatomic molecules (both linear and nonlinear) - Instrumentation of IR spectroscopy - Applications. Mass Spectroscopy basic principles - Theory - Nitrogen rule - Advantages and disadvantages of mass spectra - McLafferty rearrangement - Applications.

MODULE III PRINCIPLES OF GRAVIMETRIC ANALYSIS 9

Methods of obtaining the precipitate - Conditions for precipitation - Choice of precipitants - Advantages of using organic precipitants - Disadvantages - Types of organic precipitants - Specific and selective precipitants - Sequestering agents. Theories of precipitation - Co-precipitation - Post-precipitation. Effects of digestion - General rules for precipitation - Precipitation from homogeneous medium - Washing of precipitates - Drying of precipitates - Types, care and use of crucibles.

MODULE IV SEPARATION METHODS 9

Principles of solvent extraction - Extraction techniques (Soxhlet extractor) - Analytical applications. Chromatography - Theory - Classification - Principle, Instrumentation and Applications of thin layer, column, paper, gas and high-performance liquid chromatography.

MODULE V THERMAL METHODS AND SURFACE CHARACTERIZATIONS 9

Principles of thermogravimetric analysis (TGA) - Instrumentation - Factors influencing the thermogram - Applications of TGA. Differential thermal analysis (DTA) - Theory - Instrumentation - Thermal analysis of calcium oxalate monohydrate and calcium acetate monohydrate - Applications of DTA. Surface area determination by BET method - Particle size determination by light scattering method- Scanning Electron Microscopy (principles & theory only) and EDAX analysis.

TOTAL:45 PERIODS

COURSE OUTCOME:

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

CO1: Understand the basic principles of spectroscopy and identify the structure of the organic compound from the spectroscopic studies.

CO2: Predict the functional groups and mass of the organic & inorganic compounds from IR & mass spectroscopy.

CO3: Determine the thermal stability from TGA, exothermic & endothermic reactions of the sample from DTA and surface analysis using various advanced techniques.

CO4: Determine the concentration of the solutes in a mixture using solvent extraction and chromatographic methods.

CO5: Understand about the types of precipitants, their advantages and disadvantages; theories of precipitation; general rules for precipitation and role of crucibles.

TEXTBOOKS

1. Sharma B.K., Instrumental methods of chemical analysis, Eighteenth Edition, GOEL publishing House. 2002.
2. Ewing G.W., Instrumental methods of Chemical Analysis, Fifth Edition, McGraw Hill, New York, 1992.
3. Chatwal, Anand, Instrumental Methods of Chemical Analysis, Seventh Edition, Himalaya Publishing House. 2005.

REFERENCES

1. Vogel's textbook of Quantitative Chemical Analysis, Fifth Edition. ELBS Publications, 2007.
2. Skoog D.A. - Principles of Instrumental Analysis, Sixth Edition, Saunders College Publication, 2007.
3. Williard H.H., Meritt L.C and Dean J.H., - Instrumental Methods of Analysis, Sixth Edition, 1990.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2		2	2					1			2	1
2		2		2	2					1			2	1
3		2		2	2					1			2	1
4		2		2	2					1			2	1
5	3	2		2	2					1			2	1
Avg.	2.5	2		2	2					1			2	1

1-low, 2-medium, 3-high

FLUID MECHANICS LABORATORY											L	T	P	C
											0	0	3	1.5

LIST OF EXPERIMENTS

1. Study on Reynolds apparatus
2. Verification of Bernoulli's Theorem
3. Determination of friction factor and expansion loss coefficient in a pipe
4. Determination of relationship between friction loss and Reynolds number in an annular pipes
5. Determination of discharge coefficient for globe Valve and loss coefficient for 90° bend in a pipe
6. Determination of discharge coefficient for various notch apparatus
7. Determination of discharge / loss coefficient in venturi and orifice Meter
8. Pressure drop studies on helical coil and spiral coil
9. Pressure drop studies on fluidized bed
10. Pressure drop studies on packed bed
11. Performance studies on centrifugal pump
12. Performance studies on reciprocating pump

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 : Apply the concepts of fluid mechanics in fluid flow meters to estimate its performance characteristics.

CO2 : Calculate the friction losses and loss coefficient of pipe fittings in pipe network.

CO3 : Operate fluid transportation equipment and compare the results of analytical models to the actual behaviour of real fluid flows and draw performance curves.

CO4 : Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5 : Perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	3	2	2	3					2	1	3	
2	2	3	1	1	1	1					2	1	3	
3	1	1	1	2	3	2				2	1	2	3	
4	3	2	2	2	1	2	1	1	3		2	3	2	3
5			2				2	3	3		1	2	1	2
Avg.	2.25	2	1.8	1.75	1.75	2	1.5	2	3	2	1.6	1.8	2.4	2.5

1-low, 2-medium, 3-high

	TECHNICAL AND INSTRUMENTAL ANALYSIS LABORATORY	L	T	P	C
		0	0	3	1.5

List of Experiments

1. Analysis of cement
2. Estimation of available chlorine in bleaching powder
3. Estimation of nitrogen in inorganic fertilizer
4. Determination of total fatty matter in soap
5. Determination of acid value of an oil
6. Determination of saponification value of an oil
7. Evaluation of purity in calcium carbonate
8. Estimation of calcium oxide in quick lime
9. Estimation of magnesium silicate in talcum powder
10. Estimation of Glucose
11. Estimation of manganese dioxide in Pyrolusite
12. Estimation of loss on ignition, silica, iron and aluminum oxides in Bauxite
13. Estimation of tin, lead, copper and zinc in Brass
14. Determination of biochemical oxygen demand (BOD)
15. Determination of acidity or alkalinity of a solution using pH meter
16. Determination of concentration of unknown solution by UV-Vis Spectrophotometer
17. Determination of concentration of unknown solution by Nephelometer
18. Determination of sodium / potassium using Flame Photometer

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 :Analyse the samples by both quantitative and qualitative methods.

CO2 : Attain skills in analysing various samples and handling of instruments.

CO3 : Assess practical knowledge to carry out meaningful interpretation of data from analytical chemical measurements.

CO4 : Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5 : Perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	1		1		1							1	
2	2	2		1		1								
3	2		1	1									1	
4								1	3	3	2			1
5				1				1	2	1	2			1
Avg.	2	1.5	1	1		1		1	2.5	2	2		1	1

1-low, 2-medium, 3-high

	NUMERICAL METHODS IN CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I NUMERICAL METHODS FOR SINGLE ALGEBRAIC EQUATIONS 9

Introduction, Root finding methods for solution on non-linear algebraic equations: Bisection, Newton-Raphson and Secant methods, System of Non-linear Equations. Chemical Engineering problems involving solution of non-linear equations.

MODULE II NUMERICAL METHODS FOR SIMULTANEOUS ALGEBRAIC EQUATIONS 9

Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Seidel method, Chemical Engineering problems involving solution of linear algebraic equations.

MODULE III INTERPOLATION AND NUMERICAL INTEGRATION 9

Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression, Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, Chemical engineering problems involving numerical differentiation and integration.

MODULE IV NUMERICAL METHODS FOR ODES 9

Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs.

MODULE V NUMERICAL METHODS FOR PDES 9

Introduction to Partial Differential Equations: Characterization of PDEs, Laplace equation, Heat conduction/ diffusion equations, explicit, implicit, Crank-Nicholson method.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

CO1 :To solve systems of algebraic equation using various numerical schemes and to develop programming code using MATLAB and EXCEL.

CO2 :To Solve nonlinear algebraic equation using open and bracketing type numerical methods

CO3 :To practice numerical integration using trapezoidal, Simpsons techniques for chemical problems

CO4 :To solve single ODE and Simultaneous ODEs using various numerical schemes.

CO5 :To formulate and solve PDEs for real time chemical Engineering Problems.

TEXT BOOKS

- 1.Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.
- 2.Pradeep Ahuja, "Intrduction to Numerical Methods in Chemical Engineering", 2nd Edition, PHI Learning Private Limited, 2019.
- 3.Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.

REFERENCES

- 1.S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.
- 2.R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.

3. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.

4. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3			1	1							1	
2	3	1			1	1							2	1
3	3	3	1		2	2							3	2
4	1	2	1		1	1							1	1
5	3	3	1	1	2	1							3	1
Avg.	2.4	2.4	1	1	1.4	1.2							2	1.25

1-low, 2-medium, 3-high

	MASS TRANSFER-II	L	T	P	C
		3	0	0	3

MODULE I ABSORPTION

9

Equipment for gas-liquid operations: Packed towers and plate columns. Equilibrium solubility of gases in liquids. Choice of solvents for absorption. Single component absorption. Operating and equilibrium lines for absorber and stripper. Minimum liquid - gas ratio for absorption. Counter current multistage operation, absorption of one component in packed tower, overall coefficients, Concept of HETP, NTU and HTU - graphical and analytical methods.

MODULE II DISTILLATION

9

Vapour - Liquid - Equilibrium (VLE). Ideal solutions and Raoult's law, non-ideal solutions and Henry's law, relative volatility, azeotropes - minimum and maximum boiling. Flash distillation, differential distillation - Rayleigh's equation, steam distillation.

MODULE III CONTINUOUS FRACTIONATION

9

Determination of number of theoretical plates using McCabe - Thiele and Ponchon - Savarit methods. Location of feed plate. Reflux ratio - minimum reflux, optimum reflux, total reflux. Plate efficiency - overall and Murphree efficiencies. Azeotropic and extractive distillations.

MODULE IV EXTRACTION

9

Application of liquid-liquid extraction, Liquid-liquid equilibria, general features of triangular co-ordinate systems, Choice of solvent for extraction, Number of stages, Minimum solvent rate, Solid-liquid extraction, Typical industrial applications, Factors affecting leaching - agitation, particle size, temperature and solvent properties, leaching by percolation moving bed leaching and shank's system, Operation of stage wise and differential contact extractors.

MODULE V ADSORPTION AND ION EXCHANGE

9

Types of adsorptions, factors influencing adsorption, nature of adsorbents, Industrial adsorbents, Adsorption isotherms, Adsorption operation - single stage and multistage crosscurrent and countercurrent operations, Determination of number of stages. Recovery of solvent vapors, Principles of ion exchange - techniques and applications - equilibria, rate of ion exchange.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Compute the height of packing or number of plates required for the given separation by graphical and analytical method for absorption.

CO2: Analyze flash, differential and steam distillation methods and calculate the vapour-liquid equilibria.

CO3: Determine the number of ideal plates using Ponchon-savarit and McCabe-thiele method and categorize azeotropic and extractive distillation

CO4: Determine the number of stages and recovery efficiency for solid-liquid and liquid-liquid extraction processes.

CO5: Calculate the quantity of adsorbent required for stage-wise operations and illustrate the types of

adsorption, adsorption isotherms and ion-exchange process.

TEXT BOOKS

1. Treybal R.E., Mass Transfer Operations, Third Edition, McGraw Education (India) Private Limited, 1980.
2. Binay.K.Dutta., Principles of Mass Transfer and Separation Process, PHI Learning Pvt.Ltd, 2013.
3. N.Anantharaman, K.M.Meera Sheriffa Begum, Mass Transfer :Theory and Practice, Prentice Hall India Pvt Ltd, 2017.

REFERENCES

1. K.V.Narayanan, B.Lakshmi kutty, Mass Transfer: Theory and Applications, CBS Publishers and Distributors, 2017.
2. McCabe W. L., Smith J.C., and Harriott P., Unit Operations of chemical Engineering, seventh Edition, McGraw Hill Education (India) Private Limited, 2014.
3. Coulson J.M., Richardson J.F., Backhurst J.R Harker J.M., Coulson and Richardson's., Chemical Engineering, Vol II, 6th Edition, Butter Worth Heinemann, Oxford, 2002.
4. Alan S. Foust, Leonard A Wenzel, Curlis W.Clump, Louis Maus, L.Bryce Andersen., Principles of Unit operations, second ed, John Wiley and Sons, 2008.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2		2	1							3	1
2	3	3	2			1	1						1	
3	2	1	1			2							2	
4	1	2	1			1							3	3
5	1	2	2			1							1	1
Avg.	2	2.2	1.6		2	1.2	1						2	1.67

1-low, 2-medium, 3-high

	CHEMICAL REACTION ENGINEERING-I	L	T	P	C
		3	0	0	3

MODULE I CHEMICAL KINETICS

9

Classification of reactions, Types of rate expressions, Elementary and Non elementary reactions, Types of intermediates and testing a mechanism in nonelementary reactions, Temperature dependency of the rate constant based on Arrhenius, collision and Transition State Theories.

MODULE II DATA ANALYSIS AND INTERPRETATION

9

Differential and integral Methods of analysis of rate data, Interpretation of rate data in constant and variable volume systems, Kinetics of irreversible, Parallel and Series reactions in constant volume batch reactor.

MODULE III DESIGN OF IDEAL REACTORS

9

Development of design expressions for Batch, Plug flow and Continuous Stirred Tank reactors. Comparison, advantages and limitations. Concept of space time and velocity. Size comparison of single reactors. Plug flow reactors in series and parallel, Mixed Flow Reactors of equal and different sizes in series. Reactors of different types in series. Qualitative and quantitative treatment of parallel, series reactions.

MODULE IV TEMPERATURE AND PRESSURE EFFECTS

9

Single reactions - Heats of Reaction from Thermodynamics, Equilibrium Constants from Thermodynamics, General Graphical Design Procedure, Optimum Temperature Progression, Adiabatic and non-adiabatic operations, Multiple reactions - Product Distribution and Temperature.

MODULE V NON-IDEAL FLOW

9

Residence time distribution Function. Relationship among E, F and C curves. Moments of RTD. Models for non-ideal flow - Segregation, Tanks in series and Dispersion models.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

CO1: Classify reactions, analyze rate expressions, differentiate elementary and non-elementary reactions, apply temperature-dependent rate theories.

CO2: Use differential and integral methods to analyze rate data in constant and variable volume systems, interpret kinetics in batch reactors.

CO3: Develop design expressions for batch, plug flow, and CSTRs, compare their advantages, analyse performance through space time and velocity concepts.

CO4: Evaluate temperature and pressure effects on reactions, determine equilibrium constants, optimize reactor conditions.

CO5: Analyze RTD functions, apply segregation and dispersion models to non-ideal flow scenarios.

TEXT BOOKS

1. Levenspiel O "Chemical Reaction Engineering"(Third Edition) Wiley Eastern, New Delhi,(2000)
2. Fogler H.S. " Essentials of Chemical reaction Engineering" PHI Ltd,2010

3.KA Gavhane, Chemical Reaction Engineering-I, Nirali Prakashan Publishers, 2016.

REFERENCES

1.Smith J.M., "Chemical Engineering Kinetics"(Third Edition), McGraw Hill (ISE)(1981).

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	2	2	1	2	1					2	3	3
2	3	3	2	3	2	2	1					2	3	3
3	3	3	3	2	2	3	1					3	3	3
4	3	3	3	2	2	3	1					2	3	3
5	3	3	3	3	2	3	1					3	3	3
Avg.	3	2.8	2.6	2.4	1.8	2.6	1					2.4	3	3

1-low, 2-medium, 3-high

	CHEMICAL PROCESS SAFETY	L	T	P	C
		3	0	0	3

MODULE I OVERVIEW OF PROCESS SAFETY

9

Introduction to safety: Concept and importance of industrial safety-Bhopal disaster. Safety in site selection and lay out, Flares and rupture discs, work permit system, confined space safety practices, Hazards classification - GHS system, Accident loss and Statistics.

MODULE II TOXICOLOGICAL STUDIES

9

Toxicology, Dose-response relationship, Hodge-sterner table, Source models-basic, pool boiling, Threshold Limit Value - classification and significance, NFPA diamond, Industrial hygiene.

MODULE III FIRE AND EXPLOSION

9

Fire hazards, Fire pyramid, Types of fires, Types of fire extinguishers, Sprinklers, Explosion-classification, Firefighting techniques, Inerting.

MODULE IV TEMPERATURE AND REACTION HAZARDS

9

Extreme temperature hazards - hot and cold, Thermal burns, Reactive chemical hazards-characterization using calorimeters, Thermal runaway - causes, adiabatic temperature rise, onset temperature, phi factor.

MODULE V RISK ANALYSIS

9

Hazard identification- Process hazard checklists, Hazard survey, HAZOP, safety review; fault tree analysis, FMEA (failure mode and effect analysis), Layer of Protection Analysis, Bow-tie analysis, domino effect.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 : judge the importance of safety in chemical process plants

CO2 : evaluate the degree of toxicity

CO3 : select the extinguishing methods for fire and explosion hazards

CO4 : assess temperature hazards and reaction safety

CO5 : analyse risk using qualitative and semi-quantitative methods

TEXT BOOKS

1.Crowl, Daniel A. and Louvar, Joseph F., Chemical process safety, Fundamentals with applications, 2nd Ed., Prentice Hall, 2002

2.Tweeddale,Mark, Managing risk and reliability of process plants, Gulf Professional Publishing, 2003

3.Sam Mannan, Lees' Process Safety Essentials: Hazard identification, Assessment and Control, Butterworth Hienemann publishers, 2014.

REFERENCES

1.Kletz, Trevor, Still going wrong, Case histories of process plant disasters and how they could have been avoided, Gulf Professional Publishing, 2003.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	1	1	2	3	2	1	2	3	3	3	3	3
2	3	2	1	-	-	-	-	-	-	-	-	-	-	2
3	3	-	-	-	-	-	3	-	1	-	-	-	-	-
4	3	3	2	3	-	2	-	-	-	-	-	-	3	-
5	3	3	3	3	3	-	-	-	2	2	2	-	1	1
Avg.	3	2.8	1.8	2.3	2.5	2.5	2.5	1	1.7	2.5	2.5	3	2.3	2

1-low, 2-medium, 3-high

HEAT TRANSFER LABORATORY											L	T	P	C
											0	0	3	1.5

List of Experiments

1. Determination of heat transfer coefficients by Natural Convection
2. Heat transfer in agitated vessel (steady state)
3. Heat transfer studies in fluidized bed dryer
4. Heat transfer studies in packed bed
5. Studies in Cross flow plate fin Heat Exchanger
6. Studies in Plate type Heat Exchanger
7. Studies in on Nucleate Boiling
8. Studies in Shell and Tube Heat exchanger
9. Studies in Stefan Boltzmann apparatus
10. Studies in Film wise and Drop wise Condensation

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 : To collect quality raw data from any heat transfer operation and to compare observed with predicted performance.

CO2 : To apply the concepts of heat transfer, fluid dynamics and thermodynamics to the design and operation of heat transfer experiments.

CO3 : To determine the heat transfer co-efficient and effectiveness of heat exchangers from experimentally observed data.

CO4 : Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5 : Perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	1	1	2	3	2	1	2	3	3	3	3	3
2	3	2	1											2
3									1					
4	3	3	2	3		2	3						3	
5	3	3		3	3				2	2	2		1	1
Avg.	3	2.75	1.33	2.33	2.5	2.5	2.5	1	1.67	2.5	2.5	3	2.33	2

1-low, 2-medium, 3-high

MECHANICAL OPERATIONS LABORATORY											L	T	P	C
											0	0	3	1.5

List of Experiments

1. Determination of Critical Speed and Reduction Ratio of Ball Mill
2. Performance Studies on Jaw Crusher
3. Estimation of Separation Efficiency of Froth Floatation Cell
4. Determination of Specific Cake and Filter Medium Resistance of slurry using Plate and Frame Filter Press
5. Performance Studies on Roll Crusher
6. Estimation of area of Thickener for a Batch Sedimentation Unit
7. Determination of Effectiveness of Screen
8. Determination of Specific Cake Resistance of Slurry and Compressibility Factor of Leaf Filter under Constant Pressure Filtration
9. Estimation of Separation Efficiency of Cyclone Separator
10. Performance Studies on Hammer Mill
11. Determination of Specific Cake Resistance of Slurries Using a Continuous Rotary Vacuum drum filter press
12. Estimation of separation efficiency of Air Classifier
13. Study the Wall Effect on the Terminal Settling Velocity of a Sphere
14. Performance studies on mixing apparatus
15. Performance studies on solid transportation equipment

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 : Apply the concepts of mechanical operations in physical separation processes.

CO2 : Perform the sieve analysis using various size reduction equipment's.

CO3 : Operate and estimate the performance characteristic parameters for solid fluid and solid-solid separation equipment's.

CO4 : Conduct experiments to solve complex engineering problems effectively as al or team work.

CO5 : Perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	1	1	2	3					2	1	3	
2	2	3	1	2	1	2					2	1	3	
3	3	2	2	2	2	2	1		2	2	1	2	3	
4	3	2	2	2	1	2	1	1	3		2	3	2	3
5			2				2	3	3		1	2	1	2
Avg.	2.75	2.25	1.6	1.75	1.5	2.25	1.33	2	2.67	2	1.6	1.8	2.4	2.5

1-low, 2-medium, 3-high

	INTERNSHIP	L	T	P	C
		0	0	2	1

- The student is required to undergo 'internship' in a chemical industry of repute / research laboratory / higher learning institution for a period of 2 weeks during 4th semester vacation. The internship carries 1credit.
- The main purpose of internship is to enhance the general professional outlook and capability of the student to advance his chances of improving the career opportunities.
- The student should get prior approval from the Head of the Department before undertaking the internship and submit a detailed report (which is duly signed by the officials in the respective industry of repute / research laboratory / higher learning institution) after completing the internship.
- A committee comprising of two/Three faculty members will assess the internship for 100 marks, by evaluating the internship report and the oral presentation by a student

COURSE OUTCOMES:

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

CO1 : Apply the concepts of basic concepts in chemical engineering for relevant situation

CO2 : Develop technical report based on practical evidences.

CO3 : Prepare presentations and present ideas Infront of the panel members

CO4 : Conduct experiments to solve complex engineering problems effectively as al or team work.

CO5 : Perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	1	0	0	0	0	0	0	0	2	2
2	3	3	3	2	0	0	0	1	0	0	0	0	2	2
3	3	3	3	2	0	2	0	0	1	0	0	0	2	2
4	3	3	3	2	0	0	0	0	0	0	0	0	2	2
5	3	3	3	2	0	0	0	0	0	0	0	0	2	2
Avg.	3	3	3	2	1	2	0	1	1	0	0	0	2	2

1-low, 2-medium, 3-high

	PROCESS DYNAMICS AND CONTROL	L	T	P	C
		3	0	0	3

MODULE I OPEN LOOP SYSTEMS

12

Laplace Transforms - Standard functions and solution of ODE, Open loop systems, first order systems and their transient response for standard input functions, first order systems in series, Transportation Lag and Dead time, second order systems and their dynamics.

MODULE II CLOSED LOOP SYSTEMS

12

Closed loop control systems, development of block diagram for feed-back control systems, servo and regulatory problems, transfer function for controllers and final control element, principles of pneumatic and electronic controllers, stability analysis using Routh-Huritz and root-locus and its diagrams.

MODULE III FREQUENCY RESPONSE

8

Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, Principle of Nyquist diagram, stability criterion, Controller tuning, Zeigler Nicholas, Cohen-Coon and other methods.

MODULE IV ADVANCED CONTROL SYSTEMS

8

Introduction to advanced control systems, cascade control, feed forward control, feedback controller Model predictive control, Smith Predictor, Ratio controller, IMC and its application.

MODULE V DIGITAL CONTROLLERS

5

Introduction to Computer control loops, Digital computer, computer process Interface, digital to analog and analog to digital converters, sampling continuous signal, Hardware components of a DDC loop, supervisory controller, DCS and PLC.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

CO1 : Apply conservation principles in order to model the dynamics of simple process systems to develop first, second and multi capacity transfer functions.

CO2 : Analyse closed loop stability systems by applying transient responses and also to test the stability of the control system by Root Locus, Routh and Bode methods.

CO3 : Discuss P, PI, PD, PID controller actions and its transfer functions. Practice block diagram development for closed loop systems by applying transient responses to find the process error.

CO4 : Devise control strategies for the control of mass and heat transfer equipment using advanced controllers.

CO5 : Discuss digital process controllers and the hardware components of its direct digital controllers and its applications.

TEXT BOOKS

1.Coughanowr D., Steven Leblanc, Process Systems Analysis and Control, Third Edition, McGraw

Hill, New York, 2009.

2.Vyas R. P, Process Control and Instrumentation, Eighth Edition, Denett & Co, Nagpur, India, 2016.

3.Stephanopoulos G., Chemical Process Control: An Introduction to Theory and Practice, Sixth Edition, Prentice Hall of India Pvt.Ltd, New Delhi, 1998.

REFERENCES

1.Coleman Brosilow, Babu Joseph, Techniques of Model-Based Control, Prentice,Hall International,2002.

2.Surekha Bhanot, Process Control: Principles and Applications, Oxford University Press,2007

3.Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, Francis J. Doyle, III, Process Dynamics and Control, Fourth Edition, John Wiley and sons, New York, 2016.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2										2	2	
2	2	2			2							2	2	
3	2	2			2							2	2	
4	2	3	2		2	2	1					2	3	
5	2	3	2		2	2	1					2	3	
Avg.	2	2.4	2		2	2	1					2	2.4	

1-low, 2-medium, 3-high

	CHEMICAL REACTION ENGINEERING-II	L	T	P	C
		3	0	0	3

MODULE I CATALYSIS AND CATALYTIC REACTORS

9

Catalysts - Steps in a Catalytic Reaction - Synthesizing a Rate Law, Mechanism, and Rate-Limiting Step-Design of Reactors for Gas-Solid Reactions - Heterogeneous Data Analysis for Reactor Design - Chemical Vapor Deposition- Catalyst Deactivation

MODULE II EXTERNAL DIFFUSION EFFECTS ON HETEROGENEOUS REACTIONS

9

Mass Transfer Fundamentals - Binary Diffusion - External Resistance to Mass Transfer - Mass Transfer to a Single Particle- Mass Transfer-Limited Reactions in Packed Beds - Mass Transfer-Limited Reaction on Metallic Surfaces - The Shrinking Core Model.

MODULE III DIFFUSION AND REACTION IN POROUS CATALYSTS

9

Diffusion and Reaction in Spherical Catalyst Pellets - Internal Effectiveness Factor - Falsified Kinetics - Overall Effectiveness Factor - Overall Effectiveness Factor - Estimation of Diffusion- and Reaction-Limited Regimes - Mass Transfer and Reaction in a Packed Bed.

MODULE IV HETEROGENEOUS NON-CATALYTIC FLUID-SOLID SYSTEMS

9

Kinetic models for non-catalytic fluid-solid systems - Progressive conversion and Unreacted core Models. Development of rate expressions for various controlling regimes- Application to design.

MODULE V FLUID-FLUID REACTIONS: KINETICS AND DESIGN

9

The rate equation- The rate equation for straight mass transfer (absorption) of a - the rate equation for mass transfer and reaction - straight mass transfer - mass transfer plus not very slow reaction - Multiphase Reactors - Slurry Reactors and Trickle bed reactors.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 : Develop rate equation for catalytic reaction and catalyst deactivation.

CO2 : Analyze external diffusion Effects on heterogeneous reactions.

CO3 : Solve the problem based on diffusion and reaction in porous catalysts

CO4 : Develop the reaction kinetics for a non-catalytic reaction with chemical reaction and mass transfer controlling regime and design non-catalytic reaction system

CO5 : Explain the underlying principles in multiphase reactors.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	2	2	2	2	1					3	3	
2	3	2	3	2	2	3	1					3	3	
3	3	3	3	2	2	3	1					3	3	
4	3	3	3	2	2	3	1					3	3	
5	3	2	3	2	2	3	1					3	3	
Avg.	3	2.4	2.8	2	2	2.8	1					3	3	

1-low, 2-medium, 3-high

	APPLIED MATHEMATICS IN CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I TREATMENT AND INTERPRETATION OF ENGINEERING DATA 9

Introduction, Graphical representation of data, classification of measurements, propagation of random errors, Means of error and its distribution, Variance of error and its distribution, Confidence limit construction, Analysis of variance.

MODULE II MATHEMATICAL FORMULATION OF PHYSICAL PROBLEMS 9

Introduction, Formation of differential equation, Application of law of conservation of mass- Application of law of conservation energy, Summary of Steps, Rate Equation, Rate Equation for homogeneous reaction, Solution of Second order differential equations.

MODULE III ANALYSIS OF STAGE WISE PROCESSES BY THE CALCULUS AND FINITE DIFFERENCE 9

Introduction – Difference Equation- First order difference equation – Solution of first order and higher order difference equation, Application of geometric series in solution of difference equation- General life examples and illustrative problems on general problems and stage wise processes problems.

MODULE IV OPTIMIZATION – PROBLEM FORMULATION 9

Introduction; fitting models to data; classification of functions-unimodal and multimodal; necessary and sufficient conditions for optimum; Formulation of Objective function and constraints from verbal statement of chemical engineering situations-Practical problems on LP formulations based on chemical engineering situations.

MODULE V LINEAR PROGRAMMING 9

Graphical methods – optimization problems, Simplex method- Chemical Engineering problems, Big-M Method, Two Phase methods, Duality problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

- CO1** : Classify the experimental data and interpret the nature of data
- CO2** : Solve difference equations of first order and higher order
- CO3** : Formulate objective functions and constraints for any optimization problem
- CO4** : Solve linear programming problems using graphical techniques
- CO5** : Solve linear programming problems using algebraic techniques.

TEXT BOOKS

1. Harold S. Mickley, Thomas K. Sherwood, Charles E. Reed, Applied mathematics in Chemical

Engineering, CNR Publishers, Second Edition.

2.R Panneer Selvam, Design and Analysis of Experiments, Eastern Economy Edition.

3.Edgar, T.F., Himmelblau, D.M., "Optimization of Chemical Processes ", McGraw-Hill Book Co., New York, 1989.

REFERENCES

1.Reklaitis, G.V., Ravindran, A., Ragsdell, K.M. " Engineering Optimisation ", John Wiley, New York, 1980.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	2	2	2	2	1					3	3	
2	3	2	3	2	2	3	1					3	3	
3	3	3	3	2	2	3	1					3	3	
4	3	3	3	2	2	3	1					3	3	
5	3	2	3	2	2	3	1					3	3	
Avg.	3	2.4	2.8	2	2	2.8	1					3	3	

1-low, 2-medium, 3-high

	BIOCHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION

9

An overview of industrial biochemical processes with typical examples, comparison of chemical and biochemical processes, development and scope of biochemical engineering as a discipline. Industrially important microbial strains and their classification; structure; cellular genetics; typical examples of microbial synthesis of biologicals.

MODULE II ENZYMES AND ENZYME KINETICS

9

Enzymes fundamental concepts, classification of enzymes; industrial applications of enzymes; industrially important enzymes; mechanism of enzymatic reactions; Michaelis-Menten and Briggs Haldane equation; Models for complex enzyme kinetics; enzymes inhibition; factors affecting the reaction rates; industrial production, purification and immobilization; enzyme reactors with typical examples.

MODULE III MICROBIAL KINETICS

9

Typical growth characteristics of microbial cells; factors affecting growth; Monod's equation; modeling of batch and continuous cell growth; immobilized whole cells and their characteristics.

MODULE IV TRANSPORT IN MICROBIAL SYSTEMS

9

Newtonian and Non-Newtonian behavior of broths; agitation and mixing; power consumption; gas-liquid transport in cells; transfer resistances; mass transfer coefficients and their role in scale-up of equipments; enhancement of O₂ transfer; heat transfer correlation; sterilization cycles and typical examples of heat addition during biological production.

MODULE V BIOREACTORS

9

Batch and continuous types; immobilized whole cell and enzyme reactors; high performance bioreactors; sterile and non-sterile operations; reactors in series with and without recycle; design of reactors and scale-up with typical examples. Downstream Processes and Effluent Treatment Recovery and purification of products; Different unit operations in down streaming with special reference to membrane separations; extractive fermentation; anaerobic treatment of effluents; typical industrial examples for downstream processing and effluent disposal.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

- CO1 :** Develop a biochemical process with process flowsheet.
- CO2 :** Solve enzyme kinetic problems and estimate enzyme- catalyzed reactions.
- CO3 :** Analyze the factors affecting the cell growth and develop models for cell growth.
- CO4 :** Estimate power requirement, enthalpy and mass transfer co-efficient for fermenter.
- CO5 :** Design bioreactors for downstream processes and effluent treatment.

TEXT BOOKS

1. Shuler M.L., Kargi F., Bioprocess Engineering Basic Concepts, Second Edition, Prentice Hall of India,

2002.

2. Bailey J.E., Ollis D.F., Biochemical Engineering Fundamentals, McGraw-Hill, International Edition, Second Edition, Reprint, New York, 2010.

3. Lee J.M., Biochemical Engineering, First Edition, Prentice Hall, 1992 (Second Edition e-book 2001).

REFERENCES

1. Blanch H.W., Clark D.S., Biochemical Engineering, Marcel Dekker, 1997.

2. Rao D.G., Introduction to Biochemical Engineering, Second Edition, McGraw Hill, 2010.

3. Doran P.M., Bioprocess Engineering Principles, Second Edition, Academic press, 1995.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	2	2	2	2	1					3	3	2
2	3	2	3	2	2	3	1					3	3	2
3	3	3	3	2	2	3	1					3	3	2
4	3	3	3	2	2	3	1					3	3	2
5	3	2	3	2	2	3	1					3	3	2
Avg.	3	2.4	2.8	2	2	2.8	1					3	3	2

1-low, 2-medium, 3-high

MASS TRANSFER LABORATORY										L	T	P	C
										0	0	3	1.5

LIST OF EXPERIMENTS:

1. Determination of HETP for random packing
2. Diffusivity Measurement
3. Drying Characteristics of Solid Materials By Air Blower
4. Generation of Ternary Liquid Equilibrium Data
5. Generation of Vapour Liquid Equilibrium Data
6. Studies in Counter Current Leaching
7. Studies in Cross Current Leaching
8. Studies in Distillation of Immiscible Liquids
9. Verification of Rayleigh's Equation using Simple Distillation

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

- CO1** : Design experiments to obtain mass transfer coefficients like diffusion coefficient in liquids and gases.
- CO2** : Apply the concepts of mass transfer and thermodynamics to the design and operation of mass transfer experiments
- CO3** : Calculate drying rates of wet solids and to determine the critical moisture & equilibrium moisture content in the different regimes of drying.
- CO4** : Conduct experiments to solve complex engineering problems effectively as an individual or team work.
- CO5** : Perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2		2							3	3
2	3	3	3	2		2							3	3
3	3	3	3	2		2							3	3
4	3	2	2	2		2							3	3
5	3	2	2	2		2							3	3
Avg.	3	2.6	2.6	2		2							3	3

1-low, 2-medium, 3-high

REACTION ENGINEERING LABORATORY											L	T	P	C
											0	0	3	1.5

List of Experiments:

1. Determination of Activation Energy
2. Kinetic Studies in Batch Reactor-I
3. Kinetic Studies in Batch Reactor-II
4. Performance Characteristics of Mixed Flow Reactor
5. Performance Characteristics of Plug Flow Reactor
6. Performance Characteristics of Semi-Batch Reactor-I
7. Performance Characteristics of Semi-Batch Reactor-II
8. Adiabatic Reactor
9. Residence Time Distribution Studies in Plug Flow Reactor
10. Residence Time Distribution Studies in Mixed Flow Reactor
11. Performance Characteristics of Tubular Reactor
12. Performance Studies of Mixed Flow Reactor in Series

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 : Collect and analyse experimental data for steady state and unsteady state reactors using statistical principles, and compare results to theoretical principles.

CO2 : Collect and analyse kinetic data to determine order, activation energy, frequency factor and rate constant in rate equation.

CO3 : Collect RTD data from steady state reactors and analyse the deviation of real reactor from ideal reactors

CO4 : Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5 : Perform as a leader with good ethical principles to meet societal needs in the field of Chemical Engineering.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	1									
2	3	3	3	2				1						
3	3	3	3	2		2			1					
4	3	3	3	2										
5	3	3	3	2										
Avg.	3	3	3	2	1	2		1	1					

1-low, 2-medium, 3-high

	MINIPROJECT	L	T	P	C
		0	0	4	2

GUIDELINES

1. The objective of mini project is to enable students to work in groups of not more than three members in each group on a project involving analytical, experimental, design, simulation or combination of these in the area chemical or allied engineering
2. The student shall carry out a 'mini project work in the sixth semester. This Mini project work carries 2 credits.
3. The student is given an option to carry out this mini project work either in the college or in an industry or in a research laboratory or in a higher learning institution.
4. The project work will be carried out under supervision of a project guide from the department. In case of student carrying out the project work outside the college, an external guide from the relevant organization shall be assigned in addition to the internal guide from the department
5. The student is required to literature survey, formulate the problem and form a methodology of arriving at the solution of the problem.
6. On completion of the work, a project report/ Thesis should be prepared and submitted to the Department.
7. This Mini project report will be evaluated by a project evaluation committee comprising of internal expert and external expert.

COURSE OUTCOMES:

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

CO1 : Apply class room theory by collecting literature pertaining to the purpose project

CO2 : Demonstrate the ability to work in teams

CO3 : Write technical documents and make oral presentations related to the work completed.

CO4 : Manage a project within a stipulated time period

CO5 : Apply professional ethics and responsibilities.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	1	0	0	0	0	0	0	0	2	2
2	3	3	3	2	0	0	0	1	0	0	0	0	2	2
3	3	3	3	2	0	2	0	0	1	0	0	0	2	2
4	3	3	3	2	0	0	0	0	0	0	0	0	2	2
5	3	3	3	2	0	0	0	0	0	0	0	0	2	2
Avg.	3	3	3	2	1	2		1	1				2	2

1-low, 2-medium, 3-high

	TRANSPORT PHENOMENA	L	T	P	C
		3	0	0	3

MODULE I BASIC CONCEPT AND CONSERVATION THEOREM IN MOMENTUM TRANSPORT 9

Derivation of the basic momentum transport equation - derivation using elementary volume concept and conservation theorems. Equation of continuity and motion - Navier-Stokes and Euler equations of motion in rectangular, cylindrical and spherical co- ordinate systems. Dimensional analysis of equations of change. Analysis of momentum transport using shell balance technique and basic transport equations - types of boundary conditions.

MODULE II APPLICATIONS OF EQUATIONS OF CHANGE IN MOMENTUM TRANSPORT 9

Flow of fluids in thin films, parallel plates, circular tubes and annulus, adjacent flow of two immiscible fluids, Couetteflow, rotating surface flow and radial flow. Flow near a wall suddenly set in motion.

MODULE III BASIC CONCEPTS AND CONSERVATION THEOREMS IN ENERGY TRANSPORT 9

Basic energy transport equations - derivations using elementary volume concept and conservation theorems in different co- ordinate systems. Dimensional analysis of equations of change. Analysis of energy transport using shell balance technique and basic transport equations - types of boundary conditions.

MODULE IV APPLICATIONS OF EQUATIONS OF CHANGE IN ENERGY TRANSPORT 9

Conduction with energy sources in fixed bed catalytic reactors and in cooling fins. Forced convection in circular tubes - Natural convection from a heated plate. Unsteady state conduction of finite slab.

MODULE V MASS TRANSPORT 9

Continuity equation for a binary mixture and its derivation. Dimensional analysis of equations of change. Analysis of mass transport using shell balance technique and types of boundary conditions. Steady and unsteady state one dimensional diffusion, diffusion in porous catalyst with and without chemical reaction and diffusion in falling liquid film.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

CO1 : Determine the interrelationship between the molecular, microscopic and macroscopic descriptions of transport processes and compare the various coordinate systems to formulate Continuity, Navier-Stokes and Euler equations.

CO2 : Apply shell balance technique to formulate the differential equation of change for steady and unsteady-state flows

CO3 : Analyse the problems involving steady state and unsteady state heat conduction in simple geometries and obtain numerical solutions for the problems.

CO4 : Develop microscopic and macroscopic energy balances for steady and unsteady energy transport processes

CO5 : Apply the individual and overall mass transfer coefficient in multi-phase systems for design applications.

TEXT BOOKS

1. Byron Bird,R, Warren E Stewart, Edwin N.Lightfoot, Transport Phenomena, Revised Second Edition., John Wiley(ISE), India, 2007.
2. Robert S. Brodkey, Harry C.Hershey, Transport Phenomena-A unified approach, McGraw Hill (ISE), 2003.

REFERENCES

1. James Welty, Charles E. Wicks, Gregory L. Rorer, Robert E. Wilson, Fundamentals of Momentum, Heat and Mass Transfer, Sixth Edition, John Wiley, (ISE), 2013.
2. Carroll O.Bennet, John Earle Meyers, Momentum, Heat and Mass Transfer, Third Edition, Tata-McGraw Hill, New Delhi,1983.
3. Christie J. Geankoplis, Transport Processes and Separation Process principles, Fourth Edition, Prentice Hall Professional Technical Reference, 2003.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	2	1	3		3			2				3	
2	3	2	1	3		3			2				3	
3	3	2	1	3		3			2				3	
4	3	2	1	3		3			2				3	
5	3	2	1	3		3			2				3	
Avg.	3	2	1	3		3			2				3	

1-low, 2-medium, 3-high

	PROCESS ECONOMICS AND INDUSTRIAL MANAGEMENT	L	T	P	C
		3	0	0	3

MODULE I INTEREST AND PLANT COST 10

Time value of money-concept of interest, equivalence, Depreciation, Depletion, Capital requirement for complete plant, cost indices, various components of Cost Productions and their Estimation and Project Cost preparations.

MODULE II PROJECT PROFITABILITY AND FINANCIAL RATIOS 10

Estimation of project profitability, Project Financing, income statement and financial ratios, balance sheet preparation - case studies and problems.

MODULE III ECONOMIC BALANCE IN EQUIPMENTS 10

Essentials of economic balance, economic balance in batch operations, cyclic operations, economic balance for insulation, evaporation, heat transfer equipments.

MODULE IV PRINCIPLES OF MANAGEMENT 8

Principles of management, planning, organizing, staffing, coordinating, directing, controlling and communicating. Types of organizations, Management information systems (MIS).

MODULE V PRODUCTION PLANNING CONTROL 7

Work measurement techniques, motion study, principles of time study, elements of production control, forecasting, planning, routing, scheduling, dispatching, inventory methods, role of control charts in production and quality control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 : Practice various depreciation methods and its uses in industries for the recovery of plant cost

CO2 : Assess the various financial ratios by taking the real time data's of the industries and comment the stability of the financial statements

CO3 : Practice various Process technology cost calculations and its feasibility analysis.

CO4 : Outline the various management principles and organization types practiced in the organizations

CO5 : Discuss the production planning control methods in industries and also role of control charts in production for the quality control.

TEXT BOOKS

1. Max Peters, Klaus Timmerhaus, Ronald West, Plant design and economics for chemical Engineers, Fifth Edition, McGraw Hill (ISE), 2013.
2. Ahuja K.K, Industrial management, khanna publishers, New Delhi, 2004.
3. Robin Smith, Chemical Process Design and Integration, Second edition, John Wiley & Sons, United States, 2016.

REFERENCES

1. FC Jelen, JH Black, Cost and Optimization Engineering, Second Edition, McGraw-Hill., New York, 1990.
2. Jacob.A.Moulijn, Michiel Makkee, Annelies Van Diepen, Chemical Process Technology, Third Edition, Wiley, 2022.
3. Gopala Rao, M. & Marshall Sittig.: Dryden's Outlines of Chemical Technology, (3rd Ed.), Affiliated East-West Press, New Delhi, (2004).

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	-	-	1	1	-	-	-	-	3	2	2	2
2	2	2	-	1	2	1	-	-	1	-	3	2	2	1
3	2	3	2	-	2	2	1	1	1	-	2	2	3	1
4	-	1	1	-	1	-	1	2	3	1	3	2	2	2
5	2	3	1	-	1	-	-	1	1	-	3	2	2	2
Avg.	2	2.2	1.33	1	1.4	1.33	1	1.33	2.5	1	2.8	2	2.2	1.6

1-low, 2-medium, 3-high

	PROCESS MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION AND FIRST PRINCIPLES

9

Definition, Uses of Mathematical Models - Principles of formulation, Classification of Process Models, Fundamental laws: Total Continuity equation- Macroscopic and Microscopic Examples, Component Continuity Equation - Macroscopic and Microscopic Examples, Energy equation, Equation, Transport equations, Equations of State, Equilibrium and Chemical Kinetics. Simple Examples.

MODULE II BASIC MODELING

9

Simple Hydraulic Tank, Variable flow hydraulic tank, Enclosed tank, Adiabatic compression in gas space, Mixing vessel, Mixing with reaction, Reversible reaction, Steam jacketed vessel, Continuous - Flow boiling system.

MODULE III MODELING OF STAGED OPERATIONS AND DISTRIBUTED SYSTEMS

9

Staged Operations: Counter current extraction, Distillation columns - Binary distillation. Distributed systems: Counter current Heat Exchanger, tubular Reactor and Evaporators.

MODULE IV FITTING DATA TO MODEL- EMPIRICAL MODELING

9

Fitting Data to Linear Model, Multi-Linear Models, Matrix representation of Multi Linear Model, Fitting Data to Quadratic Model, Cubic Model and Polynomial model using Regression, Power Law models. Performance Criteria to check quality model, Co-efficient of Determination (R^2).

MODULE V SIMULATION OF BASIC MODELS

9

MATLAB/Simulink - Introduction, Basic components, Operational Blocks, Examples - Three CSTR's in series, Gravity flow tank, Numerical Solution of Model using RK4, Euler's explicit and implicit techniques, Introduction ODE 45 Solver, Dynamic Simulation of Simple Tank, Variable Flow Tank, Enclosed Tank with isothermal Compression, Mixing Vessel, Mixing Vessel with Reaction using ODE 45 Solver.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

CO1 : Apply first principles and constitutive laws to develop ordinary or partial differential equations by incorporating valid assumptions for both macroscopic and microscopic systems.

CO2 : Derive phenomenological models for simple and variable flow hydraulic tanks, enclosed mixing vessel with reaction, steam jacketed mixing vessel and Continuous flow boiling systems.

CO3 : Develop the mathematical model for simple flow systems and Homogeneous and Heterogeneous reaction kinetics.

CO4 : Formulate distributed parameter model for various stage operations like binary distillation, multi stage counter current extraction and distributed systems like heat exchanger, tubular reactors and membrane separation unit.

CO5 : Apply numerical methods to solve modeled equations using simulation tool Matlab/simulink.

TEXT BOOKS

1. Luyben, W.L.: Process Modeling, Simulation and Control for Chemical Engineers, McGraw Hill, International Student Edition, Second Edition, 1996.
2. Franks, R.G.E.: Modeling and Simulation in Chemical Engineering, Wiley-Interscience, New York, 1972.
3. Amiya.K.Jana, Chemical Process Modeling and Computer Simulation, Prentice Hall India Pvt. Ltd, Second Edition,2011

REFERENCES

1. Himmelblau, D.M. and Bischoff, K.B.: Process Analysis and Simulation, Wiley, 1968.
2. Ramirez,W.F.: Computational methods for Process Simulation, Butterworths, NewYork, 2nd Edition, 1998

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3		3						3		2	3	
2	3													
3	3	2	3	2		1							2	
4	3	2	2	2		1							2	
5	3	3	1	2		1							2	
Avg.	3	2.5	2	2.25		1				3		2	2.25	

1-low, 2-medium, 3-high

	PROCESS PLANT UTILITIES	L	T	P	C
		3	0	0	3

MODULE I WATER 9

Sources of water, softening of water- lime-soda process, zeolite and ion-exchange process, Storage and distribution of water. Treatment of Boiler feed water, Re-use and conservation of water.

MODULE II COMPRESSORS AND VACUUM PUMPS 9

Compressors and Vacuum pumps- Performance characteristics of Compressor and Vacuum pumps. Piping systems. Air leaks. Lubrication. Oil and moisture removal.

MODULE III REFRIGERATION AND VENTILATION 9

Principles of refrigeration, refrigeration systems like vapour compression and vapour absorption cycles, types of refrigerants and their importance. Production of cryogenic temperatures. Exhaust ventilation

MODULE IV STEAM 9

Steam generation: cochran, locomotive, babcock and wilcox, lamont boiler, Properties of steam. Steam turbines- de-laval, compounding of impulse steam turbine, parsons reaction turbine. Steam handling and distribution. Steam economy.

MODULE V INSULATION 9

Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and sub zero temperatures, including cryogenic insulation.

TOTAL: 45 PERIODS

COURSE OUTCOME:

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

CO1 : Discuss about the role of water as process utility and recognize importance of treatment and conservation of water.

CO2 : Explain the various types of compressors and vacuum pumps, piping systems used in industries.

CO3 : Identify the role of refrigerant for different refrigeration systems and their importations, ventilation systems.

CO4 : Outline the basic properties of steam along with their generation and utilization of steam in process plants.

CO5 : Examine the suitable insulation for different materials piping, fittings and valves.

TEXT BOOKS

1. Nordell, Eskel, "Water treatment for industrial and other uses", Reinhold publishing corporation, Newyork.(1961).
2. Goodall, P.M., " The efficient use of steam", IPC Science and Technology(1980).
3. Ashutosh Pande, "Plant Utilities", Vipul Prakashan, Mumbai.

REFERENCES

1. Perry, R.H., and Green, D.W.: Perry's Chemical Engineers Handbook, Eighth Edition, McGraw Hill (ISE), 2008.
2. W.L McCabe J.C.Smith, and Harriot. P.: Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill, Publication, 2008.
3. Ludwig, E.E.: Applied Process Design for Chemical and Petrochemical Plants, Gulf Publishing Company, Texas, Vol.1, 4th Edition 2007, Vol.2, 4th Edition 2010, Vol.3, 3rd Edition 2011.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						3			2		3	3	
2	2	3								2			2	
3	2		2							2		3	2	
4	3		2							2		2	2	
5	3								3	2		2	2	1
Avg.	2.6	3	2				3		3	2		2.5	2.2	1

1-low, 2-medium, 3-high

	PROCESS EQUIPMENT DESIGN AND DRAWING	L	T	P	C
		0	0	3	1.5

LIST OF EXPERIMENTS

1. Design of Pressure Vessel
2. Detailed design and drawing of Storage vessel
3. Process and mechanical design of evaporator
4. Process and Mechanical design of Heat Exchanger
5. Process and mechanical design of Distillation column
6. Process and mechanical design of Absorption column
7. Process and mechanical design of Rotary Drier

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1 : Design storage and agitator vessel for the specified requirement as per standard codes.

CO2 : Design shell and tube heat exchangers and evaporators for the industrial demand by considering standard codes.

CO3 : Compute the design parameters of distillation columns, absorption towers and rotary drier for the given duty according to standards codes.

CO4 : Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5 : Perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering.

TEXT BOOKS

1. Don W. Green, Robert H. Perry, Perry's Chemical Engineers' Handbook, Eighth Edition, McGraw Hill, 2007.
2. Joshi M.V., Process Equipment Design, Third Edition, MacMillan, India, 2004.
3. Bhattacharya.B.C., Introduction to Chemical Equipment Design, CBS Publishers and Distributors, New Delhi, 1985.
4. Kern, D.Q.: Process Heat Transfer, McGraw Hill (ISE), (1999).
5. Dawande, S.D.: Process Design of Equipments, Central Techno Publications, Nagpur, 1999

REFERENCES

1. Brownell, L.E., & Young, E.H.: Process Equipment Design, Wiley Eastern, New Delhi, (1977).
2. Backhurst, J.R. & Harker, J.H.: Process Plant Design, Heinemann Books, London, (1973).

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3		3						3		2	3	
2	3													
3	3	2	3	2		1							2	
4	3	2	2	2		1							2	
5	3	3	1	2		1							2	
Avg.	3	2.5	2	2.25		1				3		2	2.25	

1-low, 2-medium, 3-high

PROCESS CONTROL AND SIMULATION LABORATORY											L	T	P	C
											0	0	3	1.5

LIST OF EXPERIMENTS

1. Dynamic Response of First Order System
2. Dynamic Response of Second Order System
3. Response of A Non-Interacting System
4. Simulation of Cyclic Process Using Excel
5. Dynamic Model of Continuous Stirred Tank Reactor (CSTR)
6. Computational Study of Free Convection in a Room Temperature Water Glass
7. Phase Change Modeling and Heat Transfer Analysis in COMSOL
8. Thermal Analysis with Convection to Ambient Temperature: 2D Steady-State Simulation in COMSOL
9. Time-Dependent Heat Conduction in a Finite Slab Using COMSOL
10. Modeling Fluid Flow with Heat Transfer in a Vessel with Heating Tubes in COMSOL

Total : 45 PERIODS

Course Outcome:

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

CO1: Analyze dynamic responses of first and second order systems.

CO2: Demonstrate proficiency in using Excel and COMSOL for complex process simulations.

CO3: Assess and model phase changes and time-dependent heat conduction accurately.

CO4: Develop and evaluate control systems for chemical processes effectively.

CO5: Integrate theoretical knowledge with practical applications in heat transfer and fluid dynamics.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2	2	0	2	2	0	0	1	0	2	0	0
2	3	2	2	1	0	2	2	0	0	2	0	2	0	0
3	3	3	3	1	0	3	1	0	0	0	0	2	0	0
4	3	3	3	3	0	2	2	0	0	0	0	3	0	0
5	2	2	1	0	0	3	2	0	0	0	0	2	0	0
Avg.	2.8	2.6	2.2	1.75		2.4	1.8			1.5		2.2		

1-low, 2-medium, 3-high

	PROJECT WORK AND VIVA VOCE	L	T	P	C
		0	0	12	6

GUIDELINES FOR EXPERIMENTAL PROJECT

1. The objective of project work is to enable students to work in groups of not more than three members in each group on a project involving analytical, experimental, design, simulation or combination of these in the area chemical or allied engineering
2. The student shall carry out a project work in the eighth semester. This project work carries 6 credits.
3. The student is given an option to carry out this project work either in the college or in an industry or in a research laboratory or in a higher learning institution.
4. The project work will be carried out under supervision of a project guide from the department. In case of student carrying out the project work outside the college, an external guide from the relevant organization shall be assigned in addition to the internal guide from the department
5. The student is required to literature survey, formulate the problem and form a methodology of arriving at the solution of the problem.
6. On completion of the work, a project report/ Thesis should be prepared and submitted to the Department.
7. This project report will be evaluated by a project evaluation committee comprising of internal expert and external expert.

GUIDELINES FOR DESIGN PROJECT

1. The answers should be made on preferably 22 x 28.5 cm. size (A-4 Size) papers and the number of pages should be around fifty.
2. The written part should be type written.
3. Drawings must be as blue/ammonia prints or in Indian ink on good quality drawing paper.
4. Detailed flow sheets for the Process, Material and Energy should be given.
5. All symbols used in the flow diagrams should follow the norms prescribed as per IS. Code 3233-1965 (Recommendations on Graphical Symbols for Process Flow Diagrams).
6. All calculations should be made by application of fundamental principles and from available published data.
7. All Physical and Thermodynamic properties required for calculations should be obtained from standard Text books, Handbooks or International Critical Tables. In the absence of such data these properties must be calculated using other known techniques (like group contribution, etc.). No data should be assumed.
8. Design of equipments should be from first principles as per Indian Standard Codes and other standard text and REFERENCES.
9. A complete drawing of the designed equipment should be furnished.

10. All dimensions, mechanical details and materials of construction should be furnished as per norms prescribed in IS-696: 1972 (Code of Practice for Engineering Drawings). Wherever possible detailed or working drawings should be given.
11. Complete layout diagrams including conveying equipment must be furnished and the floor area should be evaluated for calculating building costs.
12. Cost estimation must be done as per methods followed by text and REFERENCES in Cost Engineering. Current market prices should be obtained from Trade literature or periodicals.
13. References must be given in detail to all sources of published information made use of by the students. The names of the journals/periodicals should be abbreviated as in the Chemical Abstracts (Published by the American Chemical Society).
14. All calculations should be done in SI. Units only.

COURSE OUTCOMES:

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

CO1 : Apply class room theory by collecting literature pertaining to the purpose project

CO2 : Demonstrate the ability to work in teams

CO3 : Write technical documents and make oral presentations related to the work completed.

CO4 : Manage a project within a stipulated time period

CO5 : Apply professional ethics and responsibilities.

CO & PO Mapping

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	1	0	0	0	0	0	0	0	2	2
2	3	3	3	2	0	0	0	1	0	0	0	0	2	2
3	3	3	3	2	0	2	0	0	1	0	0	0	2	2
4	3	3	3	2	0	0	0	0	0	0	0	0	2	2
5	3	3	3	2	0	0	0	0	0	0	0	0	2	2
Avg.	3	3	3	2	1	2		1	1				2	2

1-low, 2-medium, 3-high

E1	ADVANCED SEPARATION PROCESSES	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Review of conventional processes, recent advances in separation techniques based on size and surface properties. Process concept - theory and equipment used in cross flow filtration. Surface based solid - liquid separations involving a second liquid.

MODULE II MEMBRANE SEPARATIONS 9

Types, choice of membrane, plate and frame, tubular, spiral wound and hollow fiber membrane reactors, relative merits. Commercial, pilot plant and laboratory membrane permeators involving dialysis. microfiltration, ultrafiltration, nanofiltration & reverse osmosis - Economics of membrane operations.

MODULE III SEPARATIONS BY ADSORPTION TECHNIQUES 9

Mechanism, types and choice of adsorbents, foam separation - surface adsorption, nature of foams. Normal adsorption techniques, types of equipment and commercial process, recent advances and processeconomics.

MODULE IV IONIC SEPARATIONS 9

Controlling factors, applications, types of equipment employed for electrophoresis, dielectrophoresis, electro dialysis and commercial processes.

MODULE V OTHER TECHNIQUES 9

Pervaporation - basic principles, mass transfer in pervaporation, factors affecting pervaporation and permeation techniques for solids, liquids and gases. Industrial viability and examples, zone melting-equilibrium diagrams, adductive crystallization - fundamental and process techniques.

COURSE OUTCOME

At the end of the course, students will be able to

CO1: Identify and label the recent developments in separation techniques and its properties through the process concepts.

CO2: Recognize the types and choice of membrane reactors and its several separation techniques

CO3: Apply and analyze the functioning of separation processes and its economics in the industries.

CO4: Conclude the controlling factors; classify the equipment and its applications used in various ionic separations.

CO5: Compare the existing separating techniques with the other techniques like pervaporation to achieve the better processing methods can be used in modern separations of solids, liquids and gases.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Praveen Sam D & Shoba K N, "A Course in Technical English" CUP, 2020.
2. Meenakshi Raman, Sangeeta Sharma, "Technical Communication – Principles and Practice", Oxford University Press, New Delhi, 2015.

REFERENCES:

1. Herbert M.Schoen, New Chemical Engineering Separation Techniques, Interscience publishers, 1962.
2. Svarovsky L., Solid-Liquid separation, Fourth Edition, Butterworth and co publishers, 2001.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1						3	2						
2							3							
3	1	1				2	3							
4		1												
5			1						2				1	
Avg.	1	1	1			2	3	2	2				1	

1-low, 2-medium, 3-high

E2	CARBON CAPTURE	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

The Carbon Cycle, Mitigating Growth of The Atmospheric Carbon Inventory, The Process of Technology Innovation. Carbon Capture, Carbon Storage..

MODULE II FUNDAMENTALS OF POWER GENERATION 9

Physical and Chemical Fundamentals, Fossil-Fuelled Power Plant, Combined Cycle Power Generation, Future Developments in Power-Generation Technology.

MODULE III CARBON CAPTURE FROM POWER GENERATION 9

Introduction, Pre-combustion Capture, Post-combustion Capture, Oxy- fuel Combustion Capture, Chemical Looping Capture Systems, Capture-Ready and Retrofit Power Plant, Approaches to Zero-Emission Power Generation.

MODULE IV MEMBRANE SEPARATION SYSTEMS 9

Physical and Chemical Fundamentals, Membrane Configuration and Preparation and Module Construction, Membrane Technology RD&D Status, Membrane Applications in Pre-combustion Capture, Membrane and Molecular Sieve Applications in Oxy-fuel Combustion, Membrane Applications in Post-combustion CO₂ Separation, Membrane Applications in Natural Gas Processing.

MODULE V CRYOGENIC AND DISTILLATION SYSTEMS 9

Physical Fundamentals, Distillation column configuration and operation, Cryogenic oxygen production for oxy-fuel combustion, Ryan-Holmes process for CO₂ - CH₄ separation, R&D in cryogenic and distillation technologies.

COURSE OUTCOME

At the end of the course, students will be able to

CO1: Illustrate the impacts of climate change and the measures that can be taken to reduce emissions.

CO2: Discuss carbon capture and carbon storage and Explain the fundamentals of power generation.

CO3: Explain methods of carbon capture from power generation and industrial processes

CO4: Explain different carbon storage methods: storage in coal seams, depleted gas reservoirs and saline formations.

CO5: Explain Carbon dioxide compression and pipeline transport.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Carbon Capture and Storage Stephen A. Rackley Elsevier 2010.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1						3	2						
2							3							
3	1	1				2	3							
4		1												
5			1						2				1	
Avg.	1	1	1			2	3	2	2				1	

1-low, 2-medium, 3-high

E3	COLLOIDS AND INTERFACIAL ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I SURFACE TENSION, ADHESION AND CAPILLARITY **9**

Review of conventional processes, recent advances in separation techniques based on size and surface General introduction of colloids, interfaces, surfactants, and micellization. Effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; Apolar (van-der Waals) and polar (acid-base) components of interfacial tensions. Young-Laplace equation of capillarity; examples of equilibrium surfaces.

MODULE II INTERMOLECULAR, NANOSCALE AND INTERFACIAL FORCES **9**

Intermolecular, nanoscale and interfacial forces in organic, polymeric, biological and aqueous systems. Van der waals, electrostatic double layer, acid-base interactios including hydrophobic attraction and hydration pressure.

MODULE III MESO SCALE THERMODYNAMICS AND MESO SCALE PHENOMENA **9**

Mesoscale thermodynamics and Mesoscale phenomena in soft matter & applications Gibb's treatment of interfaces, concept of excess concentration, variation of interfacial tension with surface concentration, Adhesion, wetting, nucleation, flotation, patterning of soft material by self organization and other techniques.

MODULE IV STABILITY OF NANOPARTICLE DISPERSION **9**

Stability of nanoparticle dispersions: DLVO and DLVO like theories and kinetics of coagulation plus general principles of diffusion in a potential field/Brownian movement.

MODULE V NANOFUIDICS **9**

Nanofluidics and advanced & functional Interfaces: Stability of thin (< 100 nm) film, self-organization in confined systems, mesoscale patterning. Superhydrophobicity, functional coatings, structural colours, nano-adhesives, nanocomposites.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: illustrate the development in the concept of interfacial phenomena in chemical engineering.

CO2: Analyse the different forces involved in interfacial phenomena.

CO3: Apply the concepts of mesoscale thermodynamics and mesoscale phenomena.

CO4: Recognize the stability of nanoparticle dispersions.

CO5: Understand the importance of nanofluidics and advanced and functional Interfaces.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Kaushik Nath, Membrane separation processes, First Edition, Prentice Hall publishers, 2008

REFERENCES:

1. Herbert M.Schoen, New Chemical Engineering Separation Techniques, Interscience publishers, 1962.
2. Svarovsky L., Solid-Liquid separation, Fourth Edition, Butterworth and co publishers, 2001.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	3		3					2	3	1		2
2	2	3	3		3					2	3	1		2
3	2	3	3		3		1				3	1		2
4	2	3	3		3		1			2	3	1		2
5	2	3	3		3		1			2	3	1		2
Avg.	2	2.8	3		3		1			2	3	1		2

1-low, 2-medium, 3-high

E4	COMPUTER AIDED PROCESS EQUIPMENT DESIGN	L	T	P	C
		3	0	0	3

MODULE I PHYSICAL PROPERTIES EVALUATION **9**

Review on Programming languages, Physical properties evaluation, Thermodynamic properties of gases, binary mixtures, methods of calculating vapor liquid equilibrium, data for ideal and non-ideal mixture. Bubble point and dew point. Flash and distillation calculation.

MODULE II FLOWSHEETING **9**

Conceptual design- hierarchical approach- General Structure of computer aided design programme - hierarchical design procedure for chemical processes- Importance of Flow sheeting of Flow sheet - Flow sheet structure.

MODULE III DEVELOPMENT OF SOFTWARES **9**

Development of Software for reactors- batch, stirred tank and tubular flow reactor, design of reactors for multiple reactions.

MODULE IV SIMULATION SOFTWARE **9**

Introduction to simulation software Design II, Design of process equipment using Design II - tubular exchanger, surface condenser, evaporator, crystallizer, storage tank.

MODULE V APPLICATIONS OF DESIGN SOFTWARES **9**

Linear Programming, Dynamic Programming in Chemical Engineering, Formulation and solution through PC based programs. Introduction to simulation software Aspen Plus, Simulation of chemical processes using Aspen Plus. Introduction to EVAP software. Design of multiple effect evaporator using EVAP.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Apply the phase equilibrium concepts to estimate vapour or liquid phase composition, bubble point or dew point of ideal and non-ideal mixtures with the aid of ASPEN PLUS/ MATLAB /C Programming.

CO2: Analyse a complete chemical process plant and assess alternative process flow sheets by decomposing the process flow sheets with the help of tearing- precedence ordering techniques.

CO3: Develop MATLAB/C Programming codes to calculate performance indices like batch time, equilibrium conversion of ideal batch and continuous flow reactors.

CO4: Generate MATLAB or C Programming codes to compute the design parameters for tubular exchanger, surface condenser, evaporator, crystallizer and storage tank.

CO5: Apply the process simulation software like ASPEN PLUS/ MATLAB /C Programming in the design of single and multiple effect evaporators

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Douglas J.M., Conceptual Design of Chemical Processes, McGraw Hill, New York, 1988
2. Sinnott R.K., Coulson and Richardson's Chemical Engineering Vol.6, Fourth Edition, Chemical

Engineering Design, Butterworth-Heinemann, 2005.

3. Hanna O.T., Scandell, O.C., Computational Methods in Chemical Engineering, Prentice Hall, 1995.

REFERENCES:

1. Jerry O.P., Breneman G.L., Spreadsheet Chemistry, Prentice Hall, Englewood Cliffs, 1991.
2. Myers A.L., Seider W.D., Introduction to Chemical engineering and Computer Calculations, Prentice- Hall,1976.
3. Leasley M.E., Computer Aided Process Plant Design, Gulf Publishing, 1982.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2			3	2	2				2		
2	2	3	3			2	1					2		
3	2	3	3			3	1					2		
4	3	3	3			3	2					2		
5	2	3	3			2	1					2		
Avg.	2	3	2.8			2.6	1.4	2				2		

1-low, 2-medium, 3-high

E5	DRUGS AND PHARMACEUTICALS TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Development, sources, and characteristics of drugs; Important terms used in chemistry of drugs- Medicinal Chemistry, Pharmacology, Pharmacophore, Gram positive and negative bacteria, virus, fungi ; Classification and nomenclature of drugs.

MODULE II PHARMACOKINETICS AND PHARMACO DYNAMICS 9

Physico - chemical principles; Pharmacokinetics - Absorption Distribution, Metabolism and Excretion of Drugs; Bioavailability measurement - Plasma level-time and Urinary excretion studies; Basic Pharmacodynamics.

MODULE III MANUFACTURING PRINCIPLES 9

Compressed tablets and coating, Wet granulation, Dry granulation or Slugging, Capsules, Parenteral solutions, Oral liquids, Ointments, Good Manufacturing Practice as per Drugs and Cosmetics Act.

MODULE IV PHARMACEUTICALS, MICROBIOLOGICAL PRODUCTS 9

Laxatives, Radiopharmaceuticals, Cardiovascular agents, Central Nervous System stimulants, External Antiseptics, Analgesics, Antacids, Antibiotics, Antineoplastic drugs, Antidiabetic drugs, Hormones, Vitamins.

MODULE V OTHER TECHNIQUES 9

Transdermal drug delivery, Polymers in drug delivery, Liposomal drug delivery, Nano drug delivery, Ophthalmic drug delivery, Design of Controlled Drug Delivery Systems.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Develop nomenclature for upcoming drugs and gain knowledge of therapeutic agents to be used for treatment.

CO2: Estimate the pharmacokinetic parameters and analyze the transformation of drugs in the body.

CO3: Employ standards of hygiene in the manufacturing processes of drugs and pharmaceuticals.

CO4: Examine the constituents present in pharmaceutical and microbiological products.

CO5: Formulate drug delivery systems to transport pharmaceutical agents in the body to achieve therapeutic effect.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Chatwal G.R., Synthetic Drugs, Himalaya Publishing House, Delhi, 2009.
2. Brahmankar D.M. and Jaiswal S.B. Biopharmaceutics and Pharmacokinetics - A Treatise, Vallabh Prakashan, New Delhi, 2015.
3. Felton, Linda A., Remington : Essentials of Pharmaceutics, College of Pharmacy, Philadelphia, 2013.

REFERENCES:

1. Juergen Siepmann, Ronald A. Siegel, Michael J. Rathbone, Fundamentals and Applications of

Controlled Release Drug Delivery, Springer, 2011.

2. Tyagi O.D., Yadav M. A., Text Book of Synthetic Drugs, Anmol Publications, New Delhi, 2011.

3. Lachman L. Lieberman H.A. and Kanig J.L., The Theory and Practice of Industrial Pharmacy, Indian Edition, Varghese Publishing House, Mumbai, 2013.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2			3	2	2				2		
2	2	3	3			2	1					2		
3	2	3	3			3	1					2		
4	3	3	3			3	2					2		
5	2	3	3			2	1					2		
Avg.	2.2	3	2.8			2.6	1.4	2				2		

1-low, 2-medium, 3-high

E6	ENERGY MANAGEMENT IN CHEMICAL INDUSTRIES	L	T	P	C
		3	0	0	3

MODULE I PLANNING FOR ENERGY NEEDS 9

Forecasting techniques; energy demand; magnitude and pattern; input and output analysis; energy modelling and optimal mix of energy sources.

MODULE II ENERGY AND ENVIRONMENT 9

Energy; various forms; energy storage; structural properties of environment; bio-geo-chemical cycles; society, environment population and technology.

MODULE III ENERGY AND SOCIETY 9

Energy and evolution; growth and change; patterns of consumption in developing and advanced countries; commercial generation of power requirements and benefit.

MODULE IV MANAGEMENT OF ENERGY CONSERVATION IN CHEMICAL INDUSTRIES 9

Chemical industries; classification; conservation in unit operations such as separation; cooling tower; drying; conservation applied to refineries, petrochemical, fertilisers, cement, pulp and paper, food and chlor-alkali industries; conservation using optimization techniques.

MODULE V ECONOMIC BALANCE IN ENERGY CONSUMPTION 9

Cost analysis; capacity; production rate; system rate; system cost analysis; corporate models; production analysis and production using fuel inventories; input-output analysis; economics; tariffs.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Plan to optimize energy using systems and procedures to meet energy demand

CO2: Describe the Relationship between Energy & Environment.

CO3: Examine the relationship between energy systems and society.

CO4: Use optimization techniques for conservation of energy in chemical industries.

CO5: Evaluate the production rate and analyze the cost from economic balance for energy consumption.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Jerrold H Kertz, Energy Conservation and Utilization, Allyn and Bacur Inc, 1976.
2. Gemand M Gramlay, Energy, Macmillan publishing Co, Newyork, 1975.

REFERENCES:

1. Krentz J. H., Energy Conservation and Utilization, Allyn and Bacur Inc., 1976.
2. Gramlay G. M., Energy, Macmillan Publishing Co., New York, 1975.
3. Rused C. K., Elements of Energy Conservation, McGraw-Hill Book Co., 1985.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2			3	2	2				2		
2	2	3	3			2	1					2		
3	2	3	3			3	1					2		
4	3	3	3			3	2					2		
5	2	3	3			2	1					2		
Avg.	2.2	3	2.8			2.6	1.4	2				2		

1-low, 2-medium, 3-high

E7	FERTILIZER TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Chemical Fertilizers and Organic Manures - Types of chemical Fertilizers. Secondary nutrients, micro nutrients.

MODULE II NITROGEN FERTILIZERS 9

Nitrogenous Fertilizers - Methods of production of Ammonia and Urea. Nitric acid, Ammonium sulphate, Ammonium Nitrate, Calcium Ammonium Nitrate, Ammonium Chloride - Their methods of production, characteristics, storage and handling specifications.

MODULE III PHOSPHATIC FERTILIZERS 9

Raw materials, phosphate rock, Sulphur pyrites -Process for the production of Sulphuric and Phosphoric acids. Ground phosphate rock, bone meal. Single Super Phosphate, Triple Super phosphate -Methods of production, characteristics and specifications.

MODULE IV POTASSIC FERTILIZERS 9

Potassium chloride, Potassium sulphate, Potassium schoenite - Methods of production, specification, characteristics. Complex Fertilizers, NPK Fertilizers, Mono ammonium phosphate, Diammonium phosphate, Nitro phosphate Methods of production.

MODULE V FERTILIZERS IMPACTS AND STANDARDS 9

Fluid fertilizers. Controlled Release of fertilizers. Solid, Liquid and Gaseous pollution from ammonia urea and NPK fertilizer industries and standards laid down for them. Fertilizer production in India.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Illustrate chemical, organic fertilizers and nutrients

CO2: Develop the flow chart for manufacture of nitrogenous fertilizers

CO3: Examine the relationship between energy systems and society.

CO4: Use optimization techniques for conservation of energy in chemical industries.

CO5: Evaluate the production rate and analyze the cost from economic balance for energy consumption.

TOTAL : 45 PERIODS

TEXT BOOKS:

1. Gopala Rao M., Marshall Sittig, Dryden's Outlines of Chemical Technology, Third Edition, WEP East-West Press, New Delhi, 2010.

2. George T. Austin., Shreve's Chemical Process Industries, Fifth Edition, McGraw Hill Professional, 2012

3. Vincent Sauchelli., The Chemistry and Technology of Fertilizers, Reinhold Pub. Corp., 1960

REFERENCES:

1. Editorial Committee - FAI Seminar on Fertilizer in India in the Seventies (Proceedings), The Fertilizer Association of India, New Delhi, 1973.
2. Editorial Committee - Seminar on Recent Advances in Fertilizer Technology, The Fertilizer Association of India, New Delhi, 1972.
3. Sauchelli V., Manual on Fertilizer Manufacture, Industry Publication Inc, New Jersey, 1963.
4. CHEMTECH - II - (Chapter on Fertilizers by Chari, K.S.), Chemical Engineering Education Development Centre, I.I.T., Madras, 1977.
5. Menon M.G., Fertilizer Industry - Introductory Survey, Higginbothams, Madras, 1973.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2			3	2	2				2		
2	2	3	3			2	1					2		
3	2	3	3			3	1					2		
4	3	3	3			3	2					2		
5	2	3	3			2	1					2		
Avg.	2.2	3	2.8			2.6	2.8	2				2		

1-low, 2-medium, 3-high

E8	FLUIDIZATION ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Fluidized state - nature of Hydrodynamic Suspension, Regimization of the fluidized state, Operating models for fluidization systems and its industrial applications.

MODULE II HYDRODYNAMICS OF FLUIDIZATION SYSTEM 9

General bed behavior, pressure drop, empirical correlations for solid holdup, flow Models.

MODULE III SOLIDS MIXING AND SEGREGATION 9

Degree of segregation, Operation shifts, reversal points, mixing - segregation Equilibrium generalized fluidization of poly systems, Liquid phase mixing and gas phase mixing.

MODULE IV HEAT AND MASS TRANSFER IN FLUIDIZATION SYSTEMS 9

Mass Transfer - Gas- Liquid Mass Transfer, Liquid-Solid mass Transfer and wall to bed Mass Transfer. Heat Transfer - Column wall to bed Heat transfer.

Module V MISCELLANEOUS SYSTEM 9

Moving bed, slurry bubble column, two phase and three phase inverse fluidized bed, typical applications.

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1** : Analyze the various fluidization behavior, operating conditions and its industrial application
- CO2** : Develop the various flow models and test their empirical correlations
- CO3** : Develop a heat and mass transfer fluidization correlations for the industrial chemical equipment
- CO4** : Evaluate the two and three phase inverse fluidized bed correlation and their application
- CO5** : Solve the solid- liquid mixing problems for the fluidization operations by applying various temperature and other conditions

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Kunii D., Levenspiel O., Fluidization Engineering, Second Edition, Butterworth-Heinemann, 2013.
2. Leva M, Fluidization, McGraw Hill, New York, 1959.
3. J.F. Davidson, R. Clift and D. Harrison, Fluidization. Second Edition, 1985, Academic Press, New York.

REFERENCES:

1. Zenz F.A., Othmer D.F., Fluidization and Fluid Particle Systems, Sixth Edition, Reinhold, New York, 1960.
2. Geldart D., Gas Fluidization Technology, John Wiley, New York, 1986.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	2	3		2					2		2	
2	2	2	2	3		2					2		2	
3	2	2	2	3		2		1					2	
4	2	2	2	3		2					2		2	
5	2	2	2	3		2					2		2	
Avg.	2	2	2	3		2		1			2		2	

1-low, 2-medium, 3-high

E9	FOOD TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I GENERAL ASPECTS OF FOOD INDUSTRY 9

Introduction, World food demand and Indian scenario, Control of food quality by regulatory mechanism in India, Constituents of food, Quality and nutritive aspects, Food additives, Standards, Deteriorative factors and their control, preliminary processing methods, conversion and preservation operation.

MODULE II FOOD PRESERVATION TECHNIQUES 9

General bed behavior, pressure drop, empirical correlations for solid holdup, flow Models. Processing systems, Microbial survivor curves, Influence of external agents, Thermal death time, Spoilage probability. General methods of preservation by heat and cold dehydration, concentration, frying, irradiation, microwave heating, sterilization and pasteurization, fermentation and pickling, packing methods.

MODULE III PACKAGING TECHNOLOGY 9

Packaging - Introduction, Food protection, Product containment, Product communication, Product convenience, Innovations in food packaging, Food packaging and product shelf-life, Food canning technology. Heat sterilization of canned food, containers - metal, glass and flexible packaging. Canning procedures for Fruits, Vegetables, Meats, Poultry Marine products..

MODULE IV PRODUCTION AND UTILIZATION OF FOOD PRODUCTS 9

Bakery, confectionery and chocolate products; Soft and alcoholic beverages; Dairy products; Meat; poultry and fish products, treatment and disposal of food processing wastes.

MODULE V FOOD PLANT SANITATION 9

Sanitation, Sanitation Laws, Regulations and guidelines, Establishment of Sanitary practices, Waste product handling, Role of HACCP in Sanitation, Good Manufacturing practices, Standard operating procedures.

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the principles of Food Science and aware of the effects of Food Additives.
- CO2 :** Apply the Preservation techniques in the practical and real-world situations and problems.
- CO3 :** Gain Knowledge on various Food Packaging Technology.
- CO4 :** Incorporate the principles of food processing in different food sectors.
- CO5 :** Identify the government regulations for the Hygienic manufacture of foods.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. R. Paul Singh, Dennis R. Heldman., "Introduction to Food Engineering", Academic Press, 2014
2. Potter N.N., "Food Science", The AVI publishing Co., Fourth Edition, USA, 2013
3. Michael.M. Cramer, "Food Plant Sanitation : Design, Maintenance and Good Manufacturing Practices", CRC Press 2013..

REFERENCES:

1. Ernest R.V., Elementary Food Science, Fourth Edition, Springer, 2001
2. Considine D.M., Considine G.D., Considine P.E., Foods and Food production Encyclopedia, Vol. 8, Van Nostrand - Reinhold, 1982
3. Heldman D.R., "Food Process Engineering", The AVI publishing Co., USA, 1975.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	2	3		2					2		2	
2	2	2	2	3		2					2		2	
3	2	2	2	3		2		1					2	
4	2	2	2	3		2					2		2	
5	2	2	2	3		2					2		2	
Avg.	2	2	2	3		2		1			2		2	

1-low, 2-medium, 3-high

E10	INTEGRATED DESIGN OF CHEMICAL PROCESS	L	T	P	C
		3	0	0	3

MODULE I REACTOR CONDITIONS AND CONFIGURATION 9

Hierarchy and approaches of Chemical process Design and Integration. Role of process economics, optimization Reactor Performance - Idealized reactor models and their choice. Reactor conditions - Reactor temperature, pressure and concentration. Reactor Configuration - temperature control, reactors for homogeneous and hetero reactions.

MODULE II HOMOGENEOUS SEPARATORS 9

Separators for Heterogeneous mixtures. Settling and Sedimentation, Inertial and Centrifugal separation, Filtration, Scrubbing, Flotation and Drying.

MODULE III HETEROGENEOUS SEPARATORS 9

Separator for Homogeneous fluid mixtures, Distillation, Absorption, stripping and Liquid-Liquid extraction, Adsorption, Membranes, Crystallization, Evaporation, Sequencing.

MODULE IV NETWORKING 9

Reaction, separation and Recycle systems for continuous processes and for batch processes. Heat exchanger networks - Heat transfer equipments, Energy capital and total cost targets, network Design.

MODULE V PROCESS INTEGRATION 9

Heat Integration of reactions, Distillation columns, Evaporators, Dryers. Steam systems and Cogeneration, Cooling water networking design.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Compute the design calculations for the various reactor configurations of reactors used for homogenous and heterogeneous reactions.

CO2 : Solve the design problems related to Settling and Sedimentation, Centrifugal filtration and drying unit.

CO3 : Solve the design problems for distillation, absorption, stripping, and Liquid-Liquid Extraction and Evaporation units.

CO4 : Formulate steady state material balance for the unit operations such as distillation, evaporation, mixing, extraction, drying and crystallization processes with recycle by-pass and purge.

CO5 : Apply the combined material and energy integration to select the optimal process conditions for the design equipment used for separation and transport processes.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Robin Smith, Chemical Process Design and Integration, Second Edition, Willey India Pvt Ltd, New Delhi, 2009.

REFERENCES:

1. Alexandre C. Dimian, Costin Sorin Bildea, Chemical Process Design: Computer-Aided Case

- Studies, WILEY-VCH VerlagGmbH and Co KGaA, Weinheim, 2008.
2. Anil Kumar, Chemical Process Synthesis and Engineering Design, McGraw Hill, 1982.
 3. Heldman D.R., "Food Process Engineering", The AVI publishing Co., USA, 1975.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	2	3		2					2		2	
2	2	2	2	3		2					2		2	
3	2	2	2	3		2		1					2	
4	2	2	2	3		2					2		2	
5	2	2	2	3		2					2		2	
Avg.	2	2	2	3		2		1			2		2	

1-low, 2-medium, 3-high

E11	TECHNOLOGY OF COMPOSITES	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Definition, classification constituents, function and requirements, reinforcements and matrix, properties of composite materials and applications.

MODULE II FIBRE REINFORCEMENT 9

Glass, carbon, aramid and boron fibers, their production processes and properties, commercial forms of fiber, Whiskers and their applications.

MODULE III FUNDAMENTALS OF POLYMER COMPOSITES 9

Types of composites reinforced thermoplastics, thermosets, reinforcement of elastomers, materials and types of reinforcements, Thermosetting and thermo plastic materials- their curing characteristics, FRTP pellets, their production, processing, fillers and additives. Mechanical, electrical, thermal and viscoelastic properties of composites as determined by composition and its effect on processing.

MODULE IV COMPOSITES AND FABRICATION PROCESSES 9

Pressure bag/vacuum bag moulding, compression moulding, filament winding, autoclave molding, centrifugal casting, pultrusion, injection moulding. Application of cellular plastics, effects on properties, methods of production, types of products and applications.

MODULE V POST PROCESSING METHOD 9

Cutting, trimming, machining, water jet cutting, abrasive jet cutting, laser curing, joining, mechanical and adhesive points, painting, coating and other processes.

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** gain knowledge about various composite production methods, application in real process.
- CO2 :** identify, formulate new composite materials other than normal materials providing safety to the environment.
- CO3 :** Effectively understands the reinforcement of thermosets and thermoplastics.
- CO4 :** understand different molding process and application of plastics in fabrication process.
- CO5 :** Effectively understanding the post processing methods and applying in projects.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Lubin G, Von Nostrand Rein Hold, Handbook of Composites, New York 1982.
2. Mohr J.G., SPI Handbook of Technology and Engineering of Reinforced Plastics/Composites, Second Edition, New York, Van Nostrand Rein- hold Company.1973.

REFERENCES:

1. Richardson M.D.W, Polymer Engineering Composites, Applied Science Publishers, London 1977.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	2	3		2					2		2	
2	2	2	2	3		2					2		2	
3	2	2	2	3		2		1					2	
4	2	2	2	3		2					2		2	
5	2	2	2	3		2					2		2	
Avg.	2	2	2	3		2		1			2		2	

1-low, 2-medium, 3-high

E12	MINERAL PROCESSING TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I COMMUNITION 9

Testing sieve analysis. Principles of size reduction, size separation. Different types of crushers, grindingmills, screens and classifiers. Closed and open circuit operations in size reduction.

MODULE II CONCENTRATING OPERATIONS 9

Principles of specific gravity separation. Launderers, vibrating tables, spiral concentrators, cone concentrators, vanners, cordouries, pans and other types of specific gravity separators.

MODULE III SEPARATION PROCESSES 9

Electrical separation and magnetic separation of minerals. Different types of electrical and magnetic separators.

MODULE IV FROTH FLOTATION 9

Interfacial phenomenon for mineral particles in water. Collection, frothing, activation, depression, regulation and conditioning. Froth flotation machines. Design of froth flotation circuits.

MODULE V WASTE DISPOSAL 9

Dewatering and drying operations. Disposal and treatment of mineral sludges. Mineral processing flow sheets for copper, lead, zinc and gold only.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Recall the size reduction and size separation equipment's used in the mechanical operations processes.

CO2 : Understand the specific gravity separation of minerals would be exposed to the practices of beneficiation ores which is important for value upgradation for main product and for byproduct recovery.

CO3 : Understand the various commonly used methods to beneficiate (separate) minerals from less valuable gangue material, including density, electrostatic and magnetic, based approaches.

CO4 : Design the flotation circuits and identify the chemicals used for concentrating minerals in flotation process.

CO5 : Identify the suitable disposal and treatments methods for mineral wastes and flowsheet for various mineral processes.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Gaudin A.M., Principles of Mineral Dressing, First Edition, Tata McGraw Hill, New Delhi, 2002.
2. Wills B.A., Mineral Processing Technology, Seventh Edition, Maxwell Macmillan, 2006.
3. Pryor E.J., Mineral Processing, Third Edition, Elsevier, New York, 1965.

REFERENCES:

1. Richards R.H., Locke C.E., Text Book of Ore Dressing, Third Edition, McGraw Hill, New York, 1940.
2. Taggart A.F., Hand Book of Mineral Dressing, John Wiley, New York, 1954.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	2	3		2					2		2	
2	2	2	2	3		2					2		2	
3	2	2	2	3		2		1					2	
4	2	2	2	3		2					2		2	
5	2	2	2	3		2					2		2	
Avg.	2	2	2	3		2		1			2		2	

1-low, 2-medium, 3-high

E13	NANOSCIENCE AND NANOTECHNOLOGY FOR CHEMICAL ENGINEERS	L	T	P	C
		3	0	0	3

MODULE I BULK SYNTHESIS 9

Synthesis of bulk nano-structured materials -sol gel processing -Mechanical alloying and mechanical milling- Inert gas condensation technique - Nanopolymers - Bulk and nano composite materials.

MODULE II CHEMICAL APPROACHES 9

Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, clusters, colloids, zeolites, organic block copolymers, emulsion polymerization, templated synthesis, and confined nucleation and/or growth. Biomimetic Approaches: polymer matrix isolation, and surface-templated nucleation and/ or crystallization. Electrochemical Approaches: anodic oxidation of alumina films, porous silicon, and pulsed electrochemical deposition.

MODULE III PHYSICAL APPROACHES 9

Vapor deposition and different types of epitaxial growth techniques- pulsed laser deposition, Magnetron sputtering - Micro lithography (photolithography, soft lithography, micromachining, e-beam writing, and scanning probe patterning.

MODULE IV NANOPOROUS MATERIALS 9

Nanoporous Materials - Silicon - Zeolites, mesoporous materials - nanomembranes and carbon nanotubes- AgX photography, smart sunglasses, and transparent conducting oxides -molecular sieves - nano sponges.

MODULE V APPLICATION OF NANOMATERIALS 9

Molecular Electronics and Nanoelectronics - Nanobots- Biological Applications - Quantum Devices - Nanomechanics - Carbon Nanotube - Photonics- Nano structures as single electron transistor - principle and design.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Demonstrate a systematic knowledge of the range and breadth of application of nanomaterials and select appropriate techniques for a range of situations

CO2 : Review critically the potential impact in all classes of materials of the control of nanostructure.

CO3 : the methods for the chemical and nano structural characterization of such materials

CO4 : Outline the nanotechnology production routes currently available.

CO5 : Identify possible opportunities for nanomaterials in product development and enhancement

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Cao G. Nanostructures, Nanomaterials, Synthesis, Properties and Applications, Imperial College Press, 2004.

- Gaddand,W., Brenner,D., Lysherski,S. and Infrate, G.F., Handbook of NanoScience, Engineeringand Technology, CRC Press, 2002.

REFERENCES:

- Gaponenko,S.P. Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
- Barriham,K., Wedensky,D.D. Low dimensional semiconductor structures, fundamental and device applications, Cambridge University Press, 2001.
- George,J. Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	2	2	3		3					2	3	1	
2	1	2	3	3		3					2	3	1	
3	1	2	3	3		3		1				3	1	
4	1	2	3	3		3		1			2	3	1	
5	1	2	3	3		3		1			2	3	1	
Avg.	1	2	2.8	3		3		1			2	3	1	

1-low, 2-medium, 3-high

E14	PILOT PLANT SCALEUP METHODS	L	T	P	C
		3	0	0	3

MODULE I PRINCIPLES OF SIMILARITY, PILOT PLANTS AND MODELS 9

Introduction to scale up methods, pilot plants and models and principles of similarity.

MODULE II DIMENSIONAL ANALYSIS AND SCALE - UP CRITERION 9

Dimensional Analysis, Regime concept, similarity criterion and scale up methods used in chemical engineering.

MODULE III SCALE - UP OF MIXING AND HEAT TRANSFER EQUIPMENT 9

Typical problems in scale - up of mixing equipment and heat transfer equipment.

MODULE IV SCALE - UP OF CHEMICAL REACTORS 9

Kinetics, Reactor Development and scale - up techniques for chemical reactors.

MODULE V SCALE - UP OF DISTILLATION COLUMN AND PACKED TOWERS 9

Scale - up of distillation columns and packed towers for continuous and batch process.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Understand the techniques to solve problems relevant to the general practice of chemical engineering and engineering design.

CO2 : Experience in the process of original chemical engineering design in the three areas of equipment design, process design, and plant design through the process of formulating a design solution to a perceived need and then executing the design and evaluating its performance including economic considerations and societal impacts.

CO3 : Understand the effects of scale on the relative rates of mass, heat and momentum transfer, mixing effects, utility of various reactor operating modes and the acquisition of reliable kinetic, thermodynamic and transport data.

CO4 : Ability to use different approaches for process scale - up and perform a power analysis.

CO5 : understand flow regimes basic to scale up.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. John stone, Thring, Pilot plants models and scale - up methods in chemical Engineering, McGraw - Hill, New York, 1962.
2. Marko Zlokarnik, Dimensional Analysis and scale - up in Chemical Engineering, Springer - Verlag, Berlin, Germany, 1986.

REFERENCES:

1. Donald. G. Jordan. Chemical Process Development (Part 1 and 2), Interscience Publishers,

1988.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	3		3					2	3	1		2
2	2	3	3		3					2	3	1		2
3	2	3	3		3		1				3	1		2
4	2	3	3		3		1			2	3	1		2
5	2	3	3		3		1			2	3	1		2
Avg.	2	3	3		3		1			2	3	1		2

1-low, 2-medium, 3-high

E15	POLYMER SCIENCE AND ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION TO POLYMERS AND POLYMERIZATIONS 9

Polymers - Basic concepts - Classification - Natural and synthetic polymers, thermoplasts and thermosets. Polymerization - Addition, condensation, ring opening, copolymerization, ionic and coordination polymerization - Kinetics of polymerization.

MODULE II POLYMER ANALYSIS AND SOLUTION PROPERTIES 9

Molecular weight and distribution- Number average, weight average, viscosity average and Z-average molecular weight - Determination by light scattering, solution viscosity and gel permeation chromatography. Degree of polymerization. Glass transition temperature - Theory and measurements. Polymer solutions- Solubility and swelling, Thermodynamics of polymer solutions, Phase separation in polymer solutions.

MODULE III STRUCTURE AND PROPERTIES OF BULK POLYMERS 9

Morphology and order in crystalline polymers - crystal structure of polymers, morphology of polymer single crystals. Rheology and the mechanical properties of polymers - Viscous flow, kinetic theory of rubber elasticity and viscoelasticity, stress-strain behavior, compression vs tensile tests, deformation of solid polymers. Thermal analysis of polymers using TGA and DSC.

MODULE IV MANUFACTURE AND PROPERTIES OF COMMERCIAL POLYMERS 9

Hydrocarbon plastics and elastomers - low density (branched) polyethylene, high density (linear) polyethylene, polypropylene, natural rubber, rubbers derived from butadiene. Other carbon chain polymers polystyrene, acrylic polymers, poly(vinyl esters) and derived polymers. Heterochain thermoplastics - Polyamides. Thermosetting resins - Phenolic resins and amino resins.

MODULE V POLYMER PROCESSING TECHNIQUES 9

Plastic molding techniques - Injection, blow, extrusion and compression. Processing agents - Fillers, plasticizers, and other additives. Fiber Technology - Textile and fabric properties, spinning - wet and dry methods - fiber treatments. Elastomer technology - Compounding and elastomer properties, vulcanization and reinforcement.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Understand the basic concepts of polymer science and identify the polymerization techniques and its kinetics.

CO2 : Assess the molecular weight distribution techniques, glass transition, and solution properties like thermodynamics, phase separations.

CO3 : Explain the morphology, rheology, mechanical and thermal properties of bulk polymers.

CO4 : Compare and analyze the manufacture and properties of commercial polymers.

CO5 : Apply the knowledge in assessing the polymeric, fiber and elastomer processing techniques.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Billmeyer F.W., Textbook of Polymer Science, Third Edition, Wiley Interscience, 1984.
2. Charles E., Carraher Jr., Seymour/carraher's polymer chemistry, Seventh Edition, CRC Press, 2012.

REFERENCES:

1. Fried J.R., Polymer Science and Technology, Second Edition, Prentice Hall of India Pvt Ltd., 2003.
2. Bhatnagar M.S., A Textbook of Polymers, Vol. 2, S.Chand and Company Ltd., 2012s.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	3		3					2	3	1		2
2	2	3	3		3					2	3	1		2
3	2	3	3		3		1				3	1		2
4	2	3	3		3		1			2	3	1		2
5	2	3	3		3		1			2	3	1		2
Avg.	2	3	3		3		1			2	3	1		2

1-low, 2-medium, 3-high

E16	PROCESS AUTOMATION	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Principles of measurement and classification of process control instruments, temperature, pressure fluid flow, liquid level, velocity, fluid density, viscosity etc., instrument scaling, sensors, transmitters and control valves, instrumentation symbols and labels.

MODULE II PROCESS AUTOMATION 9

Structure & components of Industrial Automation systems. Architectural levels of Industrial controls, Single loop and Multi loop controllers and their tuning.

MODULE III PROGRAMMABLE LOGIC CONTROLLER 9

Introduction, architecture, definition of PLC, PLC vs PC, PLC vs DCS, Relay diagram, Ladder diagram examples, timers/counters, PLC design.

MODULE IV DISTRIBUTED CONTROL SYSTEM 9

Introduction, functions, advantages, and limitations DCS as automation tool for resource planning and support enterprise, DCS architecture of different makes, specification, Configuration and programming.

MODULE V PROCESS OPERATION MANAGEMENT SYSTEMS 9

Overview of process operation management systems, order, inventory management, process scheduling, quality management.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Demonstrate the concepts of instrumentation for the measurement, control and classification of systems by utilizing the analog / digital control devices.

CO2: Develop the skills required for automation, control and monitoring of industrial processes in high level with automation and control systems.

CO3: Employ high-level PLC control systems in the computer integration of manufacturing processes.

CO4: Integrate the industrial processes, control of sequences for automation and monitoring through distributed control systems.

CO5: Practice the manufacturing and inventory management systems currently used in the process industries.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Nakara B.C., Choudary K.K., Instrumentation and Analysis, Second Edition, Tata McGraw Hill, New Delhi, Seventh Reprint, 2006.
2. Stephanopoulos G., Chemical Process Control, Tata McGraw Hill, New Delhi, 1993.

REFERENCES:

1. Karl J.Astrom, Bjorn Willermans., Computer Controlled Systems, Prentice Hall of India Pvt. Ltd., 1994.
2. Chemical Engineering Refresher Series on Process Automation, McGraw-Hill Publications, New York, 1991

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	3		3					2	3	1		2
2	2	3	3		3					2	3	1		2
3	2	3	3		3		1				3	1		2
4	2	3	3		3		1			2	3	1		2
5	2	3	3		3		1			2	3	1		2
Avg.	2	3	3		3		1			2	3	1		2

1-low, 2-medium, 3-high

E17	PROCESS ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION TO OIL AND GAS FACILITIES 9

Introduction to Oil and Gas Industry-Process description- Piping elements- Instruments: field instruments, control valves- Process equipment- Role of Process Engineer.

MODULE II INTRODUCTION TO PROJECT ENGINEERING 9

Elements in Project Execution, Different Phases of a Project-(Basic Engineering package-BEP, Front End Engineering Design-FEED, Proposal Engineering, EPC-EPCM Contract, LSTK), Elements of Engineering, Process Engineering Deliverables.

Introduction to Piping and Instrumentation Diagrams.

MODULE III PROCESS SIMULATION AND DESIGN 9

Introduction and purpose- Software used for Simulation, Simulation inputs- Steady state simulation- Typical operation in simulation schemes- Heat and material balance generation, Dynamic Simulation Study and its uses. Introduction to Relief and Blow down Studies, Pipeline Flow assurance Study- Steady State and Transient, software used in Flow assurance Studies, Introduction to AIV/FIV studies, CFD analysis.

MODULE IV ENGINEERING DIAGRAMS 9

Block flow diagram-Process/Utility flow diagram-Symbols for P&ID development: piping elements, control system-Operation & control philosophy-Cause and Effect chart- typical PID development for Glycol Dehydration unit, Process Safety Flow diagrams, SAFE Chart. Introduction to Plot plan, General arrangement drawings.

MODULE V FACILITIES ENGINEERING 9

Process Design Basis and Design Criteria, Overview of various process equipment and its design principles: Separators, Pumps, Compressors, Heat exchangers, Absorber column, Heaters, Air coolers, Storage Tanks, Line hydraulics (Gas, Liquid and Multiphase lines)- Pump Hydraulics- Control valve hydraulics, software used in Equipment design (Column, Heat Exchanger etc.). Introduction to various Codes and Standards followed in a PROJECT (API, TEMA, ISA etc).

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Know about the basic concept of equipment in oil and gas industry.
- CO2 :** Know about the project execution, different phases in a project.
- CO3 :** Understand the software used for simulation and flow studies.
- CO4 :** Understand the PFD, P&ID for various processes.
- CO5 :** Understand the works in an EPC company.

TEXT BOOKS

1. Perry's Chemical Engineers' Handbook, Robert H. Perry, October 2007.
2. GPSA Engineering Data Book, Gas Processors Suppliers Association, 13th Edition 2012..

REFERENCES:

1. American Petroleum Institute (API) Standards.
2. ISA Standards
3. TEMA standards, Tubular Exchanger Manufacturers Association, Inc.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	2	3		3					2	3	1		2
2	2	3	3		3					2	3	1		2
3	2	3	3		3		1				3	1		2
4	2	3	3		3		1			2	3	1		2
5	2	3	3		3		1			2	3	1		2
Avg.	2	2.8	3		3		1			2	3	1		2

1-low, 2-medium, 3-high

E18	PULP AND PAPER TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION TO SOURCE OF PULP AND PROPERTIES 9

Source of Pulp wood. Structure and properties of pulp wood. Preparation of pulp wood: Debarking, chipping,depithing. Softwoods. Hardwoods. Comparison of different raw materials.

MODULE II PULPING PROCESS AND TREATMENT 9

Manufacture of pulp - Mechanical, Sulphite, Kraft and alkaline process. Treatment of pulp :Washing, screening, cleaning and Bleaching of pulp. H-factor.control parameters: Effect of raw material on pulp quality; kappa number..

MODULE III CHEMICAL RECOVERY 9

Kraft and soda recovery cycles.black liquor characterization, oxidation and causticization. lime mud reburning.

MODULE IV PAPER MAKING EQUIPMENT AND PROCESSES 9

Manufacture of paper and boards. Additive preparation. Special papers. Auxiliary paper mill equipment. Pollution control and effluent treatment in paper and pulp industries.

MODULE V PAPER TESTING AND SCOPE OF PAPER INDUSTRY 9

Specification for paper and boards.Testing of paper and paper products. Future and scope of paper industry in India. Use of alternate raw materials.

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Identify the available sources and preparation of pulp.
- CO2 :** Explain the steps involved in mechanical and chemical pulping process and determine the kappa number and H- factor for bleached pulp
- CO3 :** Analyze the significance of recycling of chemicals in paper manufacturing process
- CO4 :** Analyze the importance of additives in paper machine operation and control measures involved in paper and pulp industry
- CO5 :** Illustrate the quality parameters of paper and usage of alternate raw material for the scope of paper industry

TOTAL: 45 PERIODS

TEXT BOOKS

1. John B. Calkin, Modern Pulp and paper Making, Third Edition, Reinhold Pub.Corp, 1960.
2. Stephenson N., Pulp and Paper manufacture, Vol.1, 2, 3 and , McGraw Hill, New York, 1950.
3. Halpern M.G, Pulp Mill Processes, Park Ridge, N.J: Noyce Data Corporation, 1975

REFERENCES:

1. Britt.K.W., Handbook of Pulp and Paper Technology, Second Edition, CBS Publishers Delhi,1984.
2. Smook, G.A., Handbook for pulp and paper technologist, Third Edition, Angus Wilde Publications, Inc., 2003.
3. Casey J.P., Pulp and Paper: Chemistry and Chemical technology, Third Edition, Vol. 4, Wiley Interscience, 1983.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1		2	2	3		3					2	3	1	
2		2	3	3		3					2	3	1	
3		2	3	3		3		1				3	1	
4		2	3	3		3		1			2	3	1	
5		2	3	3		3		1			2	3	1	
Avg.		2	3	3		3		1			2	3	1	

1-low, 2-medium, 3-high

E19	SUGAR TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Sugar industry in India. Chemical and Physical properties of Sucrose and reducing sugars. Source for Sucrose. Formation of sucrose plants. Non sugar compounds of sugar cane. Inorganic constituents of sugar cane juices and sugars. Analytical methods used in Sugar Industry.

MODULE II PURIFICATION 9

Chemical technology of the purification processes. Fundamental reactions and physical chemistry aspects of clarification. Liming, sulphitation and carbonation processes. Filtration of sugar juice.

MODULE III EVAPORATION 9

Evaporation of sugar juice. Heat transfer in evaporators. Evaporation equipment and its auxiliaries. Methods of obtaining steam and quality of steam. Steam economy. Chemistry of the evaporation process. Scale formation and cleaning of evaporators.

MODULE IV CRYSTALLIZATION 9

Solubility of sucrose. Solubility of sucrose - nucleation in super saturated solutions - kinetics and growth of crystallization. Chemistry of crystallization. Control methods and equipment used in sugar crystallization; Technology of sugar crystallization. Evaporation and circulation in vacuum pans.

MODULE V CENTRIFUGATION 9

Theory of the centrifugal processes. Centrifugal operation. Engineering principles of sugar centrifugals and the centrifugal process. Centrifugal equipment and its auxiliaries. Production of final molasses and its utilizations. Grading of sugar.

COURSE OUTCOME

At the end of the course, students will be able to

CO1 : Determine the raw materials required for the manufacture of sugar and the analytical methods to be followed for high grade product.

CO2 : To produce a clear juice that is light in color and free of suspended matter

CO3 : Employ evaporation process to improve the concentration of syrup from clear juice.

CO4 : Determine the optimum temperature to control the size of sugar crystals and study the kinetics on growth rate

CO5 : Separate the sugar crystals based on the size and colour and utilise spent molasses to extract sucrose

TOTAL: 45 PERIODS

TEXT BOOKS

1. Honig P., Principles of Sugar Technology, Vol.1,2 and 3, Elsevier Publishing Company, 2013.
2. Van der Poel P.W., Schwartz T.K., Schiweck H.M., Sugar Technology [Beet and Cane Sugar

Manufacture], Beet Sugar Development Foundation (Fort Collins, Colo.), Fourth Edition, Verlag Dr Albert Bartens KG, 1998.

REFERENCES:

1. Payne J.H., Sugarcane factory Analytical control, Fifth Edition, Elsevier Publisher, London, 1968.
2. Jenkins G.H., Introduction to Sugarcane technology, Elsevier Publisher, London, 2010.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2			3	2					2		1
2	2	3	3			2	1					2		1
3	2	3	3			3	1					2		1
4	3	3	3			3	2					2		1
5	2	3	3			2	1					2		1
Avg.	2.2	3	2.8			2.6	1.4					2		1

1-low, 2-medium, 3-high

E20	SURFACE COATING TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I FILM FORMATION AND DRYING OILS 9

Film formation - Film forming compositions - Properties - Types of polymerization in film forming compounds. Drying oils - Composition - Manufacturing procedure.

MODULE II RESINS 9

Resins - Types - Natural resins and its extraction - Alkyl resin - Manufacturing procedure – Compositions.

MODULE III SOLVENTS AND ADDITIVES 9

Diluents - Thinners - Plasticizers - Driers - Additives - Anti settling agents in surface coating.

MODULE IV PIGMENTS 9

Pigments - Properties - Types - White pigments - Properties - Red pigments - Green pigments - Bluepigments - Black pigments - Properties and manufacturing procedure.

MODULE V COATINGS TYPES 9

Formulation of exterior coating - Interior - Decorative - Industrial - Special purpose - Marine – Bituminous.

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Analyze and improve the surface properties of materials for protection in demanding contact conditions or aggressive environments.

CO2 : Calculate the composition and properties of various resins and manufacturing procedures.

CO3 : Evaluate the amount of solvents and additives required for surface coating with its appropriate properties to meet out the quality standards.

CO4 : Design and develop the modern technologies involved in the synthetic pigments and choose the suitable pigments for better surface coatings.

CO5 : Differentiate the interior and exterior decorative coatings to be appropriately used for commercial purposes.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Payne H., Organic Coating Technology, Vol. I, John Wiley and Sons Inc., New York, 1954.
2. Payne, H., Organic coating technology, Pigments and Pigmented Coatings, Vol.2, John Wiley and Sons Inc., New York, 1961.

REFERENCES:

1. Noel Heaton, Introduction to Paint Technology, Second Edition, Charles Griffin and Co. Ltd., London,1940.

2. Wood H.R, Morrel R.S, The Chemistry and Technology of Drying Oils, Ernest Benn Ltd., Seventh Edition, 1984.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2									2		
2	2	3	3									2		
3	2	3	3									2		
4	3	3	3									2		
5	2	3	3									2		
Avg.	2.6	3	2.8									2		

1-low, 2-medium, 3-high

E21	TOTAL QUALITY MANAGEMENT	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Definition of TQM, basic approach, gurus of TQM, TQM frame work, defining quality, obstacles, benefits of TQM, leadership - Concepts, The deming philosophy, The role of TQM leaders, implementation, quality council, quality statements, strategic planning.

MODULE II TQM PRINCIPLES 9

Customer satisfaction - Customer perception of quality, using customer complaints, service quality, customer retention; employee involvement - Motivation, empowerment, teams, recognition and reward, performance appraisal, benefits; Continuous process improvement - The juran trilogy, The PDSA cycle, kaizen, six sigma; supplier partnership - Partnering, sourcing, supplier selection, supplier rating, relationship development; performance measures - Basic concepts, strategy, presentation, quality costs analysis techniques.

MODULE III STATISTICAL PROCESS CONTROL 9

The seven tools of quality, statistical fundamentals, process capability, control charts for variable and attributes, new seven management tools.

MODULE IV TQM TOOLS 9

Benchmarking - Reasons to benchmark, process, pitfalls and criticisms; Quality function deployment - Benefits, house of quality, QFD process; Taguchi's quality loss function; Total Productive Maintenance (TPM) - Concept, improvement needs; FMEA - Stages of FMEA.

MODULE V QUALITY SYSTEMS 9

Benefits of ISO registration, ISO 9000 series of standards, sector-specific standards, ISO requirements, implementation, documentation, internal audits, registration; environmental management system-ISO 14000 series standards, concepts of ISO 14001, requirements of ISO 14001, benefits of EMS.

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Describe the basic concepts of Total Quality Management.
- CO2 :** Identify the Principles of Total Quality Management.
- CO3 :** Apply and acquire knowledge on quality tools & Techniques.
- CO4 :** Formulate the Quality Management System for use in any process industries.
- CO5 :** Justify and Gain confidence in implementing Quality system Management in process industries.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Besterfield, Dale H., Carol Besterfield-Michna, Glen Besterfield and Mary Besterfield-Sacre,;Total Quality Management, Third Edition, Second Impression, Pearson Education Inc,

Delhi, 2007.

2. Subburaj Ramasamy, : Total Quality Management, Second reprint, Tata McGraw Hill publishingCompany Ltd, New Delhi, 2006.

REFERENCES:

1. Kumar S, Total Quality Management, 1st Ed., Reprint, Laxmi Publications (P) Ltd., Delhi, 2007.
2. Naagarazan R.S and Arivalagar A.A, :Total Quality Management, First Edition, Reprint, New Age International (P) Ltd., New Delhi, 2005.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2			3	2					2		
2	2	3	3			2	1					2		
3	2	3	3			3	1					2		
4	3	3	3			3	2					2		
5	2	3	3			2	1					2		
Avg.	2.6	3	2.8			2.6	1.4					2		

1-low, 2-medium, 3-high

**VERTICAL-I
PETROLEUM PROCESS TECHNOLOGY**

E22	PETROLEUM CHEMISTRY AND REFINING FUNDAMENTALS	L	T	P	C
		3	0	0	3

MODULE I CRUDE CHEMISTRY AND PRODUCTS 9

Origin, Formation and Evaluation of Crude Oil -Indian petroleum industries- types of Hydrocarbon- composition of crude oil (PONA, S, N₂ etc) -Thermo-physical and physical properties of crude oil- petroleum standards- chemical analysis data- Testing methods of petroleum products- Chemical quality of products-Types of crude-Crude assay- selection of crude based on product yield

MODULE II BASICS FOR REFINING 9

Properties of gas-Ideal gas laws-partial pressure-specific gravity-density-Properties of liquid- viscosity and index-boiling point-pressure of fluid at rest-flow resistance-static/induced pressure- specific/latent heat/condensation-modes of heat transfer-diffusion mass transfer-properties of solid.

MODULE III PETROLEUM THERMODYNAMICS AND CALCULATIONS 9

First/second law-behavior of gas and liquid — PVT relationship- equation of state-VLE- equilibrium constant-Multi component liquid vapor composition calculation-specific gravity calculation-TBP distillation-ASTM-conversion to pseudo-components-Molecular weight calculation-pseudo-critical properties-calculation of enthalpy of petroleum fractions-Generalized equation for thermo physical properties of petroleum.

MODULE IV REFINERY UNIT OPERATIONS AND CALCULATION 9

Distillation-types-column internals-multi component distillation-relative volatility- azeotropic mixture- absorption- desorption- adsorption- refrigeration - extraction- drying curve-humidification principle- crystallization-stripping operation-boiling curve- application of all operation in refinery and its basic design calculations.

MODULE V REFINERY PROCESSES AND CATALYST FUNDAMENTAL 9

Treating processes of petroleum products- Thermal/catalytic/hydro cracking-reforming/ isomerization /alkylation -principles and reactions- Catalyst phenomenon and theory- surface area/void volume/porosity- catalyst classification and preparation/selectivity/yield/reactivity- heterogeneous reactions- catalytic reactor types (packed bed/moving bed/fluidized bed)- residence time-space velocity- Catalyst loading techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Demonstrate the classification, composition and testing methods of crude petroleum and its products. Learn the mechanism of refining process.

CO2 : visualize the insights of primary treatment processes to produce the precursors.

CO3 : apply the secondary treatment processes cracking, vis-breaking and coking to produce more petroleum products.

CO4 : Appreciate the need of treatment techniques for the removal of sulphur and other impurities from petroleum products

CO5 : Demonstrate the societal impact of petrochemicals and learn their manufacturing processes and learn the importance of optimization of process parameters for the high yield of petroleum products.

TEXT BOOKS

1. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi, 2000
2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edition, McGraw-Hill, 2005.
3. Treybal, R.E., "Mass Transfer Operations", 3rd Edn., McGraw-Hill, 1981.

REFERENCES:

1. W. L. Nelson, Petroleum Refinery Engineering, McGraw-Hill Book Co , 1969
2. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press , 5th Edition, 2007
3. Wayne C. Edmister, "Applied Hydrocarbon Thermodynamics", Gulf Publishing Co., 2nd edition, 1988

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	2			3	2					2	1	
2	2	3	3			2	1					2	1	
3	2	3	3			3	1					2	1	
4	3	3	3			3	2					2	1	
5	2	3	3			2	1					2	1	
Avg.	2.6	3	2.8			2.6	1.4					2	1	

1-low, 2-medium, 3-high

E23	PRIMARY REFINING TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I FEED PREPARATION 9

Pipelines from port to tank farm -safety and regulations -storage techniques in crude oil-impurities removal- measuring by dipping -spiking techniques -types of salts in crude - desalting process – electric desalter- preheating train and design- furnace and its operations.

MODULE II ATMOSPHERIC DISTILLATION 9

Operation and process description of ADU-design characteristics of ADU tower-cutpoints-degree of fractionation-over flash-column pressure and overhead temperature- Preflash system- overhead system-side streams-intermediate pump around and reflux systems- Refinery off gas – LPG treatment-Naphtha stabilizer and splitter-side stripping sections-operating variables.

MODULE III VACUUM DISTILLATION 9

Operation of VDU- Need of vacuum- ejectors and its types/principle- Overhead ejector system- flash zone- draw off temperature- internal flow in VDU- light/middle/heavy cuts- routing to secondary units- lube based treatments-packing section tower loading of VDU.

MODULE IV LUBE OIL BASE STOCKS 9

Viscosity index calculation and pour point - LOBS processing by solvent treatment and hydro treatment- solvent selection-solvent extraction by NMP, furfural,- MEK solvent dewaxing/- refrigerating and filtration -hydro finishing- types of LOBS based on VI- types or groups of lube processing- spindle/LN/IN/HN/BN processing and blending.

MODULE V ASPHALT AND WAX TECHNOLOGY 9

Vacuum residue properties- propane deasphalting-asphalt processing and types-chemical structure- air blowing of bitumen- slack wax processing- wax and types/properties- wax deoiling- unit operations in wax plants- refrigerating and filtration/ hydro treating of wax- molding and storage.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Understand the methodologies in the primary petroleum refining processes like crude preparation, atmospheric and vacuum distillation, Lube, asphalt and wax processing.

CO2 : Understand each refinery process working through various technologies

CO3 : Assess the operating variables that are applied to achieve the objectives of each refinery process.

CO4 : Evaluate the methodologies of processing and blending techniques.

CO5 : Assess the prepared feed and adopted techniques in refining technology for applying in real time applications.

TEXT BOOKS

1. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi, 2000

2. W. L. Nelson, Petroleum Refinery Engineering,, McGraw-Hill Book Co , 1969

3. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press , 5th Edition, 2007

REFERENCES:

1. J.G. Speight and B. Ozum, "Petroleum Refining Processes", Marcel Dekker Inc, New York, 2002
2. G.D. Hobson, "Modern Petroleum Technology", Vol I & II, John Wiley & Sons, New York, 5th edition, 1984
3. David.S.J."STAN" Jones and Peter R.Pujado "Handbook of Petroleum Processing, Springer, 2006.

1.

2. CO-PO & PSO MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
1	2												2	1	
2	2												2	1	
3	2												2	1	
4	3												2	1	
5	2												2	1	
Avg.	2.6												2	1	

1-low, 2-medium, 3-high

E24	SECONDARY REFINING TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I THERMAL CRACKING AND COKING 9

Resid upgradation technologies- cracking-thermal cracking-mechanism/principle/reactions- process variables- Vis-breaking- soaker process- coil vis-breaker-Disadvantages-Coking- thermodynamics and mechanism of coking-delayed coking-operation-fluid coking-flexi-coking- types of coke and properties- yield pattern of cracking and coking.

MODULE II CATALYTIC CRACKING 9

Principles of catalytic cracking-mechanisms- FCC- main reaction of FCC- role of FCC in refinery- Fluidization- feedstocks/products/yield pattern- Kinetics and thermodynamics of FCC reactions- FCC catalyst and licensor technologies- reaction/regeneration/fractionation sections-slide valves and its importance- riser/cyclone separator/reactor internals-RFCC/MSCC/Petro FCC.

MODULE III HYDROGEN AND HYDROCONVERSION 9

H₂ requirements-steam reforming and shift conversion-operation and thermodynamics of reformer and Ni catalyst-Hydro treatment processes- catalyst and reaction chemistry- Naphtha/Diesel/lube/wax/gasoline hydro treatment-Hydrocracking process- Typical hydrocracker in refinery- catalyst/severity/conversion/Temperature profile for yield pattern-reaction kinetics of hydrocracker- Operation and variables.

MODULE IV REFORMING/ISOMERISATION/ALKYLATION 9

Reforming feed index-RON-various reforming technologies-platforming reactions-kinetics and thermodynamics of Pt catalyst reactions-Operation in Straight Run and Continuous Run mode- yield calculation- Isomerization techniques- reactions and kinetics- various technologies in isom- importance of catalyst-hexane production-Alkylation process-reactions – various alkylation processes- process variables in reforming/isom/alky.

MODULE V FINISHING PROCESSES AND UTILITIES 9

Sources of sulfur in refinery-types of sulfur compounds in crude-sweetening processes- various sulfur treatment process in products-H₂S properties and removal by physical and chemical process- Amine selection –amine absorption and regeneration-sour water stripping- Merox process- Sulfur recovery from H₂S by Claus /super Claus/ modified Claus technology/SCOT Process/CS₂ process; Electricity and steam generation by Gas turbine/boiler-Cooling tower operation-Fuel oil-Cryogenic distillation of air to N₂ and O₂ production- Instrument air operation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : acquires knowledge on different methodologies in the secondary petroleum refining processes like thermal cracking, coking, catalytic cracking, hydrocracking.

CO2 : understand the operation on FCC, Vis breaker, DCU, Reformer.

CO3 : Demonstrate the operation on utilities like steam, cooling water, instrument air, H₂, N₂

CO4 : understand the basic knowledge on isomerization, alkylation and reforming process.

CO5 : gather some knowledge in the finishing processes and their operations in refining industries.

TEXT BOOKS

1. BK BhaskaraRao, Modern Petroleum Refining Processes, Oxford & IBH Publishing Co. Pvt. Ltd.
2. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi, 2000
3. W. L. Nelson, Petroleum Refinery Engineering,, McGraw-Hill Book Co , 1969

REFERENCES:

1. J.G. Speight and B. Ozum, "Petroleum Refining Processes", Marcel Dekker Inc, New York, 2002
2. G.D. Hobson, "Modern Petroleum Technology", Vol I & II, John Wiley & Sons, New York, 5th edition, 1984
3. David.S.J."STAN"Jones and Peter R.Pujado "Handbook of Petroleum Processing, Springer,2006.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2											2	1	1
2	2											2	1	1
3	2											2	1	1
4	3											2	1	1
5	2											2	1	1
Avg.	2.6											2	1	1

1-low, 2-medium, 3-high

E25	REFINERY ADVANCEMENTS AND ENVIRONMENTAL REGULATIONS	L	T	P	C
		3	0	0	3

MODULE I ENVIRONMENTAL REGULATION AND GOVERNMENT POLICIES 9

Classes of petroleum based on flash point- storage tank design- GAS/LIQUID/SOLID wastes from refinery units-environmental standards on air and water pollution and control-Solid waste management- Sludge conditioning and treatment and disposal- Effluent treatment plant-TTP-greenhouse gases-Bharat stages and its regulations- Recent modification for BS-6- Policies on biofuel-EBP-Bio-diesel.

MODULE II CORROSION AND SAFETY 9

Corrosion- reaction and types- refinery corrosion tests- controlling parameters- corrosion control in equipment and pipelines-Types of fire- Safety triangle- Firefighting equipment-PPE- HAZOP studies- Petroleum disasters case study- process safety protocol- pressure relief systems- flare systems- CBD/OWS- MSDS for units- oil spilling and skimming.

MODULE III ADVANCEMENTS IN REFINERY 9

Instrumentation- Flow/pressure/temperature/level transmitter-Control systems and logics – controller types- mode of controllers- cascade, split range, ratio etc. - P/PI/PID controllers and control tuning-process optimization by APC/DMC- DCS/PLC systems.

MODULE IV REFINERY UNIT INTEGRATION AND RECENT TRENDS 9

Overall modern refinery flow sheet- products routing- naphtha utilization route up and integration- Diesel/gasoline/ATF/kerosene route up to blending header- Blending processes- line blending- Blending of diesel and MS calculation- LP model for blending operation- Recent trends in ADU with pre flash- RFCC-OHCU-Prime G+-catalytic dewaxing- PSA technology-DWC technology- Blue H₂ process-Pre-reforming- moving bed in CRU and isom-Advanced lube processing.

MODULE V ENERGY SAVING AND REFINERY ECONOMICS 9

Furnace efficiency calculation-steam utilization- plume length- insulation of pipelines- heat tracing-steam traps-Standard Refinery Fuel Tonnage- Fuel and loss- operational cost- margin cost- refining capacity-complexity factor- crude oil evaluation and procurement-monthly production planning-cracks-Gross Refinery Margin-operation optimization by Linear Programming model-shutdown planning- Refinery Transfer Price-taxation-pricing.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the regulations and government policies in refining industries.
- CO2 :** Acquire some knowledge on advanced techniques, automation and instrumentation techniques.
- CO3 :** Understand the different controllers and automated control systems in refineries.
- CO4 :** Gathers knowledge on unit integrations in refineries.
- CO5 :** Understand the basis on energy saving techniques and refinery economics.

TEXT BOOKS

1. W. L. Nelson, Petroleum Refinery Engineering, McGraw-Hill Book Co , 1969
2. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press, 5th Edition, 2007
3. Sankara Papavinasam, Corrosion Control in the Oil and Gas Industry 1 st Edition, 2013

REFERENCES:

1. Jean Masseron, Technip; Petroleum Economics, 4th revised Edition, 2000. (ISBN-10: 2710805979; ISBN-13: 978-2710805977).
2. Cheremisinoff N.P. and Graffia M.L., “Environmental Health and Safety Management. A Guide to Compliance”, Pressure safety de-sign practices for refinery and chemical operations”, Jaico Publication. 2003
3. Fontana, M.G., “Corrosion Engineering”,3rd Edition, McGraw Hill, 1989

CO-PO & PSO MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
1	2	3	3										2	1	1
2	2	3	3										2	1	1
3	2	3	3										2	1	1
4	3	3	3										2	1	1
5	2	3	3										2	1	1
Avg.	2.6	3	3										2	1	1

1-low, 2-medium, 3-high

E26	PETROLEUM EQUIPMENT DESIGN	L	T	P	C
		3	0	0	3

MODULE I DESIGN OF CASING AND TUBING 9

Casing program, casing and tubing design, principles of cementing, completion added skin, well perforating, hydraulic fracturing. BHA (Bottom hole assembly). ESP(Electrical submersible pumps), SRP(Sucker rod pumping) unit design.

MODULE II PRODUCTION AND PROCESSING EQUIPMENT 9

Design of Surface Facilities -Design of production and processing equipment, including separation problems, treating, and transmission systems.

MODULE III UPSTREAM PROCESSES9

Capstone design in the areas of geology, reservoir engineering, production, drilling and well completions to practical design problems based on real field data with all of the associated shortcomings and uncertainties. Use of commercial software.

MODULE IV MIDDLE STREAM PROCESSES 9

Oil desalting-horizontal and spherical electrical dehydrators- Natural Gas Dehydration-Horton sphere-Natural Gas Sweetening. Crude & Condensate Stabilization-design of stabilizer- Oil and Gas Treatment. Treating Equipment.

MODULE V DOWNSTREAM PROCESSES 9

Refinery Equipment Design-atmospheric distillation column Design and construction of on/ offshore pipelines, Fields Problems in pipeline, Hydrates, scaling & wax etc and their mitigation

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the drill bit fundamentals, codes and standards
- CO2 :** Understand design of production and processing equipment.
- CO3 :** Understand the Capstone design in reservoir engineering.
- CO4 :** Understand the design of oil and Gas Treatment Equipment
- CO5 :** Understand the design of pipe systems.

TEXT BOOKS

1. Moody, G.B. Petroleum Exploration Hand book.
2. Sahay.B et al Wellsite Geological Techniques for petroleum Exploration.

REFERENCES:

1. William C.Lyons& Gary J.Plisga, Standard Hand Book of Petroleum & Natural Gas Engineering”, 2nd Edition 2005, Gulf professional publishing comp (Elsevier).

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2	3	3									2	1	1
2	2	3	3									2	1	1
3	2	3	3									2	1	1
4	3	3	3									2	1	1
5	2	3	3									2	1	1
Avg.	2.6	3	3									2	1	1

1-low, 2-medium, 3-high

E27	PETROCHEMICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I PETROCHEMICALS EVOLUTION 9

Petrochemical Industries and their feedstock selection History, Economics, Growth of petrochemical industry-structure of Petrochemical complexes- Classification of petrochemicals- Basic building processes- Integration with refinery-flow scheme.

MODULE II INTERMEDIATES FOR PETROCHEMICALS INDUSTRIES 9

Production Methods - Reforming and cracking of feed stocks; Sources: Chemicals from synthesis gas, olefins and aromatics-Ethylene, Propylene, C₄hydrocarbons, higher olefins, Benzene, Toluene, Xylene and their derivatives.

MODULE III COMPLEX PETROCHEMICAL PRODUCTS 9

Acrylonitrile, Acrylic acid, dimethyl terephthalate, ethanol, ethylene glycol, linear alkyl benzene, methyl tertiary butyl ether, vinyl acetate, vinyl chloride, Maleic and phthalic anhydride, ethyl benzene, Phenol, Cumene, Styrene, Bisphenol, Aniline – Process flow scheme- various technology- advantages-yield pattern-process variables.

MODULE IV POLYMERS 9

Polymers production: Fibers, Rubbers and Plastics. Acrylonitrile butadiene styrene (ABS), polyethylene-LDPE, HDPE, Polypropylene, PVC, PS, SAN, SBR, PAN, Nylon and Polycarbonates.

MODULE V GLOBAL CHEMICALS 9

Petrochemicals-Lubricants, additives, adhesives, agrochemicals, cosmetics raw materials, electronic chemicals, detergents, paint, healthcare and pharmaceuticals, Fertilizers- Ammonia, Urea, NPK etc.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic knowledge on petrochemical industry and their growth, history.
- CO2 :** understand the different methods of production in petrochemical products and their derivatives
- CO3 :** gather knowledge on the production of complex petrochemical products
- CO4 :** understand the petrochemical industries and its application with production techniques in polymers
- CO5 :** understand the application of petrochemicals in all process fields.

TEXT BOOKS

1. Bhaskara Rao, B.K. "A Text on Petrochemicals", 2nd Edition, Khanna Publishers, New Delhi, 1998
2. H. Steiner, "Introduction to petrochemicals", Pergamon Press, New York, 1961.
3. Wiseman.P., "Petrochemicals", UMIST Series in Science and Technology, John Wiley & Sons, 1986..

REFERENCES:

1. Brownstein A.M., 'Trends in Petrochemical Technology', Petroleum publishing company, 1976.
2. G. Margaret Wells, 'Handbook of Petrochemicals and Processes' 2nd Revised Edition, Gower Publishing Company.
3. Groogins, "Unit Process in Organic Synthesis", McGraw Hill Book Company, New York.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	1											1	
2	1	1											1	
3	1	1											1	
4	1	1											1	
5	1	1											1	
Avg.	1	1											1	

1-low, 2-medium, 3-high

VERTTICAL- II
ENERGY ENGINEERING

E28	BIO ENERGY	L	T	P	C
		3	0	0	3

MODULE I BIOMASS SOURCES AND CLASSIFICATION **9**

Biomass characteristics & preparation; Chemical composition and properties of biomass; Size reduction, Briquetting of loose biomass, Drying, Storage and handling of biomass.

MODULE II BIOGAS TECHNOLOGY **9**

Feedstock for producing biogas; Microbial and biochemical aspects and operating parameters for biogas production, Kinetics and mechanism. Dry and wet fermentation, Digestors for rural application- High-rate digesters for industrial waste water treatment.

MODULE III PYROLYSIS AND THERMO-CHEMICAL CONVERSION **9**

Thermo-chemical conversion of lignocellulosic biomass. Incineration for safe disposal of hazardous waste, Biomass processing for liquid fuel production, Pyrolysis of biomass-pyrolysis regime, effect of particle size, temperature, and products obtained.

MODULE IV GASIFICATION OF BIOMASS **9**

Thermochemical principles: Effect of pressure, temperature and introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers, Safety aspects.

MODULE V COMBUSTION OF BIOMASS AND COGENERATION SYSTEMS **9**

Combustion of woody biomass-theory, calculations and design of equipment, Cogeneration in biomass processing industries. Case studies: Combustion of rice husk, Use of bagasse for cogeneration.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the fundamental knowledge on classification, characterization and sources of biomass.
- CO2 :** learn the production of biogas
- CO3 :** gather knowledge on the operations of incineration, pyrolysis.
- CO4 :** understand the process in gasification of biomass
- CO5 :** knowledge on the types of combustion of biomass

TEXT BOOKS

1. Anju Dahiya, Bioenergy: Biomass to biofuels First Edition, Academic Press, 2014.
2. Li, Yebo, and Samir Kumar Khanal. Bioenergy: principles and applications. John Wiley & Sons, 2016.

REFERENCES:

1. Vaughn C Nelson, Kenneth L. Starcher. Introduction to bioenergy. CRC Press, 2017.

2. Wall, Judy D., Caroline S. Harwood, and Arnold Demain. "Bioenergy." Bioenergy.. ASM Press, 2008.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	1											1	
2	1	1											1	
3	1	1											1	
4	1	1											1	
5	1	1											1	
Avg.	1	1											1	

1-low, 2-medium, 3-high

E29	RENEWABLE ENERGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Energy: Past, Today, and Future. A brief history of energy consumption. Energy & Environment. Renewable Energy – Quality, quantity, availability, advantageous and limitations.

MODULE II SOLAR ENERGY 9

Sun and its Energy: Basics of Solar Energy. Solar Energy in the Past. Solar Thermal Energy Solar Photovoltaic.

MODULE III BIO ENERGY & GEOTHERMAL ENERGY 9

Conversion. Bio degradation. Biogas generation. Fuel properties. Biomass gasifier. Geothermal Resources, Geothermal Technologies.

MODULE IV WIND ENERGY 9

Wind Resources. Wind Turbines. Environmental Impact. Data and energy estimation. Conversion. Wind mill Performance and applications.

MODULE V TIDAL ENERGY 9

Tidal energy; Ocean Energy Potential against Wind and Solar. Wave Characteristics and Statistics. Wave Energy Devices. Tide Energy Technologies. Ocean Thermal Energy. Osmotic Power.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the fundamental knowledge on history, consumption of energy.
- CO2 :** learn the production of solar energy.
- CO3 :** gather knowledge on the geothermal and bio energy.
- CO4 :** understand the production of wind energy and their utilization
- CO5 :** knowledge on the production and utilization of tidal energy

TEXT BOOKS

1. Mukherjee, D., and S. Chakrabarti. Fundamentals of renewable energy systems. New Age International, 2004.
2. Jenkins, Nicholas, and Janaka Ekanayake. Renewable energy engineering. Cambridge University Press, 2017.

REFERENCES:

1. Kishore, V. V. N., ed. Renewable energy engineering and technology: principles and practice. The Energy and Resources Institute (TERI), 2010.
2. Tiwari, Gopal Nath, and Rajeev Kumar Mishra. Advanced renewable energy sources. Royal Society of Chemistry, 2012.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	1											1	
2	1	1											1	
3	1	1											1	
4	1	1											1	
5	1	1											1	
Avg.	1	1											1	

1-low, 2-medium, 3-high

E30	HYDROGEN AND FUEL CELL TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work Potentials, prediction of reversible voltage, fuel cell efficiency, Types of fuel cells.

MODULE II FUEL CELL KINETICS 9

Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

MODULE III CHARACTERIZATION TECHNIQUES 9

Fuel cell characterization - in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modeling and system integration: - 1D model – analytical solution and CFD models.

MODULE IV RENEWABLE SOURCES 9

Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

MODULE V APPLICATIONS OF FUEL CELL 9

Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the fundamental knowledge on history, consumption of energy.
- CO2 :** learn the production of solar energy.
- CO3 :** gather knowledge on the geothermal and bio energy.
- CO4 :** understand the production of wind energy and their utilization
- CO5 :** knowledge on the production and utilization of tidal energy

TEXT BOOKS

1. Gregor Hoogers, "Fuel Cell Technology Handbook", CRC Press, 2003.
2. R.P. O'Hayre, S. Cha, W. Colella, F.B. Prinz, "Fuel Cell Fundamentals", Wiley, 2006.
3. J. Bard, L. R. Faulkner, "Electrochemical Methods", Wiley, 2004.

REFERENCES:

1. S. Basu, "Fuel Cell Science and Technology", Springer, 2007.
2. H. Liu, "Principles of Fuel Cells", Taylor & Francis, 2006.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	1											1	
2	1	1											1	
3	1	1											1	
4	1	1											1	
5	1	1											1	
Avg.	1	1											1	

1-low, 2-medium, 3-high

E31	POWER PLANT ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I POWER PLANTS 9

Features, Components and Layouts - Working of Power Plants, Power Plant Economics.

MODULE II BOILER CLASSIFICATION 9

Boiler Types - Fire Tube & Water Tube Boilers - Fluidized Bed Boilers - Positive Circulation Boilers - Thermal Liquid Heaters & Vaporizers.

MODULE III STEAM TURBINES 9

Classification - Features - Working – Performance; Losses in Steam Turbines -Trouble Shooting.

MODULE IV GAS TURBINES 9

Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

MODULE V GASIFICATION CYCLES 9

Integrated Gasification Combined Cycle (IGCC) – Indirect Fired Combined Cycle (IFCC) – Magneto Hydrodynamics (MHD) – Fuel Cells – Micro turbines– RDF based power plants.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the fundamental knowledge on components, layouts and working of power plants
- CO2 :** learn the types, classification and usage of boilers
- CO3 :** gather knowledge on classification and usage of steam turbines
- CO4 :** understand the types of gas turbines
- CO5 :** knowledge on the application of integration of various process in power plants.

TEXT BOOKS

1. Thomas C. Elliott, "Standard Hand Book of Power Plant Engineering"

REFERENCES:

1. E L Wakil, "Power Plant Engineering", McGraw-hill Book Co, N.Y. 2001
2. Arora and Domkundwar, A course in Power Plant Engineering, Dhanpat Ra, N.Delhi.2003
3. Nag, P.K., "Power Plant Engineering", 2nd Edition, TMH, 2001.

CO-PO & PSO MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
1	1												1	1	
2	1												1	1	
3	1												1	1	
4	1												1	1	
5	1												1	1	
Avg.	1												1	1	

1-low, 2-medium, 3-high

E32	NON-RENEWABLE ENERGY SOURCES	L	T	P	C
		3	0	0	3

MODULE I PETROLUEM 9

Origin of Petroleum, Composition, Extraction of Petroleum. Products of Petroleum refining: Diesel; Gasoline; LPG; Fuel oil; Tar; and Bitumen. Environmental Issues associated with petroleum resources

MODULE II COAL 9

Types of coal; Composition of coal; Oxygen content, Proximate and Ultimate Analysis of coal; Carbonization, Coal for generation of electricity, coal liquefaction, coal blending. Environmental Issues associated with usage of coal.

MODULE III NATURAL GAS 9

Resources of Natural Gas, Properties and classification of natural gas, transportation of natural gas, products from natural gas, liquefied natural gas, chemicals from natural gas, shale gas; Environmental Issues associated with usage of coal.

MODULE IV NUCLEAR ENGINEERING FUNDAMENTALS 9

Nuclear models, binding energy, Radio activity, half-life, mechanism of nuclear fission and fusion, decay chains, neutron reactions. Nuclear Fuels; Nuclear fuel reserves of Uranium and Thorium, Nuclear fuel cycles, characteristics, production and purification, other fuels Zirconium, Beryllium.

MODULE V NUCLEAR ENERGY 9

Nuclear reactors and classification, boiling water reactors (BWR), pressurized heavy water reactor (PHWR), fast breeder reactor (FBR), basics of nuclear fusion reactor. Nuclear Power Plant -Waste Management and Safety.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the fundamental knowledge on components, layouts and working of power plants
- CO2 :** learn the types, classification and usage of boilers
- CO3 :** gather knowledge on classification and usage of steam turbines
- CO4 :** understand the types of gas turbines
- CO5 :** knowledge on the application of integration of various process in power plants.

TEXT BOOKS

1. Breeze, Paul. Nuclear power. Academic Press, 2016.
2. Viswanathan, Balasubramanian. Energy sources: fundamentals of chemical conversion processes and applications. Newnes, 2016.
3. Rao, S., and B. B. Parulekar. "Energy Technology: Non-conventional, Renewable and Conventional." Khanna Publication, 3rd (2012).

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1											1	1	
2	1											1	1	
3	1											1	1	
4	1											1	1	
5	1											1	1	
Avg.	1											1	1	

1-low, 2-medium, 3-high

E33	SUSTAINABILITY ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I SUSTAINABILITY AND ITS RELEVANCE 9

Introduction to the idea of sustainability and its relevance, social issues and the environment from unsustainable to sustainable development.

MODULE II WATER CONSERVATION FOR SUSTAINABLE ENVIRONMENT 9

Water conservation, rainwater harvesting, watershed management, resettlement and rehabilitation of people, its problems and concerns.

MODULE III ENVIRONMENTAL ACTS 9

Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act. Issues involved in enforcement of environmental legislation- public awareness

MODULE IV SUSTAINABILITY - A CHAIN APPROACH 9

Tools used to ensure sustainability in engineering activities (environmental management systems and environmental impact assessment); green buildings; green chemistry; sustainable cities; sustainable transportation; sustainable sources of energy; economic and social factors affecting sustainability.

MODULE V CASE STUDIES 9

Case studies, environmental ethics, issues and possible solutions- climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies. Wasteland reclamation, consumerism and waste products.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1** : *Understand the importance of Sustainable Environment.*
- CO2** : *Know about the types of water conservation and its importance*
- CO3** : *Acquire knowledge on the Environmental Acts*
- CO4** : *Develop an assessment technique for Sustainable development*
- CO5** : *Assess and report a real time problem and solutions for the Sustainable development*

TEXT BOOKS

1. Bhavik.R. Bhakshi, Sustainable Engineering- Principle and practice ,Cambridge University Press.
2. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT LTD,New Delhi, 2007.

REFERENCES:

1. Dara SS (2005) A Text Book of Environmental Chemistry and Pollution Control, S. Chand & Company, New Delhi.
2. Erach Bharucha, "Textbook of Environmental Studies", Universities Press(I) PVT, LTD, Hyderabad, 2015.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1						3	2						
2							3							
3	1	1				2	3							
4		1												
5			1						2				1	
Avg.	1	1	1			2	3	2	2				1	

1-low, 2-medium, 3-high

VERTICAL-III
INDUSTRIAL BIOTECHNOLOGY

E34	BIOCHEMISTRY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION TO BIOMOLECULES – CARBOHYDRATES 9

Basic principles of organic chemistry, role of carbon, types of functional groups, chemical, nature of water, pH and biological buffers, bio molecules structure and properties of Carbohydrates (mono, di, oligo & polysaccharides) Proteoglycans, glucosaminoglycans. mutarotation, glycosidic bond, reactions of monosaccharides, reducing sugars. Starch, glycogen, cellulose and chitin. Proteoglycans, glucosaminoglycans. hyaluronic acid, chondroitin sulfate.

MODULE II STRUCTURE AND PROPERTIES OF OTHER BIOMOLECULES 9

Fatty acids, glycerol, saponification, iodination, hydrogenation, phospholipids, glycolipids, sphingolipids, cholesterol, steroids, prostaglandins. Amino Acids, Peptides, Proteins, measurement, structures, hierarchy of organization primary, secondary, tertiary and quaternary structures, glycoproteins, lipoproteins. Determine of primary structure. Purines, pyrimidines, nucleoside, nucleotide, RNA, DNA-Watson-Crick structure of DNA, reactions, properties, measurement, nucleoprotein complexes.

MODULE III METABOLISM CONCEPTS AND CARBOHYDRATE METABOLISM 9

Functions of Proteins, Enzymes, introduction to biocatalysts, metabolic pathways, primary and secondary metabolites. Interconnection of pathways and metabolic regulation. Glycolysis, TCA cycle, gluconeogenesis, pentose phosphate shunt & glyoxalate shunt.

MODULE IV INTERMEDIARY METABOLISM AND REGULATION 9

Fatty acid synthesis and oxidation, reactions of amino acids, deamination, transamination and decarboxylation, urea cycle, Bioenergetics - High energy compounds, electronegative potential of compounds, respiratory chain, ATP cycle, calculation of ATP yield during oxidation of glucose and fatty acids.

MODULE V PROTEIN TRANSPORT AND DEGRADATION 9

Protein targeting, signal sequence, secretion; Folding, Chaperone and targeting of organelle proteins, Protein degradation, receptor-mediated endocytosis, turnover.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic concepts on carbohydrates
- CO2 :** learn the concepts of proteins
- CO3 :** gather knowledge on importance of nucleic acids
- CO4 :** understand the knowledge on lipids
- CO5 :** gather knowledge on intermediary metabolism and their pathways.

TEXT BOOKS

1. Lehninger Principles of Biochemistry 6th Edition by David L. Nelson, Michael M. Cox W.H.Freeman and Company 2017.
2. Satyanarayana, U. and U. Chakerapani, "Biochemistry" 3rd Rev. Edition, Books & Allied (P) Ltd., 2006.
3. Rastogi, S.C. "Biochemistry" 2nd Edition, Tata McGraw-Hill, 2003.

REFERENCES:

1. Berg, Jeremy M. et al. "Biochemsitry", 6th Edition, W.H. Freeman & Co., 2006.
2. Murray, R.K., etal "Harper's Illustrated Biochemistry", 31st Edition, McGraw-Hill, 2018.
3. Voet, D. and Voet, J.G., "Biochemistry", 4th Edition, John Wiley & Sons Inc.,2010

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						2							
2	3				1				1			1		
3	3		1											
4	3		2											
5	3	3	3	2	1	3	2	1	2	1	1	1	3	1
Avg.	3	3	2	2	1	3	2	1	1.5	1	1	1	3	1

1-low, 2-medium, 3-high

E35	BIOPROCESS TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION TO BIOPROCESS 9

Biologists and Engineers, comparison of chemical and biochemical processing overview of biological basics, About cells and its growth, the stoichiometry of microbial growth and product Bioprocesses: Regulatory Constraints.

MODULE II MEDIA FORMULATION AND DEVELOPMENT 9

Media formulation, Media Sterilization: Methods of heat sterilization of media, thermal death kinetics, design criteria, batch and continuous sterilization. Air Sterilization: Methods of air sterilization, mechanism of air sterilization, solid and liquid handling. Industrially fermented broth.

MODULE III BIOREACTORS 9

Purpose and importance of bioreactors, Classification of bioreactors, bioreactors for animal cells, bioreactors for plant cells, bioreactors for immobilized cells, operations of bioreactors, stirred tank reactor, plug flow reactor (PFR), fluidized bed reactor, bubble column, airlift reactor, Agitation, and Aeration: Mechanical agitation, power consumption in agitation, bubble aeration, bioreactors for waste management.

MODULE IV TRANSPORT PROCESSES 9

Aspects of rheology, Fluid flow in packed-bed and Fluidized bed columns, Gas-liquid mass transfer in cellular systems Diffusivity and mechanism of mass transfer - derivation of the equations of mass transport by diffusion-stationary and unsteady mass transport by diffusion, mass transfer coefficient, macroscopic balances for mass transport. Mechanisms and applications of heat transfer-mode of heat transfer-conduction, convection and radiation, Application of Heat and Mass transfer in biochemical processes.

MODULE V BIOETHICS AND BIOSAFETY 9

Introduction to Bioethics. Social and ethical issues, the process of biotechnology involved in generating new forms of life for informed decision making, Definition of Biosafety. Biosafety for human health and environment. Social and ethical issues. Use of genetically modified organisms and their release into the environment.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the fundamental knowledge on bioprocess technology.
- CO2 :** learn the production process of biomolecules
- CO3 :** gather knowledge on the operations of bioreactors and their purpose
- CO4 :** understand the transportation processes in reactors and their behaviors
- CO5 :** knowledge on the biosafety and information on bioethics.

TEXT BOOKS

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996.
3. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books

REFERENCES:

1. Bird R.B., Steward W.E., and Lightfoot E.N., Transport Phenomena, John Wiley & sons, Inc., New York, 2002
2. C J Geankoplis, Transport Processes and Separation Processes Principles, 4th Edition, New Jersey, PHI Publishers, 2010

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						2							
2	3				1				1			1		
3	3		1											
4	3		2											
5	3	3	3	2	1	3	2	1	2	1	1	1	3	1
Avg.	3	3	2	2	1	3	2	1	1.5	1	1	1	3	1

1-low, 2-medium, 3-high

E36	FERMENTATION AND BIOPROCESSING	L	T	P	C
		3	0	0	3

MODULE I FERMENTATION PROCESSES 9

Importance of fermentation, Fermentation and redox potential, solid-liquid fermentation, solid state fermentation, Kinetics of fermentations, Biosensors for fermentations, Production processes in fermentation.

MODULE II MICROBIAL GROWTH KINETICS 9

Diversity of patterns of microbial growth in situ and ex situ, Microbial growth under homogeneous conditions, Heterogeneous microbial growth, Growth kinetics, Derivation of mathematical models, and identification.

MODULE III DESIGN OF FERMENTERS 9

Fermentation processes and microorganisms, Kinetics and stoichiometry, Mass balances and design for batch, continuous and fed-batch reactors, Comparison of batch, continuous and fed-batch reactors, Heat generation and heat balances, examples of industrial fermentation processes.

MODULE IV INSTRUMENTATION AND CONTROL 9

Common Instruments for Process Automation – Temperature, Gas Flowrate, Liquid Flowrate, Off-Gas Analysis, pH, Dissolved Oxygen, Pressure, Foam Level, Stirring , Redox Potential, Advanced Instrumentation for Bioprocess Control and Automation - Flow Injection Analysis, Sequential Injection Analysis Fluorescence, Mass Spectrometry, Near Infrared Spectroscopy, Soft sensors, Biomass, Bioreactor automation.

MODULE V FERMENTATION AND COMMODITY PRODUCTS 9

Engineering of Secretory Pathways, production of heterologous proteins, fungal, yeast fermentation of industrial products.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic concepts on carbohydrates
- CO2 :** learn the concepts of proteins
- CO3 :** gather knowledge on importance of nucleic acids
- CO4 :** understand the knowledge on lipids
- CO5 :** gather knowledge on intermediary metabolism and their pathways.

TEXT BOOKS

1. Aydin Berenjian, Essentials in Fermentation Technology, Sringer 2019.
2. Peter F. Stanbury, Allan Whitaker and Stephen, Principles of Fermentation Technology (Second Edition), J. Hall, Pergamon, 1995.

REFERENCES:

1. Henry C. Vogel and Celeste M. Todaro, Fermentation and Biochemical Engineering Handbook; Third Edition, Elseveir,2014.
2. Owen P. Ward, Fermentation Biotechnology: Principles, Processes, and Products, (Prentice Hall advanced references series), 1989.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						2							
2	3				1				1			1		
3	3		1											
4	3		2											
5	3	3	3	2	1	3	2	1	2	1	1	1	3	1
Avg.	3	3	2	2	1	3	2	1	1.5	1	1	1	3	1

1-low, 2-medium, 3-high

E37	BIO SEPERATION AND DOWNSTREAM PROCESSING	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Introduction to By-products and Bioseparation: Range and characteristics of bio products, Characteristics of Fermentation Broth, Selection of unit operation with due consideration of the physical, chemical and biochemical aspects of biomolecules. Stages of Downstream Processing.

MODULE II CENTRIFUGATION AND FILTRATION 9

Primary Separation: Removal of insoluble and Biomass (and particulate debris) separation techniques, Flocculation and sedimentation, Centrifugation-Ultracentrifugation, Gradient centrifugation, Filtration: Theory of Filtration, Pre-treatment of Fermentation Broth, Filter Media and Equipment, Conventional and Cross-flow Filtration, Continuous Filtration, Filter cake resistance, specific cake resistance, Washing and dewatering of filter cakes.

MODULE III ABSORPTION 9

Gas Absorption: Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, absorption factor, stripping factor, minimum gas liq ratio, Single stage gas absorption Cross Current, Co- current, Counter current, Multistage Counter current Operation, Absorption with Chemical Reactions, Related problems.

MODULE IV EXTRACTION 9

Liquid-Liquid Separation Process: Single Stage Operation, Equipments for liquid-liquid extraction. Types of extraction processes: Reactive extraction, Aqueous two-phase systems, Reverse micellar extraction, solid-liquid extraction, Supercritical fluid Extraction. Different types of extractors and designing of extractors. Distillation: Simple, Steam and Equilibrium distillation, Fractionation, McCabe Thiele method, azeotropes.

MODULE V CHROMATOGRAPHY AND MEMBRANE SEPARATION 9

Theory of chromatography, Shape and yield of a chromatographic peak, Binary chromatography, Hydrodynamic chromatography. Membrane-based bioseparation - Classification of membrane processes, Ultrafiltration, Microfiltration, Dialysis, Liquid membrane processes, Membrane chromatography, Electrophoresis, Affinity ultrafiltration, Field-flow fractionation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic concept of bio separation processes
- CO2 :** acquire knowledge on theory, design, and application of bioprocessing
- CO3 :** understand the basic concepts absorption and their problems in bioprocessing
- CO4 :** gather knowledge on extraction of bioproducts using different methods
- CO5 :** acquire knowledge on chromatography techniques and their analysis, membrane separation process

TEXT BOOKS

1. Roger G. Harrison, Paul Todd, ScottR. Rudge, Demetri P. Petrides, Bio separations Science and Engineering, Oxford University Press
2. B.Shivshankar, Bioseparations: Principles and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012

REFERENCES:

1. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley Interscience Publication, 1988.
2. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982. Scopes Ak, Protein Purification, IRL Press, 1993
3. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						2							
2	3				1				1			1		
3	3		1											
4	3		2											
5	3	3	3	2	1	3	2	1	2	1	1	1	3	1
Avg.	3	3	2	2	1	3	2	1	1.5	1	1	1	3	1

1-low, 2-medium, 3-high

E38	ENZYME IMMOBILISATION TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Catalysis and biocatalysis, Enzyme classification and nomenclature, enzyme structure, functionality and relationship, enzyme activity, enzyme sources, synthesis, recovery and purification, enzymes as process catalysts.

MODULE II HOMOGENEOUS ENZYME KINETICS 9

Hypothesis of enzyme kinetics, rapid equilibrium and steady-state hypothesis, determination of kinetic parameters, various types of kinetic inhibition, reactions with more than one substrate, effect of environmental variables- pH, temperature, and ionic strength.

MODULE III BASICS OF IMMOBILISATION 9

Immobilisation – Functional properties, Classification of Immobilisation techniques – Adsorption, matrix entrapment, crosslinking, covalent binding- advantages & disadvantages of each method, selection and characterization of matrices for immobilization, effect of physico chemical parameters on immobilised enzymes.

MODULE IV HETEROGENEOUS ENZYME KINETICS 9

Mass transfer effects in heterogeneous biocatalysis, partition effects, Immobilised enzyme kinetics external (film) diffusion, internal (pore) diffusional kinetics, Thiele modulus and Effectiveness factor. Effects of electrostatic potential of the micro environment.

MODULE V ENZYME REACTORS & APPLICATION OF IMMOBILISED ENZYMES 9

Design of reactors with immobilised enzymes, Design of advanced immobilized enzyme systems, Application of immobilised enzymes in food industry, textile industry, Pharmaceutical industry & in medicine, in the production of biofuels, detergent industry, production of various bio-products, as biosensors

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic knowledge on classification of enzymes and their nomenclature
- CO2 :** understand Enzymes, homogeneity, and heterogeneity
- CO3 :** understand structural, functional properties, and metabolic pathways of enzymes
- CO4 :** learn immobilization procedures, and their different types.
- CO5 :** knowledge on designing enzyme reactors.

TEXT BOOKS

1. M.F.Chaplin and C.Bucke, Enzyme Technology, Cambridge University press, 1990.
2. K. Buchholz,V. Kasche and U.T. Bornscheur,, Biocatalysts and Enzyme Technology, Wiley, 2005.

REFERENCES:

1. Shanmugam,S, Satish Kumar,T, Enzyme Technology, JK International Private Limited, 2008.
2. A.Illanes, Enzyme Biocatalysis: Principles and Application, Springer, 2008.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						2							
2	3				1				1			1		
3	3		1											
4	3		2											
5	3	3	3	2	1	3	2	1	2	1	1	1	3	1
Avg.	3	3	2	2	1	3	2	1	1.5	1	1	1	3	1

1-low, 2-medium, 3-high

E39	BIO REACTOR DESIGN	L	T	P	C
		3	0	0	3

MODULE I BIOREACTOR DESIGN & MEDIA REQUIREMENTS 9

Microbial growth and product formation kinetics, Bioreactor Selection, Reactor operational mode and selection.

MODULE II DESIGN EQUATIONS FOR BIOREACTORS 9

Basic Design Equations/ Mole Balances: Batch, Fed-Batch and Repetitive Batch Reactors, Continuous: Stirred tank and tubular flow reactors, Microbial death kinetics, Design criterion for sterilization, Batch and continuous sterilization of medium, Multiple reactions-series, parallel and mixed-mode, Air sterilization.

MODULE III BIOREACTOR REQUIREMENTS 9

Process-General requirements; Basic design and construction of bioreactors and their ancillaries; Material of construction, Vessel geometry, Bearing Assemblies, Motor drives, Aseptic seals; Flow measuring devices, Valves, Agitator and Sparger Design, Sensors, Non-isothermal homogeneous reactor systems. Adiabatic reactors, batch and continuous reactors, optimum temperature progression.

MODULE IV DESIGN OF BIOREACTORS 9

Process and mechanical design of Bioreactors, volume, sparger, agitator-type, size and motor power, heat transfer calculations for coil and jacket, sterilization system, scale-up, scale down, bioinstrumentation and control.

MODULE V NOVEL BIOREACTORS DESIGN 9

Design of Immobilized enzyme packed bed Reactor. Fluidized bed reactors, Slurry Reactors, Airlift & Loop reactors, Packed bed and Hollow fiber membrane bioreactors, Bioreactors for waste treatment processes; SSF bioreactors. bioreactor design considerations for plant and animal cell cultures.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Compare kinetics and reaction rates for various bioreactor designs, based on operational mode and type of substrate.

CO2 : Differentiate and estimate productivity in commercial bioreactors- packed bed, fed batch reactors

CO3 : understand various requirements such as material of construction, valves, agitator, sensors.

CO4 : Understanding the mechanical design and heat transfer calculations for various type of bioreactor

CO5 : Analyze immobilization techniques in reactors and use it for various applications.

TEXT BOOKS

1. Wolf R. Vieth , Bioprocess Engineering -Kinetics, Mass Transport, Reactors and Gene Expression A Wiley-Interscience Publication 1994.
2. Kalidas C, Chemical Kinetic Methods: Principles of relaxation techniques New Age International 1996
3. Forment G F and Bischoff K B, Chemical Reactor Analysis and Design John Wiley 1990

REFERENCES:

1. Shijie Liu, Bioprocess Engineering -Kinetics, Biosystems, sustainability and reactor Design, , Elsevier Publication 2013.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3						2							
2	3				1				1			1		
3	3		1											
4	3		2											
5	3	3	3	2	1	3	2	1	2	1	1	1	3	1
Avg.	3	3	2	2	1	3	2	1	1.5	1	1	1	3	1

1-low, 2-medium, 3-high

**VERTICAL-IV
ENVIRONMENTAL AND SAFETY ENGINEERING**

E40	AIR POLLUTION CONTROL	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Introduction to Air Quality; An Overview of the Clean Air Act Amendments; Air Pollution Regulatory Framework - Regulatory System – Laws and Regulations – Clean air Act – Provisions for Recent Developments. Ambient Air Quality Standards in India; Properties of Air Pollutants; Sources and effects of air pollution, emission standards, Air Quality Index.

MODULE II GASEOUS POLLUTANTS 9

Absorption- Principles, Description of equipment-Packed and Plate columns -Design and Performance equations, Adsorption- Principle Adsorbents, Equipment descriptions - PSA - Adsorption cycle - Solvent recovery system-Continuous Rotary bed, Fluidized bed, Design and Performance equations; Incinerators, Hydrocarbon incineration kinetics- Equipment description- Design and Performance equations.

MODULE III PARTICULATE AIR POLLUTION 9

Particle Collection mechanisms– Fluid particle Dynamics – Particle size Distribution – Efficiency – Gravity Settling chambers Cyclones- Electrostatic precipitators and Bag houses.

MODULE IV AIR POLLUTION CONTROL 9

Principles of Pollution Prevention- Characteristics and control of VOCs and HCs, Characteristics and control of sulphur oxides and nitrogen oxides, Control of mobile source pollutants - Control of particulate matters – Techniques of air pollution control – equipment.

MODULE V AIR POLLUTION MODELING 9

Meteorology and winds- Stability of the atmosphere, lapse rates & inversions- Air pollution dispersion models, Gaussian equation and variation, Industrial Air Pollution Sources and Prevention.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Understand the nature and characteristics of air pollutants, and basic concepts of air quality management.

CO2 : Identify, formulate and solve air pollution problems using air pollution control devices to meet applicable standards

CO3 : Understand the knowledge about particulate air pollutants and control devices.

CO4 : Relate the air quality behaviour and its measurement

CO5 : Control the air pollution in industries using various models.

TEXT BOOKS

1. Richardw.Boubeletal.,“Fundamentals of Air Pollution”,AcademicPress,NewYork,1994.
2. NoelDeNevers,“AirPollutionControlEngg.”,McGrawHill,NewYork,1995.
3. M.N.Raoetal.,“AirPollution”TataMcGrawHill,1989.

REFERENCES:

1. David, H.F., Liu, Bela G., Liptak Air Pollution, Lweis Publishers, 2000.
2. Stern, A.C., Air Pollution (Vol.I – Vol.VIII), Academic Press, 2006.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1												1	1
2	1												1	1
3	1												1	1
4	1												1	1
5	1												1	1
Avg.	1												1	1

1-low, 2-medium, 3-high

E41	WASTE WATER TREATMENT	L	T	P	C
		3	0	0	3

MODULE I WASTE WATER TREATMENT AN OVERVIEW 9

Terminology – Regulations – Health and Environment Concerns in waste water management – Constituents in waste water; inorganic, Organic and heavy metal constituents.

MODULE II CHEMICAL UNIT PROCESSES 9

Role of unit processes in waste water treatment- Principles of Chemical treatment – Coagulation - flocculation– Precipitation–flotation – solidification and stabilization –disinfection.

MODULE III BIOLOGICAL TREATMENT 9

Objectives of biological treatment – significance – Principles of aerobic and anaerobic treatment - kinetics of biological growth – Factors affecting growth – attached and suspended growth - Determination of Kinetic coefficients for organics removal – Biodegradability assessment - selection of process- reactors-batch-continuous type.

MODULE IV TREATMENT METHODS 9

Activated Sludge process and variations, Sequencing Batch reactors, Membrane Biological Reactors- Trickling Filters- RBC-Moving Bed Reactors- fluidized bed reactors, aerated lagoons, waste stabilization ponds- Design of units – UASB, up flow filters, Fluidized beds MBR, septic tank and disposal.

MODULE V ADVANCED WASTE WATER TREATMENT 9

Technologies used in advanced treatment – Classification of technologies- Removal of Colloids and suspended particles– Membrane Filtration – Ion Exchange – Advanced oxidation process – Zero liquid Discharge. - Software Applications

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the Physical and chemical Characteristics of wastewater and their measurement
- CO2 :** Understand the various pollutant treatment techniques.
- CO3 :** Understand the concepts using biological treatment methods
- CO4 :** Analyze the reactors used for various treatment techniques
- CO5 :** Understand the membrane based electrochemical process for pollutant treatment.

TEXT BOOKS

1. Waste water Engineering Treatment and Reuse: McGraw Hill, G. Tchobanoglous, FI Biston, 2002.
2. Industrial Waste Water Management Treatment and Disposal by Waste Water McGraw Hill III Edition 2008.

3. S.P. Mahajan, Pollution control in process industries, 27th Ed. Tata McGraw Hill Publishing Company Ltd., 2012.

REFERENCES:

1. Casey, T.J., Unit Treatment Processes in Water and Wastewater Engineering, John Wiley & Sons, 2006.
2. Metcalf & Eddy, Inc. Wastewater Engineering - Treatment, Disposal, and Reuse, Fourth Edition, Tata McGraw-Hill, 1995. 14

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1												1	1
2	1												1	1
3	1												1	1
4	1												1	1
5	1												1	1
Avg.	1												1	1

1-low, 2-medium, 3-high

E42	SOLID WASTE MANAGEMENT	L	T	P	C
		3	0	0	3

MODULE I SOURCES AND CHARACTERISTICS 9

Sources and types of municipal solid wastes- Public health and environmental impacts of improper disposal of solid wastes- sampling and characterization of wastes - factors affecting waste generation rate and characteristics - Elements of integrated solid waste management – Requirements and salient features of Solid waste management rules (2016) – Role of public and NGO"s- Public Private participation – Elements of Municipal Solid Waste Management Plan.

MODULE II SOURCE REDUCTION, WASTE STORAGE AND RECYCLING 9

Waste Management Hierarchy - Reduction, Reuse and Recycling - source reduction of waste – On-site storage methods – Effect of storage, materials used for containers – segregation of solid wastes – Public health and economic aspects of open storage – case studies under Indian conditions – Recycling of Plastics and Construction/Demolition wastes.

MODULE III COLLECTION AND TRANSFER OF WASTES 9

Methods of Residential and commercial waste collection – Collection vehicles – Manpower – Collection routes – Analysis of waste collection systems; Transfer stations –location, operation and maintenance; options under Indian conditions – Field problems- solving.

MODULE IV PROCESSING OF WASTES 9

Objectives of waste processing – Physical Processing techniques and Equipment; Resource recovery from solid waste composting and bio meth nation; Thermal processing options – case studies under Indian conditions.

MODULE V WASTE DISPOSAL 9

Land disposal of solid waste- Sanitary landfills – site selection, design and operation of sanitary landfills – Landfill liners – Management of leachate and landfill gas- Landfill bioreactor – Dumpsite Rehabilitation

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** State solid waste characteristics and its sources.
- CO2 :** Identify and analyze different methods of treatment of solid waste.
- CO3 :** Illustrate Industrial practices in solid waste management
- CO4 :** Discuss the significance of recycling reuse and reclamation of solid wastes.
- CO5 :** Assess the relationships between environmental guidelines, human activities and quality of impacted soil, water and air.

TEXT BOOKS

1. William A. Worrell, P. AarneVesilind (2012) Solid Waste Engineering, Cengage Learning, 2012.

- John Pitchel (2014), Waste Management Practices-Municipal, Hazardous and industrial – CRC Press, Taylor and Francis, New York.

REFERENCES:

- Government of India, “Manual on Municipal Solid Waste Management”, CPHEEO, Ministry of UrbanDevelopment, New Delhi, 2000.
- Manser A.G.R. and Keeling A.A.,” Practical Handbook of Processing and Recycling of Municipal solid Wastes”, Lewis Publishers, CRC Press, 1996.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1												1	1
2	1												1	1
3	1												1	1
4	1												1	1
5	1												1	1
Avg.	1												1	1

1-low, 2-medium, 3-high

E43	ENVIRONMENTAL IMPACT ASSESSMENT	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Impacts of Development on Environment – Rio Principles of Sustainable Development- Environmental Impact Assessment (EIA) – Objectives – Historical development – EIA Types – EIA in project cycle – EIA Notification and Legal Framework.

MODULE II ENVIRONMENTAL ASSESSMENT 9

Screening and Scoping in EIA – Drafting of Terms of Reference, Baseline monitoring, Prediction and Assessment of Impact on land, water, air, noise, flora and fauna - Matrices — Networks — Checklist Methods - Mathematical models for Impact prediction.

MODULE III ENVIRONMENTAL MANAGEMENT PLAN 9

Plan for mitigation of adverse impact on water, air and land, water, energy, flora and fauna – Environmental Monitoring Plan – EIA Report Preparation – Public Hearing-Environmental Clearance.

MODULE IV SOCIO ECONOMIC ASSESSMENT 9

Baseline monitoring of Socio-economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental impacts – Cost benefit Analysis.

MODULE V MONITORING STUDIES AND APPLICATIONS 9

Environmental monitoring - guidelines - policies - planning of monitoring programmes; Environmental Management Plan- Post project audit ; Case studies of EIA of developmental projects in Food, Fertilizer and Petrochemical industry

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the concept of environmental Impact assessment.
- CO2 :** Know various components and assessment techniques of EIA.
- CO3 :** Understand Environmental management plan.
- CO4 :** Understand socio economic assessment plans
- CO5 :** gain knowledge about EIA monitoring studies through various industrial exposure

TEXT BOOKS

1. Canter, L. W., Environmental Impact Assessment, McGraw Hill, New York, 1996.
2. Petts, J., Handbook of Environmental Impact Assessment Vol. I and II, Blackwell Science, London, 2009.
3. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey, 2003.

REFERENCES:

1. Becker H. A., Frank Vanclay, "The International handbook of social impact assessment" conceptual and methodological advances, Edward Elgar Publishing,2003.
2. Barry Sadler and Mary McCabe, "Environmental Impact Assessment Training Resource Manual", United Nations Environment Programme, 2002.
3. Judith Petts, "Handbook of Environmental Impact Assessment Vol. I and II", Blackwell Science New York, 1998.
4. Morris, P., and Therivel, R., Methods of Environmental Impact Assessment, 3rd Edition, Taylor & Francis, 2009.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1												1	1
2	1												1	1
3	1												1	1
4	1												1	1
5	1												1	1
Avg.	1												1	1

1-low, 2-medium, 3-high

E44	PROCESS SAFETY MANAGEMENT	L	T	P	C
		3	0	0	3

MODULE I PROCESS SAFETY INFORMATION 9

Safety vs Process Safety, Importance of Process Safety, Elements of Process safety - Overview; Process Safety Information (PSI) – Importance of Process Safety Information, Types of PSI, Collection of PSI, familiarization of formats for capturing PSI, Challenges.

MODULE II SAFETY PROGRAMMES AND PROCEDURES 9

Need for safety in industries; Safety Programmes – components and realization; Potential hazards– extreme operating conditions, toxic chemicals; safe handling-Implementation of safety procedures – periodic inspection and replacement; Standard Operating Procedure – Overview and its importance, how to write effective operating procedure, Types of Procedures, Standard operating conditions and consequence of deviation; Emergency planning.

MODULE III ACCIDENT ANALYSIS 9

Accidents – identification and prevention, promotion of industrial safety. Process Safety Incident reporting and Investigation – Element overview, reporting and its importance; Process safety incident classification, Root cause analysis, making recommendations; Past accident analysis- Fixborough-Mexico- Chernobyl nuclear disaster-Bhopal gas analysis- process safety indicators.

MODULE IV PROCESS HAZARD ANALYSIS 9

Hazard identification- safety audits, checklist, what if analysis, vulnerability models- event tree analysis- fault tree analysis. Asset Integrity Process Hazard Analysis - Introduction to PHA, Overview of PHA Techniques, Selection of PHA techniques Implementation of recommendation – Key Aspects. Cyclic PHA /Revalidation; Review of PHA methodology (Prerequisites, Team Composition and their attributes.

MODULE V SAFETY MANAGEMENT 9

Employee Participation – Overview, Benefits of Employee participation, Various modes of engaging workforce in PSM, Challenges; Management of Change – Types of Changes, Managing Changes in PSM Perspective, Framework, evaluating changes-Institutionalizing and integrating safety into the PSM fabric, 5 tier approach, selection, training, Performance monitoring; Case studies – Process safety management in industry – present and futuristic approach.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the chemical process safety, safety codes
- CO2 :** safe handling of chemicals and plant inspection
- CO3 :** learn the different analysis to overcome the accidents in process industry.
- CO4 :** understand the hazard analysis in process industry
- CO5 :** knowledge on safety management in different process industry

TEXT BOOKS

1. Daniel A. Crowl, J.F., Chemical Process Safety: Fundamentals with Applications, Louvar, Prantice Hall, NJ, 1990. Louvar, Prantice Hall, NJ, 1990.
2. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Interscience, 1965.
3. Marcel, V.C., Major Chemical Hazard- Ellis Harwood Ltd., Chi Chester, UK, 1987.

REFERENCES:

1. Handley, W., "Industrial Safety Hand Book ", 2nd Edn., McGraw-Hill Book Company, 1969.
2. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., "Industrial Accident Prevention", McGrawHill Book Co., 1980.
3. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1												1	1
2	1												1	1
3	1												1	1
4	1												1	1
5	1												1	1
Avg.	1												1	1

1-low, 2-medium, 3-high

E45	RISK ANALYSIS AND HAZOP	L	T	P	C
		3	0	0	3

MODULE I RISK ANALYSIS 9

Risk analysis introduction, quantitative risk assessment, rapid risk analysis –comprehensive risk analysis – identification, evaluation and control of risk.

MODULE II RISK ASSESSMENT 9

Risk assessment – introduction and available methodologies, Risk assessment steps- Quantitative risk analysis-event tree, fault tree, consequence analysis and layer of protection analysis- Bow tie analysis.

MODULE III EMERGENCY PLANNING 9

Overall risk analysis--emergency planning-on site & off site emergency planning, risk management ISO 14000, EMS models case studies- marketing terminal, gas processing complex; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.

MODULE IV HAZARD 9

Hazard - Hazard identification – methods: Process Hazard Analysis - Introduction to PHA, Overview of PHA Techniques, Selection of PHA techniques Implementation of recommendation – Key Aspects. Cyclic PHA /Revalidation; Review of PHA methodology (Prerequisites, Team Composition and their attributes.

MODULE V HAZOP 9

Introduction to HAZOP-Significance of HAZOP -HAZOP procedure –HAZOP Analysis -Computer usage in HAZOP- softwares employed - Limitations of HAZOP – case studies

TOTAL: 45 PERIODS

COURSE OUTCOME

At the end of the course, students will be able to

- CO1 :** Understand the knowledge of types of risks arising in working environment.
- CO2 :** Perform Risk Assurance and Assessment
- CO3 :** Design Risk management systems and planning
- CO4 :** Analyze the effect of process hazard
- CO5 :** hazop and its consequences and to create hazard free working premises

TEXT BOOKS

1. Daniel A. Crowl, J.F., Chemical Process Safety: Fundamentals with Applications, Louvar, Prantice Hall, NJ, 1990. Louvar, Prantice Hall, NJ, 1990.
2. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Interscience, 1965.
3. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, Dyadem Press, 2004.

REFERENCES:

1. Handley, W., "Industrial Safety Hand Book ", 2nd Edition. McGraw-Hill Book Company, 1969.
2. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., "Industrial Accident Prevention", McGraw-Hill Book Co., 1980.
3. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1												1	1
2	1												1	1
3	1												1	1
4	1												1	1
5	1												1	1
Avg.	1												1	1

1-low, 2-medium, 3-high

VERTICAL-V
COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING

E46	COMPUTATIONAL TECHNIQUES	L	T	P	C
		3	0	0	3

MODULE I ALGEBRAIC EQUATIONS **9**

Gauss elimination, LU decomposition, matrix inversion, Tri-diagonal matrix algorithm, Gauss-Seidel method, Chemical Engineering problems involving solution of linear algebraic equations

MODULE II NON-LINEAR ALGEBRAIC EQUATIONS **9**

Introduction, Root finding methods for solution on non-linear algebraic equations: Bisection, Newton-Raphson and Secant methods, System of Non-linear Equations, Chemical Engineering problems involving solution of non-linear equations.

MODULE III INTERPOLATION AND NUMERICAL INTEGRATION **9**

Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression, Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, Chemical engineering problems involving numerical differentiation and integration.

MODULE IV NUMERICAL METHODS FOR ODES **9**

Euler method – explicit and implicit, Runge-Kutta method – 2nd and 4th order, Boundary value problems – shooting method, Chemical engineering problems involving single and system of ODEs.

MODULE V NUMERICAL METHODS FOR PDES **9**

Introduction to Partial Differential Equations: Characterization of PDEs, parabolic, elliptic and first order hyperbolic equations, explicit and implicit methods, Chemical engineering problems involving the three types of PDEs.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** utilize the numerical methods for linear algebraic equations.
- CO2 :** Identify different methods for interpolation and numerical integration
- CO3 :** Understand the numerical methods for linear algebraic equations.
- CO4 :** knowledge on the numerical methods for ordinary differential equations.
- CO5 :** understand the basic methods for partial differential equations

TEXT BOOKS

1. Chapra. S. C. & Canale, R. P., "Numerical Methods for Engineers", Eighth Edition, McGraw Hill, 2021.
2. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.

REFERENCES:

R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	1	1	1										1	1
2	1	1	1										1	1
3	1	1	1										1	1
4	1	1	1										1	1
5	1	1	1										1	1
Avg.	1	1	1										1	1

1-low, 2-medium, 3-high

E47	OPTIMIZATION OF CHEMICAL PROCESSES	L	T	P	C
		3	0	0	3

MODULE I PROBLEM FORMULATION AND CLASSIFICATION 9

Introduction; formulation of objective functions; fitting models to data; classification of functions; necessary and sufficient conditions for optimum; unimodal, multimodal functions; analytical methods.

MODULE II LINEAR PROGRAMMING 9

Review on basic concepts of LP formulations; Simplex methods; Big-M method, two phase method and Duality in linear programming.

MODULE III NON-LINEAR PROGRAMMING 9

The Lagrange multiplier method, Integer, quadratic, geometric and dynamic programming.

MODULE IV NUMERICAL METHODS 9

Unimodal functions; Newton, quasi Newton, secant methods; region elimination methods, polynomial approximation; quadratic and cubic interpolation techniques for optimum. Multimodal functions; direct methods; Powell's technique; indirect methods; gradient and conjugate gradient methods; secant method.

MODULE V APPLICATIONS 9

Heat transfer and energy conservation; separation processes; fluid flow systems; reactor design and operation; large scale systems

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1:** be familiar on the basic problem formulation and optimization
- CO2:** Understand mathematical characteristics of Linear programming
- CO3:** Learn computational solution techniques for nonlinear unconstrained optimization
- CO4:** Understand various techniques used in constrained optimization
- CO5:** Understand various techniques used in constrained optimization

TEXT BOOKS

1. Edgar T.F., Himmelblau D.M., Lasdon, L.S., Optimization of Chemical Processes, Second Edition, McGraw-Hill, New York, 2001.
2. Rao, S. S., Engineering Optimization: Theory and Practice, Fifth Edition, Wiley, New York, 2019

REFERENCES:

1. Reklaitis G.V., Ravindran A., Ragsdell, K.M., Engineering Optimization, Wiley, New York.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E48	PINCH ANALYSIS AND HEAT EXCHANGER NETWORK DESIGN	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Pinch analysis, process synthesis, pinch point, composite curves, energy targeting: problem table algorithm, shifted composite curve, capital cost, total cost targeting, process modification.

MODULE II TARGETING 9

Heat exchanger networks, energy targeting, area targeting, unit targeting, shell targeting, cost targeting, super targeting, and continuous targeting.

MODULE III PINCH ANALYSIS 9

Identification of streams, temperature, enthalpy diagram, minimum temperature difference, construction of composite curves, energy cost target, optimum target, design of heat exchanger network.

MODULE IV PINCH DESIGN AND OPTIMIZATION 9

Networks for maximum energy recovery, Pinch design method, flexibility criteria of the pinch, optimization of heat exchanger network, optimality for a minimum area network, Sensitivity analysis.

MODULE V ENERGY AND RESOURCE ANALYSIS OF VARIOUS PROCESSES 9

Batch process, flexible process, distillation process, evaporation process, reaction process, process using mass separating agent, heat pipes and heat pumps.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the pinch concept and process thermodynamics.
- CO2 :** Identify minimum energy targets
- CO3 :** Understand the knowledge of diagrams and energy cost target.
- CO4 :** Identify different choices and constraint during heat exchange networking.
- CO5 :** Apply strategies for retrofitting existing process plant, integration of energy demands in multiple processes.

TEXT BOOKS

1. Kemp, I. C., Pinch Analysis and Process Integration, Second edition, Elsevier, 2006.
2. Shenoy, V. U., Heat Exchanger network synthesis, Gulf Publishing, 1995.

REFERENCES:

1. Douglas, J. M., Conceptual Design of Chemical Process, McGraw Hill, 1988

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E49	CHEMICAL PROCESS FLOWSHEETING	L	T	P	C
		3	0	0	3

MODULE I FLOWSHEETING **6**

Introduction, symbols, flowsheet presentation with examples, manual flowsheet calculation, flowsheeting approaches.

MODULE II DECOMPOSITION OF NETWORKS **11**

Partitioning and tearing a flowsheet, tearing algorithms based on signal flow graph, algorithms based on reduced graph, comparing various tearing algorithms.

MODULE III SEQUENTIAL MODULAR APPROACH TO FLOWSHEETING **11**

Principle of method, convergence of flowsheet using different methods - Newton's method, direct substitution, Wegstein's method, dominant Eigenvalue method, quasi-Newton method, criteria for acceleration.

MODULE IV FLOWSHEETING BY EQUATION SOLVING METHODS **8**

Precedence ordering, disjoining, tearing a system of equations, SWS algorithm, maintaining sparsity, solution of system of equations using Newton's method.

MODULE V CASE STUDIES **9**

Batch Simulation of process flowsheets involving mass recycle, energy recycle, tear stream and design specification, demonstration of open source flowsheeting software.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic concept in preparation of flowsheet.
- CO2 :** knowledge on preparing networks
- CO3 :** understand different approach in flowsheeting.
- CO4 :** learn the flowsheet preparation by equation solving methods
- CO5 :** Evaluate the case studies using flowsheeting software

TEXT BOOKS

1. Babu, B V., Process Plant Simulation, Oxford University Press, 2004
2. Richard.M.Felder, Ronolad W Rosseau, Elementary Principles of Chemical Processess, 4th edition, Wiley, 2004.

REFERENCES:

1. A.Westerberg, H.P.Hutchison, Process Flowsheeting, Cambridge University Press, Cambridge, London,1979.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E50	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

MODULE I GOVERNING EQUATIONS 9

Governing equations of fluid flow and heat transfer - Navier-Stokes equations for a Newtonian fluid, Classification of physical behaviour, Classification of fluid flow equations, Auxiliary conditions for viscous fluid flow equations.

MODULE II TURBULENCE AND ITS MODELLING 9

Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, free turbulent flows, flat plate boundary layer and pipe flow, Turbulence models, mixing length model, The k-omega model, Reynolds stress equation model, algebraic stress equation model.

MODULE III FINITE VOLUME METHOD FOR DIFFUSION PROBLEMS 9

Introduction to finite volume method, one-dimensional steady state diffusion, two-dimensional diffusion, discretised equations for diffusion problems.

MODULE IV FINITE VOLUME METHOD FOR CONVECTION-DIFFUSION PROBLEMS 9

Steady one-dimensional convection and diffusion, the central differencing scheme, properties of discretisation schemes - conservativeness, boundedness, transportiveness, Assessment of the central differencing scheme for convection-diffusion problems, The upwind differencing scheme, hybrid differencing scheme, power-law scheme, higher order differencing schemes, quadratic upwind differencing scheme.

MODULE V FINITE VOLUME METHOD FOR UNSTEADY FLOWS 9

Batch Simulation of process flowsheets involving mass recycle, energy recycle, tear stream and design specification, demonstration of open source flowsheeting software.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Understand the basics of CFD and governing equations for conservation of mass momentum and energy
- CO2 :** Understand mathematical characteristics of partial differential equations
- CO3 :** learn computational solution techniques for time integration of ordinary differential equations
- CO4 :** gain knowledge in various discretization techniques used in CFD
- CO5 :** Understand flow field computation techniques for steady and unsteady flows

TEXT BOOKS

1. Versteeg H. K. and Malalasekera, W., An introduction to computational fluid dynamics: the finite

volume method, Second edition, Pearson, 2008.

2. Anderson, J. D. Computational fluid dynamics: The Basics with Applications, McGraw-Hill, 1995.

REFERENCES:

1. Ranade, V. V., Computational flow modeling for Chemical Reactor Engineering, Academic Press, 2002

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E51	DESIGN AND ANALYSIS OF EXPERIMENTS	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Basic principles, guide lines for designing experiments, basic statistical concepts, inferences about the difference in mean, randomized, pair comparison designs, analysis of variance.

MODULE II RANDOMIZED BLOCKS, LATIN SQUARES AND RELATED DESIGNS 9

Completely randomized, randomized Latin square, Graceo-Latin Square and crossover designs.

MODULE III FACTORIAL DESIGNS 9

Advantage of factorials, description, calculation of direct and interaction effects. 2k factorial designs. Blocking and confounding –principles and use of confounded designs.

MODULE IV FRACTIONAL FACTORIAL DESIGN 9

Two three and mixed level fractional designs and applications.

MODULE V RESPONSE SURFACE DESIGN 9

Fitting regression model. Response Surfaces-First and Second order designs.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** Given a set process data, characterize the process behavior using descriptive statistics
- CO2 :** Identify if the process in control. If not, identify special patterns that may exist
- CO3 :** Design experiments to identify the main effects, interaction effects and their significance
- CO4 :** Student well equipped in designing experiment.
- CO5 :** Analyze any Response surface diagrams.

TEXT BOOKS

1. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley and Sons inc., Fifth Edition, 2003.
2. Cochran W.G. , Cox G.M., Experimental Designs., Second Edition, John Wiley and Sons, 1957

REFERENCES:

1. Davies O.L., The Design and Analysis of Experiments, Longman Group Ltd., 1978.
2. Andre I Khuri and John A Cornel, Response surfaces - Design and Analysis, New York Marcel Dekker, 1996.
3. Stephen R Schmidt and Robert GLaunsby, Understanding Industrial Designed Experiments, Air Academy Press, 1992.
4. John Lawson, John Erjavee, Modern Statistics for Engineering and Quality Improvement, Duxbury, 2001

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

VERTICAL-VI
CHEMICAL PLANT DESIGN

E52	CHEMICAL PLANT DESIGN	L	T	P	C
		3	0	0	3

MODULE I ROTARY EQUIPMENT 9

Pumps: Various types: Centrifugal, Reciprocating & Other Positive displacement types – Plunger, Piston, Diaphragm, Gear, Screw, Lobe, Vane, etc.; Compressors: Various types: Axial, Centrifugal, Reciprocating, and other positive displacement type.

MODULE II STATIC EQUIPMENT - HEAT TRANSFER EQUIPMENT 9

Heat Exchangers– Shell and Tube, Double Pipe, Plate & Frame type, Tube in tube Scraped surface, and Fin tube, Coolers, Condensers, Fin Fan Coolers; Fired Heaters & Boilers– With or without air preheaters, Balanced draft or simply natural draft or even only forced draft, With and without waste heat generation.

MODULE III STATIC EQUIPMENT – MASS TRANSFER EQUIPMENT 9

Multi Component Distillation columns, Extractive distillation, Reactive Distillation, Azeotropic distillation, Divided wall columns, Dryers, Adsorption Isotherm, Pressure Swing Adsorption, Importance of recycles and Optimization needs, Adsorption processes & operating variables, Liquid – Liquid Solvent Extraction.

MODULE IV EQUIPMENT ANCILLARIES 9

Static Mixer, Agitators, Jet Mixing, Ejectors, Eductors, Structured Packing, Grid Packing and Random Packing, Demisters, Vortex Breaker, Calming Baffles, Schoepentoeter, Vapour horn device, Cyclone separators

MODULE V DESIGN OF PRESSURE VESSELS 9

Pressure Vessels – Vertical / Horizontal, Knock Out Drums, Steam and Blow down drum, Cold & Hot Separators, Surge drum, Deaerators, Water Seal Pot, Molecular seals, Shock Absorbers, Pressure snubber.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic on designing chemical process unit for rotary equipment
- CO2 :** learn the operations of boilers, heat exchangers, refrigeration and air conditioners.
- CO3 :** knowledge on operations of reactors, humidifiers and mass transfer operations
- CO4 :** learn the different types of equipments in process industries
- CO5 :** understand the knowledge on usage of different valves such as pressure, safety and internal.

TEXT BOOKS

1. Robert H. Perry; Don W. Green and James O. Maloney, Chemical Engineer's Hand Book,

Eighth edition, Prentice Hall, 2013.

2. Robert.E.Treybal, Mass Transfer Operations, Third Edition, 2000.

REFERENCES:

1. Donald.Q.Kern, Process Heat Transfer, 2004.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E53	PLANT LAYOUT	L	T	P	C
		3	0	0	3

MODULE I STANDARDS FOR AREA CLASSIFICATION 9

Standards for area classification—Electrical Area classifications, OSHA (Occupational Safety and Health Administration) regulations, National Fire Protection Association (NFPA), Petroleum Hazards Classification, IP15 Petroleum classification based on flash point, OISD standards (Oil Industry Safety Directorate).

MODULE II INTER UNIT DISTANCES 9

Distance between plants, substation, centralized control room, utilities sections / captive power plants; Inter-distance between adjacent Columns, Storage tanks, Tank dykes; Flare stack location (based on Prevailing up-wind direction), Design to keep it smokeless, Sterile zone/area – Governing API /OISD Standards, Field cabins

MODULE III STORAGE TANKS 9

Storage Tanks — Fixed or Floating roof, Mounded Bullet tanks, Cryogenic storage tanks & their special design requirements, Special designs along with breather systems, Lightening arrestors, Earth pits, other appurtenances.

MODULE IV AT RISK SYSTEMS AND EQUIPMENT 9

At-risk systems and equipment: Fuel gas systems, Fuel oil network, Hydrogen gas for generator cooling in power plants; Plant battery systems, Ammonia systems, Solid handling of coal and coke dust, Sulphur yard.

MODULE V BASIC ENGINEERING DESIGN PACKAGE 9

Basic Engineering Design Package (BEDP): First document to be prepared and approved between Process Engineering Team and Owner’s representative. It shall cover not limited to – Site Conditions (weather, wind rose, seismic activity, water table, etc.); System of measurement (inFPS or MKS for flow of gas / liquid / steam, temperature, pressure, heat duty, inferential properties, etc.), Design considerations and margins, Design philosophies such as Operating & Control philosophy, Vent & Drain philosophy, Isolation philosophy, sparing philosophy etc. Raw material details (Capacity, conditions, logistics including receipt modes & storage criteria) Product offtake plans and modes of distribution, environmental norms.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the importance of plant layout in mitigating risk on people, plant, Planet.
- CO2 :** understand the knowledge in placing equipment for ease of operability & maintainability
- CO3 :** understand the storage tanks operation and usage at safety level
- CO4 :** knowledge on usage of equipment at safety levels and their risk assessment
- CO5 :** understand the basic engineering design package

TEXT BOOKS

1. Gavin Towler and Ray Sinnott, Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design, Butterworth Heiniman publisher, 2008.

REFERENCES:

1. OISD Guideline on Plant Layout - OISD-STD-118
2. OSHA Guidelines on Plant Layout
3. API Guidelines on Plant layout

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E54	DESIGN SAFETY	L	T	P	C
		3	0	0	3

MODULE I SAFETY SYSTEMS 9

Safety systems: Deployment of sensors (Toxic, HC and Thermal) at critical locations, Fire network including elevated fire monitors, Egress system, Escape route and Assembly point, Water curtain, eye wash requirement, Clean and cooler water supply.

MODULE II ELECTRICAL SYSTEMS 9

Power systems – KV level, 3 phase and single phase, LT, HT generation and distribution network systems, MCC / PCC (motor control centre and power control centre) substations, Electrical Energy Audits, Exergy analysis, Cogen design aspects; Emergency Power needs based on process criticalities.

MODULE III FLARE SYSTEM 9

LP, HP, LLP and H₂S flares, Types – Single Point Flares (Sonic & Subsonic), Multi Point Flares, Coanda Flares, Vent Tips, Enclosed Flares and Air Assisted Gas Flares; Pilot gas system, electronic ignition, Flare tip design, Flare noise reduction, Fire Ball prevention.

MODULE IV RISK MITIGATION MEASURES 9

HAZOP (Hazard and Operability Study), HAZID (Hazard identification), HAZAN (Hazard Analysis), EERA (Emergency escape route analysis), SIL (Safety Integrity levels) study, QRA (Quantitative Risk Assessment) and Dispersion studies.

MODULE V PROCESS CONTROL AND INSTRUMENTATION 9

Pneumatic (analogue controls) to DCS journey, Single loop Vs Multi loop controls, I/O cards, Graphic design & grouping to minimize user latency in process control; Designed for safety through redundancy right from dedicated impulse lines to card level.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** learn the safety systems both to prevent incident & to minimize loss.
- CO2 :** understand the safety in electrical systems
- CO3 :** knowledge on flare systems and their safety
- CO4 :** get thorough knowledge on risk analysis and mitigation
- CO5 :** knowledge on the control systems and their safety usage in different process industries.

TEXT BOOKS

1. Daniel A Crowl, Chemical Process Safety: Fundamentals with applications, Pearson, Third Edition, 2014.
2. Samarendra Kumar Biswas, Umesh Mathur, Fundamentals of process safety engineering, CRC Press, 2022.

REFERENCES:

1. Aarti Kashayup, Chemical Process Safety, Scitus publisher, 2015.
2. Klein James A and Bruce K Vaughan, Process Safety: Key Concepts and Practical approaches, CRC Press, 2020.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E55	MATERIAL SELECTION	L	T	P	C
		3	0	0	3

MODULE I CORROSION **9**

Different Degradation Mechanism as seen in various Chemical process industries, Corrosion (wet H₂S, Naphthenic acid bearing Crude Processing, CO₂ stress corrosion cracking, polythionic acid formation potential, amine stress corrosion cracking, microbiologically induced corrosion, corrosion under insulation, galvanic corrosion).

MODULE II ASSETS RELIABILITY ENHANCEMENT & INCIDENT ELIMINATION **9**

Risk envelope, Inputs on FERT (Fire, Explosivity, Reactivity and Toxicity), Quantification of unplanned interruption viz. impact on Safety, Environment and Loss of properties / business erosion, Early Event Detection using AI / ML, Surface Chemistry.

MODULE III FLOW AND ACOUSTIC INDUCED VIBRATION IN PIPES **9**

Flow regimes – Slug flow, plug flow, annular, dispersed, etc. Flows in Vertical and Horizontal pipes, Design criticalities in two phase (gas & liquid) and slurry flow (solid and liquid), Handling of steam condensate & prevention of water hammering, Piping Configurations for symmetrical flow distribution.

MODULE IV FOULING AND COKING **9**

Asphaltenes precipitation, Wax deposits, Gum formation, Ageing of hydrocarbon on prolonged storage and filter plugging; Dewatering and prevention of ingress of corrosion products leading to fouling, dead zone (stagnant) prevention, Inserting storage tanks to avoid oxidation induced feed / product degradation.

MODULE V ADVANCEMENT IN MATERIAL SCIENCE **9**

Academy to list the course content including use of graphene, metal organic framework, super conductors, replacement of Lithium for battery making, etc. In addition, Nano materials, there are lot more efforts needed to minimize dependence on import for some of the metals used in catalyst, defence needs, etc. which can only be substituted with effective end application needs and metallurgy and or alloy use.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basic concept on corrosion and their types in chemical industry.
- CO2 :** know the degradation mechanism that engineers' face in chemical plants
- CO3 :** recognize the different flows in pipes and their acoustic induced vibrations
- CO4 :** gain knowledge in the concept of fouling in pipes and different methods of decoking
- CO5 :** gather some knowledge on advancement in material science usage

TEXT BOOKS

1. Florian.B Mansfeld, Corrosion mechanisms , CRC Press, Newyork.
2. Alasdair H. Neilson, Ann-Sofie Allard, Organic Chemicals in the Environment Mechanisms of Degradation and Transformation,

REFERENCES:

1. NACE documents - American Petroleum Institute (API) 571 standards

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E56	STATUTORY REQUIREMENTS & CUSTOMER CARE	L	T	P	C
		3	0	0	3

MODULE I PEOPLE AND PROCESS SAFETY

9

Factory Act, IBR (Indian Boiler Regulations), Weights & Measures, Power Connection from State Electricity Board, Labour Legislation, Compensation, Fines, Litigations, Image, etc. and other commercial approvals like company registration, GST Registration, IT act, Excise Regulations.

MODULE II ENVIRONMENTAL REGULATIONS

9

Water act, Air act, for highly polluting industry category EIA (Environment Impact Assessment) is mandatory, Environmental Protection Act, License needed for 'Drugs & Pharmaceuticals' from State Drug Controller, Hazardous substance management, Waste Management rules, Pollution Control Boards / Consent to operate (State and Union Government) specially for Industries Requiring Water and Affecting Effluent Disposal.

MODULE III CUSTOMER CARE

9

Customer definition, Kano Model, CRM, PFABFS model (Property, Feature, Advantage, Benefit and Savings both monetary and emotional value); Product Supply Specification based on end use applications with competitive edge over peer industries; Quality Cost, Custody transfer precision, Wing to Wing co-operation with customers / suppliers to enhance value chain returns; Development of new products and services – Ideation, proof of concept, pilot run & commercialization.

MODULE IV INTERNSHIP PREPARATION AND DO'S & DON'TS

9

Safety Contact, Mandatory use of PPE, Assembly points, Alarm station, Mock drills, Firefighting apparatus use on demand, know the escape routes; Shadow the trainer, learning objective – pick any one viz. Catalysis – past say three to five catalyst change, the conversion variation, generation of low value side reactions, sintering & loss of margin, H₂ loss, any tell-tale indications from apple core tests of spent catalyst.

MODULE V SUSTAINABILITY REPORTING

9

Academy to list the course content including use of graphene, metal organic framework, super conductors, replacement of Lithium for battery making, etc. In addition, Nano materials, there are lot more efforts needed to minimize dependence on import for some of the metals used in catalyst, defence needs, etc. which can only be substituted with effective end application needs and metallurgy and or alloy use.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1 :** understand the basis on different acts and their regulations
- CO2 :** basic knowledge in different ACT on water, air and environmental protection.
- CO3 :** knowledge on the preparation of Kano model, CRM, PFABFS.
- CO4 :** gain the knowledge on Do's and Don'ts in an internship program.
- CO5 :** understand the concepts of ZLD, GHG release and circular economy

TEXT BOOKS

- 1. Todd Zenger , Beyond Competitive Advantage ,2016
- 2. Michael E. Porter, Competitive Advantage: Creating and Sustaining Superior performance, 2017.

REFERENCES:

- 1. Paul B. Thompson, Patricia E. Norris, Sustainability What Everyone Needs to Know, 2017

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

E57	PIPING AND INSTRUMENTATION	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION 9

Types of flow sheets, flow sheet presentation, flow sheet symbols, process flow diagram - Synthesis of steady state flow sheet - Flow sheeting software.

MODULE II BASICS OF PIPING DRAWINGS 9

P&ID objectives, guide rules, symbols, line numbering, line schedule, P&ID development, typical stages of P&ID, P&ID for rotating equipment and static pressure vessels, process vessels, absorber.

MODULE III CHEMICAL EQUIPMENTS DESIGN AND CONTROL 9

Control System for heater, heat exchangers, reactors, dryers, distillation column and evaporators.

MODULE IV INSTRUMENTATION DESIGN 9

Distributed Control Systems (DCS), Safety Instrument System (SIS), instrument symbols, instrument signal lines, temperature instruments, flow instruments.

MODULE V APPLICATIONS 9

Applications of P and ID in design stage - Construction stage - Commissioning stage - Operating stage - Revamping stage - Applications of P and ID in HAZOPS and risk analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Determine the process flow sheets to identify the various process alternatives and to develop the piping and instrumentation diagrams

CO2 : Design and formulate piping drawings for the various manufacturing chemical equipment pressure vessels, Process vessels and absorber.

CO3 : Generate the process flow sheet and control strategies for the heat and mass transfer equipment Heat exchanger, reactors, dryers, Distillation column and Evaporators

CO4 : Outline and design the safety systems to the processes for control variables temperature, pressure and flow by employing DCS and SIS.

CO5 : Identify the P&I diagrams design and HAZOPS and Risk analysis for the application of process industries

TEXT BOOKS

- Ernest E. Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Vol.1, Gulf Publishing Company, Houston, 1989.
- Max. S. Peters, Timmerhaus K.D., Plant Design and Economics for Chemical Engineers, McGraw Hill, Inc., New York, 1991.

REFERENCES:

- Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGraw Hill Publishing Company Limited, New Delhi 1981.

2. Westerberg A.N., Process Flow sheeting, Cambridge University Press, 1979

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

OPEN ELECTIVES
(OFFERED TO ALL THE OTHER DEPARTMENT)

OE1	INDUSTRIAL SAFETY ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I SAFETY IN METAL WORKING MACHINERY AND WOOD WORKING MACHINES 9

General safety rules, principles, maintenance, Inspections of turning machines, boring machines, milling machine, planing machine and grinding machines, CNC machines, Wood working machinery, types, safety principles, electrical guards, work area, material handling, inspection, standards and codes- saws, types, hazards.

MODULE II PRINCIPLES OF MACHINE GUARDING 9

Guarding during maintenance, Zero Mechanical State (ZMS), Definition, Policy for ZMS - guarding of hazards - point of operation protective devices, machine guarding, types, fixed guard, interlock guard, automatic guard, trip guard, electron eye, positional control guard, fixed guard fencing- guard construction- guard opening. Selection and suitability: lathe - drilling - boring - milling - grinding - shaping - sawing- shearing presses - forge hammer - flywheels - shafts - couplings -gears - sprockets wheels and chains pulleys and belts - authorized entry to hazardous installations-benefits of good guarding systems.

MODULE III SAFETY IN WELDING AND GAS CUTTING 9

Gas welding and oxygen cutting, resistance welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing - explosive welding, selection, care and maintenance of the associated equipment and instruments - safety in generation, distribution and handling of industrial gases-colour coding - flashback arrestor - leak detection-pipeline safety-storage and handling of gas cylinders.

MODULE IV SAFETY IN COLD FORMING AND HOT WORKING OF METALS 9

foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes. Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills - hot bending of pipes, hazards and control measures. Safety in gas furnace operation, cupola, crucibles, ovens, foundry health hazards, work environment, material handling in foundries, foundry production cleaning and finishing foundry processes.

MODULE V SAFETY IN FINISHING, INSPECTION AND TESTING 9

Heat treatment operations, electro plating, paint shops, sand and shotblasting, safety in inspection and testing, dynamic balancing, hydrottesting, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal

monitoring devices, radiation hazards, engineering and administrative controls, Indian Boilers Regulation. Health and welfare measures in engineering industry-pollution control in engineering industry-industrial waste disposal

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

- CO1** : Practice the safety norms and inspect turning machines, boring machines, milling machine, planning machine, grinding machines, CNC machines and wood working machinery to create risk free working environment.
- CO2** : Assess the adequacy of machinery guarding to eliminate or reduce the hazards from the point operation, flying chips and sparks and moving parts.
- CO3** : Apply the safety concepts in welding, gas cutting, storage and handling of gas cylinders, metal forming processes, etc.,
- CO4** : Predict, identify and evaluate, hazardous conditions and practices safety rules in in cold forming and hot working of metals
- CO5** : Employ the safety rules in inspection and testing process and take plan the preventive measures in health and welfare of workers' aspects in engineering industry.

TEXT BOOKS

1. Wells G.L.,R.M.C. Seagrave-Flow sheeting for safety, Indian Institute of Chemical Engineering, London U.K,1977.
2. TrevurKletz Butterworth, Learning from accidents, - London, 1988.
3. John Barton and Richard Rogers, Chemical reaction Hazards - A guide to safety, Institution of Chemical Engineering London, 1997.

REFERENCES:

1. Rohatgi A.K, Safety handling of Hazardous Chemicals Enterprises, Bombay, 1986.
2. Shukla S.K., Envirohazards and Techno Legal aspects, Shashi Publications, Jaipur India, 1993.
3. John V.Grimaldi and Rollin H.Simonds, " Safety Management", Richard D Irwin, 199

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

OE2	RISK ANALYSIS AND HAZOP	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION AND DISPERSION MODELS

9

Risk analysis introduction, quantitative risk assessment, rapid risk analysis - Comprehensive risk analysis - Emission and dispersion- Leak rate calculation. Single and two-phase flow - Dispersion model for dense gas - Flash fire - Plume dispersion - Toxic dispersion model - Evaluation of risk.

MODULE II RADIATION INTENSITY

9

Radiation - Tank on fire - Flame length - Radiation intensity calculation and its effect on plant, people and property radiation VCVCE - Explosion due to over pressure - Effects of explosion, risk contour -Effects, explosion, BLEVE - Jet fire - Fire ball.

MODULE III RISK ANALYSIS

9

Overall risk analysis - Generation of meteorological data - Ignition data - Population data - Consequences analysis and total risk analysis - Overall risk contours for different failure scenarios - Disaster management plan - Emergency planning - On site and off-site emergency planning, risk management ISO 14000, EMS models case studies - Marketing terminal, gas processing complex, refinery.

MODULE IV HAZARD ANALYSIS

9

foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes. Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills - hot bending of pipes, hazards and control measures. Safety in gas furnace operation, cupola, crucibles, ovens, foundry health hazards, work environment, material handling in foundries, foundry production cleaning and finishing foundry processes.

MODULE V CASE STUDIES

9

Hazop - Guide words, parameters, derivation - Causes - Consequences - Recommendation - Coarse Hazop study - Case studies - Pumping system - Reactor - Mass transfer system.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Identify individual hazards in a process and deduce the associated risks.

CO2 : Identify radiation intensity and effects of explosion

CO3 : Perform risk analysis of various types of problems

CO4 : Evaluate effect about key hazard identification techniques

CO5 : Apply risk analysis techniques and Hazop study

TEXT BOOKS

1. Ragavan K.V., Khan A.A., Methodologies in Hazard identification and assessment -Manual, CLRI publication, 1990.
2. Marcel.V.C., Major Chemical Hazard, Ellis Hawood Ltd., Chi Chester, UK, 1987.
3. Skeleton B., Process Safety Analysis, Institution of chemical Engineers, U.K., 1997.

REFERENCES:

1. Daniel A Crowl., Louvar J.F., Chemical Process Safety: Fundamentals with Applications, Prentice Hall, New Jersey, 2002.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
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3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

OE3	GREEN TECHNOLOGY	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION

9

The concept of green technology; evolution; nature, scope, importance and types; developing a theory; green technology in India; relevance in twenty first century..

MODULE II SUSTAINABILITY & ENVIRONMENT

9

Organizational environment; internal and external environment; Indian corporate structure and environment; how to go green; spreading the concept in organization; environmental and sustainability issues for the production of high-tech components and materials, life cycle analysis of materials, sustainable production and its role in corporate social responsibility (CSR) and corporate environmental responsibility (CER).

MODULE III ECOSYSTEM APPROACHES

9

Approaches from ecological economics; indicators of sustainability; ecosystem services and their sustainable use; bio-diversity; Indian perspective; alternate theories.

MODULE IV ACTS OF GREEN TECHNOLOGY

9

Environmental reporting and ISO 14001; climate change business and ISO 14064; green financing; financial initiative by UNEP; green energy technology; green product technology.

MODULE V GREEN ECONOMICS

9

Definition; green techniques and methods; green tax incentives and rebates (to green projects and companies); green project technology in action; business redesign; eco-commerce models.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Outline the green technology concepts and relevance in twenty first century requirements.

CO2 : Defend the environmental and sustainability issues, role of CSR and CER and Indian corporate structure and environment.

CO3 : Recall the indicators of sustainability and their use and can also find the alternate theories.

CO4 : Criticize the environmental reporting, ISO 14001, ISO 14064, financial initiative by UNEP, etc.

CO5 : Analyse the green tax incentives and rebates, business redesign and its models.

TEXT BOOKS

1. Jazmin Seijas, Green Technology and Green Technologies: Exploring the Causal Relationship, Nogarida, 2008.

REFERENCES:

1. Green Marketing and Technology: A global Perspective by John F. Whaik, 2005.
2. Leo A. Meyer, The Green Energy Technology.
3. Richard Maltzman and David Shiden, Green Project Technology.
4. Jacquelin Ottman, Green Marketing.

5. Green and World by Andrew S. Winston.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

OE4	CORROSION SCIENCE AND ENGINEERING	L	T	P	C
		3	0	0	3

MODULE I INTRODUCTION

9

Introduction, classification, economics and cost of corrosion. emf series, galvanic series, corrosion theories derivation of potential Current relations of activities controlled and diffusion controlled corrosion process. Potential - pH diagram, Fe-H₂O system, application and limitation. Passivation - Definition, anodic passivation theory of passivation, oxidation laws, effects of oxygen and alloying on oxidation rates.

MODULE II CORROSION CONTROL METHODS

9

Forms of corrosion - Definition, factors and control methods of various forms of corrosion such as pitting, inter granular, crevice, dezincification, stress corrosion, corrosion fatigue, fretting corrosion, hydrogen embitterment, corrosion processes and control methods in fertilizers, petrochemical, chemical building industries.

MODULE III MECHANISM OF CORROSION

9

Environmental aspects, atmospheric corrosion - Classification, factors influencing atmospheric corrosion, temporary corrosion preventive methods, corrosion in immersed condition, effect of dissolved gases, salts, pH, temperature, and flows rates on corrosion, marine corrosion, underground corrosion. Biological corrosion, definition, mechanism of corrosion, control of bio- corrosion.

MODULE IV CORROSION PREVENTION

9

Corrosion control aspects, electrochemical methods of protection-theory of cathodic protection design of cathodic protection, sacrificial anodes, impressed current anodes, anodic protection. Corrosion inhibitors for acidic, neutral and alkaline media, cooling water system - Boiler water system. Organic coating, surface preparation, natural, synthetic resin, paint, formulation and application. Design aspects in corrosion prevention, corrosion resistant materials.

MODULE V CORROSION TEST

9

Corrosion testing, monitoring and inspection, laboratory corrosion tests, accelerated chemical tests for studying different forms of corrosion. Electrochemical methods of corrosion rate measurements by DC and AC methods, corrosion monitoring methods, chemical and electrochemical removal of corrosion products, newer techniques to study corrosion processes, inspection methods by NDT. Surface analytical techniques such as AES, ESCA, SEM. Evaluation of paints by conventional and electrochemical methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 : Classify the types of corrosion and theories and also relate the various controlled corrosion process.

CO2 : Examine the factors involved in the corrosion and control methods of various corrosion.

CO3 : Analyse the mechanism of corrosion and evaluate the effects like pH, temperature, flow rate on corrosion.

CO4 : Design and develop the corrosion control methods like cathodic protection, sacrificial anode and impressed current anodes and anodic protection.

CO5 : Predict the different corrosion testing, monitoring and inspection tests by surface analytical studies.

TEXT BOOKS

1. Roberge P. R., Corrosion Engineering, McGraw Hill, New York, 2008.
2. Fontana M.G., Greene N.D., Corrosion Engineering, Third Edition, McGraw Hill, NewYork, 2005.
3. Uhling H. H., Revie R.W., Corrosion and Corrosion Control, John Wiley and Sons, Inc, 1985.

REFERENCES:

1. Banarjee.S.N., An introduction to corrosion and corrosion inhibitors, Oxonian Press Ltd., New Delhi, 1985.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

OE5	NANOMATERIAL SYNTHESIS AND CHARACTERIZATION LABORATORY	L	T	P	C
		0	0	3	1.5

LIST OF EXPERIMENTS

1. Chemical synthesis of Ag nanoparticles; UV-Visible absorption of the colloidal sol.
2. Chemical synthesis of CdS nanoparticles; Optical absorption spectra; Band gap estimation from the band edge.
3. Synthesis of ceria nanofibres by Solvothermal method.
4. Synthesis of silica nanoparticles using Stober method.
5. Synthesis of Au nanoparticles by simple chemical method.
6. Synthesis of Fe₃O₄ nanoparticles by simple reduction method.
7. Effect of reducing agent on the synthesis of metal nanoparticles.
8. Aqueous to organic phase transfer of Ag and CdS nanoparticles; Confirmation by UV-Visible absorption.
9. Effect of concentration on the synthesis of silver nanoparticles.
10. Effect of reducing agent on gold nanoparticles.
11. Fabrication of silver nanofilms.
12. Synthesis of polyvinyl alcohol fibres by electrospinning method.
13. Synthesis of Au and Ag nanoparticles at aqueous-organic liquid interface; UV-visible spectroscopy of the colloidal film; comparison with the corresponding colloidal sol.
14. Sol gel synthesis of ZnO/TiO₂/CdO nanoparticles.
15. A bioroute to Au nanoparticles.
16. Sol-gel spin coating route to SnO₂ nanothin films: surface roughness measurement by AFM.
17. Hydrothermal synthesis of ZnS Nanorods: Nanorods formation by SEM analysis.
18. Fabrication and wettability characterization of nanostructured soft polymer surfaces.
19. Preparation of nanofluids.
20. Determination of viscosity of nanofluids.
21. Evaporation studies of nanofluids.
22. Measurement of stability of nanofluids.
23. Optical properties of nanofluids.
24. Measurement of onset of natural convection in nanofluids.
25. Thermal conductivity measurement of nanofluids.

TOTAL: 45 PERIODS

Students will able to

CO1: Synthesize several nano materials in different methods in lab scale.

CO2: calibrate and operate the instruments for material characterization.

CO3: Interpret the properties of synthesized nanomaterials by analyzing the results.

CO4: Conduct experiments to solve complex engineering problems effectively as an individual or team work.

CO5: Perform as a leader with good ethical principles to meet societal needs in the field of chemical and allied engineering.

CO-PO & PSO MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
1	3												1		
2		3											1		1
3	3												1		
4													1		
5		3			2								1		
Avg.	3	3			2								1		1

1-low, 2-medium, 3-high

OE6	MULTIVARIATE STATISTICAL LABORATORY	L	T	P	C
		0	0	3	1.5

LIST OF EXPERIMENTS

1. Point and Interval Estimation for Normal and Chi-Square Distribution using Excel and R.
2. Point and Interval Estimation for T-Distribution and F-Distribution using Excel and R.
3. K-means Clustering.
4. One-way ANOVA Model in Excel and R.
5. Linear Regression
6. Logistic Regression
7. Naive Bayesian Classifier
8. Decision Trees
9. Simulation of Principal component analysis using Excel and R.
10. Simulation of Fischer Discriminant Analysis using Excel and R.
11. Modeling the Change by Differential Equations using R and Excel.
12. Modeling the Change by Difference Equations using R and Excel.
13. Multivariate Normal & Hotelling's T2 Distribution.
14. Multivariate Analysis of Variance (MANOVA).
15. Correspondence Analysis using R.

TOTAL: 45 PERIODS

Students will able to

CO1: To solve ordinary differential equation and algebraic equation using solver and goal seek in Excel.

CO2: To create function in VBA and develop programming codes to solve user-defined calculations in Excel.

CO3: To perform mathematical operations and develop script file to solve algebraic equations using MATLAB.

CO4: To apply and familiarize in-built functions of MATLAB for solving ordinary and partial differential equations

CO5: Apply ethical principles while doing experiments.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3											1		
2		3										1		1
3	3											1		
4												1		
5		3			2							1		
Avg.	3	3			2							1		1

1-low, 2-medium, 3-high

VERTICAL-I
B.TECH. MINOR IN ENVIRONMENTAL AND SUSTAINABILITY ENGINEERING

OE7	SUSTAINABLE INFRASTRUCTURE DEVELOPMENT	L	T	P	C
		3	0	0	3

MODULE I SUSTAINABLE DEVELOPMENT GOALS 9

Definitions, principles and history of Sustainable Development - Sustainable development goals (SDG): global and Indian – Infrastructure Demand and Supply - Environment and Development linkages - societal and cultural demands – Sustainability indicators - Performance indicators of sustainability and Assessment mechanism.

MODULE II SUSTAINABLE INFRASTRUCTURE PLANNING 9

Overview of Infrastructure projects: Housing sector, Power sector, Water supply, road, rail and port transportation sector, rural and urban infrastructure. Environmental Impact Assessment (EIA), Land acquisition -Legal aspects, Resettlement & Rehabilitation and Development - Cost effectiveness Analysis - Risk Management Framework for Infrastructure Projects, Economic, demand, political, socio-environmental and cultural risks.

MODULE III SUSTAINABLE CONSTRUCTION PRACTICES AND TECHNIQUES 9

Sustainability through lean construction approach - Enabling lean through information technology – Lean in planning and design - IPD (Integrated Project Delivery) - Location Based Management System - Geospatial Technologies for machine control, site management, precision control and real time progress monitoring - Role of logistics in achieving sustainable construction — Data management for integrated supply chains in construction.

MODULE IV SUSTAINABLE CONSTRUCTION MATERIALS 9

Construction materials: Concrete, steel, glass, aluminium, timber and FRP - No/Low cement concrete - Recycled and manufactured aggregate - Role of QC and durability - Sustainable consumption – Eco-efficiency - green consumerism - product stewardship and green engineering - Extended producer responsibility – Design for Environment Strategies, Practices, Guidelines, Methods, And Tools.

MODULE V SUSTAINABLE MAINTENANCE OF INFRASTRUCTURE PROJECTS 9

Case Studies - Sustainable projects in developed countries and developing nations - An Integrated Framework for Successful Infrastructure Planning and Management - Information Technology and Systems for Successful Infrastructure Management, - Structural Health Monitoring for Infrastructure projects.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 Understand the environment sustainability goals at global and Indian scenario.

CO2 Understand risks in development of projects and suggest mitigation measures.

CO3 Apply lean techniques, LBMS and new construction techniques to achieve sustainability in infrastructure construction projects.

CO4 Explain Life Cycle Analysis and life cycle cost of construction materials.

CO5 Explain the new technologies for maintenance of infrastructure projects.

TEXT BOOKS

1. Charles J Kibert, Sustainable Construction : Green Building Design & Delivery, 4th Edition ,Wiley Publishers 2016.
2. Steve Goodhew, Sustainable Construction Process, Wiley Blackwell,UK, 2016.
3. Craig A. Langston & Grace K.C. Ding, Sustainable Practices in the Built Environment,Butterworth Heinemann Publishers, 2011.

REFERENCES:

1. William P Spence, Construction Materials, Methods & Techniques (3e), Yesdee PublicationPvt. Ltd, 2016.
2. New Building Materials and Construction World magazine
3. Kerry Turner. R, "Sustainable Environmental Management", Principles and Practice Publisher:Belhaven Press,ISBN:1852930039.
4. Munier N, "Introduction to Sustainability", Springer2005
5. Sharma, "Sustainable Smart Cities In India: Challenges And Future Perspectives",SPRINGER, 2022.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

OE8	MATERIALS FOR ENERGY SUSTAINABILITY	L	T	P	C
		3	0	0	3

MODULE I SUSTAINABLE ENERGY SOURCES 9

Introduction to energy demand and challenges ahead – sustainable source of energy (wind, solar etc.) – electrochemical energy systems for energy harvesting and storage – materials for sustainable electrochemical systems building – India centric solutions based on locally available materials – Economics of wind and solar power generators vs. conventional coal plants – Nuclear energy

MODULE II ELECTROCHEMICAL DEVICES 9

Electrochemical Energy – Difference between primary and secondary batteries – Secondary battery (Li-ion battery, Sodium-ion battery, Li-S battery, Li-O₂ battery, Nickel Cadmium, Nickel Metal Hydride) – Primary battery (Alkaline battery, Zinc-Carbon battery) – Materials for battery (Anode materials – Lithiated graphite, Sodiated hard carbon, Silicon doped graphene, Lithium Titanate) (Cathode Materials – S, LiCoO₂, LiFePO₄, LiMn₂O₄) – Electrolytes for Lithium-ion battery (ethylene carbonate and propylene carbonate based)

MODULE III FUEL CELLS 9

Principle of operation of fuel cells — types of fuel cells (Proton exchange membrane fuel cells, alkaline fuel cell, direct methanol fuel cells, direct borohydride fuel cells, phosphoric acid fuel cells, solid oxide fuel cells, and molten carbonate fuel cells) — Thermodynamics of fuel cell — Fuel utilization — electrolyte membrane (proton conducting and anion conducting) — Catalysts (Platinum, Platinum alloys, carbon supported platinum systems and metal oxide supported platinum catalysts) — Anatomy of fuel cells (gas diffusion layer, catalyst layer, flow field plate, current conductors, bipolar plates and monopolar plates)

MODULE IV PHOTOVOLTAICS 9

Physics of the solar cell – Theoretical limits of photovoltaic conversion – bulk crystal growth of Si and wafering for photovoltaic application - Crystalline silicon solar cells – thin film silicon solar cells multijunction solar cells – amorphous silicon based solar cells – photovoltaic concentrators – Cu(InGa)Se₂ solar cells – Cadmium Telluride solar cells – dye sensitized solar cells – Perovskite solar cells – Measurement and characterization of solar cells - Materials used in solar cells (metallic oxides

MODULE V SUPERCAPACITORS 9

Supercapacitor –types of supercapacitors (electrostatic double-layer capacitors, pseudo capacitors and hybrid capacitors) - design of supercapacitor-three and two electrode cell-parameters of supercapacitor-Faradaic and non - Faradaic capacitance — electrode materials (transition metal oxides (MO), mixed metal oxides, conducting polymers (CP), Mxenes, nanocarbons, non-noble metal, chalcogenides, hydroxides

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: acquire knowledge about energy sustainability.

CO2: understand the principles of different electrochemical devices.

CO3: learn about the working of fuel cells and their application.

CO4: learn about various Photovoltaic applications and the materials used.

CO5: gain knowledge on different types of supercapacitors and the performance of various materials

TEXT BOOKS

1. John A. Kilner, Stephen J. Skinner, Stuart J. C. Irvine and Peter P. Edwards, Functional materials for sustainable energy applications
2. Wolf Vielstich, Arnold Lamm, Hubert Andreas Gasteiger, Harumi Yokokawa, Hand Book of Fuel Cells: Fuel Cell Technology and Applications, Wiley, London 200
3. B.E. Conway, Electrochemical supercapacitors: scientific fundamentals and technological applications, Kluwer Academic / Plenum publishers, New York, 1999.

REFERENCES:

1. T.R. Crompton, Batteries reference book, Newners, 3rd Edition, 2002.
2. Materials for Supercapacitor applications; B. Viswanathan. M. Aulice Scibioh
3. Electrode Materials for Supercapacitors: A Review of Recent Advances, Parnia Forouzandeh, Vignesh Kumaravel and Suresh C. Pillai, catalysts 2020.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

OE9	ENVIRONMENTAL QUALITY MONITORING	L	T	P	C
		3	0	0	3

MODULE I ENVIRONMENTAL MONITORING AND STANDARDS 9

Introduction- Environmental Standards- Classification of Environmental Standards- Global Environmental Standards- Environmental Standards in India- Ambient air quality standards- water quality standard- Environmental Monitoring-Need for environmental monitoring- Concepts of environmental monitoring- Techniques of Environmental Monitoring.

MODULE II MONITORING OF ENVIRONMENTAL PARAMETERS 9

Current Environmental Issues- Global Environmental monitoring programme-International conventions- Application of Environmental Monitoring- Atmospheric Monitoring - screening parameters – Significance of environmental sampling- sampling methods – water sampling - sampling of ambient air-sampling of flue gas.

MODULE III ANALYTICAL METHODS FOR ENVIRONMENTAL MONITORING 9

Classification of Instrumental Method- Analysis of Organic Pollutants by Spectrophotometric methods - Determination of nitrogen, phosphorus and, chemical oxygen demand (COD) in sewage; Biochemical oxygen demand (BOD)- Sampling techniques for air pollution measurements; analysis of particulates and air pollutants like oxides of nitrogen, oxides of sulfur, carbon monoxide, hydrocarbon; Introduction to advanced instruments for environmental analysis.

MODULE IV ENVIRONMENTAL MONITORING PROGRAMME (EMP) & RISKASSESSMENT 9

Water quality monitoring programme- national water quality monitoring- Parameters for National Water Quality Monitoring- monitoring protocol; Process of risk assessment- hazard identification- exposure assessment- dose-response assessment; risk characterization.

MODULE V AUTOMATED DATA ACQUISITION AND PROCESSING 9

Data Acquisition for Process Monitoring and Control - The Data Acquisition System - Online Data Acquisition, Monitoring, and Control - Implementation of a Data Management System - Review of Observational Networks -Sensors and transducers- classification of transducers- data acquisition system- types of data acquisition systems- data management and quality control; regulatory overview.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: apply basic concepts of environmental standards and monitoring.

CO2 : estimate the ambient air quality and water quality standards.

CO3 : apply instrumental methods and their principles for environmental monitoring.

CO4: Demonstrate the significance of environmental standards in monitoring quality and sustainability of the environment.

CO5: create the various ways of raising environmental awareness among the people.

TEXT BOOKS

1. Frank R. Burden, Environmental monitoring Handbook, The McGraw-Hill Companies, Inc, 2002.
2. Pradyot Patnaik, Handbook of environmental analysis: chemical pollutants in the air, water, soil, and solid wastes, CRC Press, 1997.

REFERENCES:

1. G. Bruce Wiersma, Environmental monitoring, CRS Press, 2004.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3										3	3
2	3	3	3										3	3
3	3	3	3										3	3
4	3	3	3										3	3
5	3	3	3										3	3
Avg.	3	3	3										3	3

1-low, 2-medium, 3-high

VALUE ADDED COURSES

	CRITICAL THINKING	L	T	P	C
		1	0	0	1

CRITICAL THINKING PROCESS

9

Critical Thinking - Characteristics of Critical Thinker - Critical Thinking Process -Critical Thinking Styles - Logical Fallacies - Inductive and Deductive Reasoning.

CRITICAL THINKING SKILLS

6

Critical Thinking Skills set - Solving Problems - Critical argumentation

TOTAL: 15 PERIODS

COURSE OUTCOME

CO1 : Demonstrate the logical connection between the ideas.

CO2 : Distinguish relevant from non-relevant data, fact from opinion.

CO3 : Solve problems by accessing information and presenting arguments in a logical way

Pedagogy

Lecture, Exercises

Evaluation and Grading

Exercises ... 50%

Case Action Plan ... 50%

REFERENCE:

1. De Bono, Edward (2015) Lateral Thinking : Creativity Step by Step, (International Edition), Harper Perennial Publishers
2. Tidd, Joe, and Bessant, R. John (2015). Managing Innovation : Integrating Technological, Market and Organizational Change, 5/e, New Delhi : Wiley India.
3. Christensen, M. Clayton and Raynor, E. Micheael (2013). The Innovators Solution, Boston : Harvard Business School Press.
4. Khandwalla, N. Pradip (2009). Life long Creativity - An Unending Quest, New Delhi : McGraw Hill Education

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1		2	2		2	2	3				3	2	2	2
2		2	2		2	2	3				3	2	2	2
3		2	2		2	2	3				3	2	2	2
Avg.		2	2		2	2	3				3	2	2	2

1-low, 2-medium, 3-high

	CREATIVITY & INNOVATION	L	T	P	C
		1	0	0	1

THE CREATIVITY PHENOMENON

8

The Realm of Creativity - Creativity Process - Components of Creativity - Enhancing Creative Intelligence, Mastering Creative Problem Solving - Existential, Entrepreneurial and Empowerment Creativity - Acquiring a Creative Persona - Techniques of Creative Problem Solving.

THE PRACTICE OF INNOVATION

7

Purposeful Innovation - Impetus to innovate - Sources of Innovation Opportunity - Types and Patterns of Innovation - Designing and Implementing Innovation Strategies.

TOTAL : 15 PERIODS

COURSE OUTCOMES

The course is intended to kindle the spirit of creativity and innovation among students. The student mind is largely conditioned to approach issues in logical and sequential order. This course will provide opportunities for students to be spontaneous and creative and think out of the box.

CO1 : Apply the techniques of creativity in decision making and problem solving under various scenarios

CO2 : Analyze various methods that enhance creative ability

CO3 : Design solutions to problems through the systematic process of innovation

PEDAGOGY

Lecture, Journaling, Exercises

EVALUATION AND GRADING

Article Review ... 20%

Presentation ... 30%

Exercises ... 50%

REFERENCES

1. De Bono, Edward (2015). Lateral Thinking: Creativity Step by Step, (International Edition), Harper Perennial Publishers
2. Tidd, Joe, and Bessant, R. John (2015). Managing Innovation: Integrating Technological, Market and Organizational Change, 5/e; New Delhi: Wiley India
3. Christensen, M. Clayton, and Raynor, E. Michael (2013). The Innovators Solution, Boston: Harvard Business School Press
4. Khandwalla, N. Pradip (2009). Lifelong Creativity - An Unending Quest, New Delhi: McGraw Hill Education

CO-PO & PSO MAPPING

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
1							2					3	2	2	2
2			3									3	2	2	2
3			3		3		3					3	2	2	2
Avg.			3		3		3					3	2	2	2

1-low, 2-medium, 3-high

	LEADERSHIP	L	T	P	C
		1	0	0	1

MODULE I CHARACTERISTICS OF LEADERSHIP

7

Leadership Theories, Characteristics of a Leader, Leadership in Teams.

MODULE II PRACTICE

8

Leadership and Motivation, Leadership and Values, Vision.

TOTAL: 15 hours

COURSE OUTCOMES

This course introduces the students to the foundations of leadership, the role of a leader in the changing business environment and the stories of remarkable leaders from various walks of life. The leaders are those who have left their mark and made a difference in whatever area they chose to influence - political, social, business, environmental etc. It is important to understand their contributions towards the development of societies and economies.

CO1 : Explain the impact of changes in the business environment on business (K2)

CO2 : Apply theories of leadership to create an effective team environment (K3)

CO3 : List the characteristics of effective leadership (K4)

Pedagogy

Discussion, Seminar, Role Play

Evaluation and Grading

Presentation ... 50%

Assignment ... 50%

REFERENCES

1. Hurley, Kathleen and Priscilla, Shumway (2015). Real Women, Real Leaders: Surviving and Succeeding in the Business World, New Jersey: WileyIndia
2. Yukl, Garry (2013). Leadership in Organizations, 8/e; New Jersey: Pearson Education
3. Sandberg, Sheryl (2013). Lean In: Women, Work, and the Will to Lead, New York: Knopf Doubleday PublishingGroup
4. HBR (2011). HBR's 10 Must Reads - On Leadership, USA: Harvard Business Publishing
5. Barsh, Joanna, Susie, Cranston and Geoffrey, Lewis (2011). How Remarkable Women Lead - The Breakthrough Model for Work and Life, New York: McKinsey & Company, Inc

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1							3		3		3	2	2	2
2							3		3		3	2	2	2
3							2		2		3	2	2	2
Avg.							2.67		2.67		3	2	2	2

1-low, 2-medium, 3-high

EMOTIONAL INTELLIGENCE											L	T	P	C
											1	0	0	1

MODULE I EMOTIONAL INTELLIGENCE

5

Concept of Emotional Intelligence, Understanding the history and origin of Emotional Intelligence, Contributors to Emotional Intelligence, Science of Emotional Intelligence, EQ and IQ, Scope of Emotional Intelligence.

MODULE II: COMPONENTS OF EMOTIONAL INTELLIGENCE

5

Components of Emotional Intelligence: Self-awareness, Self-regulation, Motivation, Empathy, Social skills. Emotional Intelligence Competencies, Elements of Emotional Intelligence, Models of Emotional Intelligence: The Ability-based Model, The Trait Model of Emotional Intelligence, Mixed Models of Emotional Intelligence.

MODULE III EMOTIONAL INTELLIGENCE AT WORK PLACE

5

Emotional Intelligence at Work place: Importance of Emotional Intelligence at Work place, Cost -savings of Emotional Intelligence, Emotionally Intelligent Leaders, Case Studies Measuring Emotional Intelligence: Emotionally Intelligence Tests, Research on Emotional Intelligence, Developing Emotional Intelligence.

TOTAL : 15 PERIODS

COURSE OUTCOME

Students will be able to

CO1: perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering

CO2: exhibit team spirit with a balanced mindset.

CO3: experience th importance of life-long learning.

REFERENCES

1. Daniel Goleman (1996). Emotional Intelligence - Why it can Matter More than IQ. Bantam Doubleday Dell Publishing Group
2. Daniel Goleman (2000). Working with Emotional Intelligence. Bantam Doubleday Dell Publishing Group
3. Liz Wilson, Stephen Neale & Lisa Spencer-Arnell (2012). Emotional Intelligence Coaching. Kogan Page India Private Limited

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1								3						
2								2	3					
3								1				3		
Avg.								2	3			3		

1-low, 2-medium, 3-high

	HEALTH AND LIFESTYLE	L	T	P	C
		1	0	0	1

MODULE I INTROUDTCION

Introduction to Health Health is wealth; Role of lifestyle habits on health; Importance of adolescence; Stages, Characteristics and changes during adolescence; Nutritional needs during adolescence why healthy lifestyle is important for adolescence. Eating Habits - eating disorders, skipping breakfast, junk food consumption.

MODULE II HEALTH

Food and Nutritional Requirements during Adolescence Fluid intake; nutrition related problems; lifestyle related problems, Role of physical activity; resting pattern and postures, Personal habits - alcoholism, and other tobacco products, electronic addiction etc.

MODULE III LIFE STYLE

Need for a Positive Life Style Change Peer pressure & procrastination, Stress, depression, suicidal tendency.

TOTAL : 15 PERIODS

COURSE OUTCOME

Students will be able to

- CO1:** perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering
- CO2:** exhibit team spirit with a balanced mindset.
- CO3:** experience th importance of life-long learning

TEXTBOOKS

1. B.Srilakshmi, "Dietetics", New age international (P) ltd, publishers, 2010.
2. "Nutrient requirement and Recommended Dietary Allowances for Indians", published by Indian Council of Medical Research, ICMR, 2010.

REFERENCE

- 1.K Park "Textbook of preventive and social medicine", 2010. WHO Report on Adolescent Health: 2010.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1								3						
2								2	3					
3								1				3		
Avg.								2	3			3		

1-low, 2-medium, 3-high

	PSYCHOLOGY FOR ENGINEERS	L	T	P	C
		1	0	0	1

MODULE I PSYCHOLOGY

5

Psychology of Adolescents: Adolescence and its characteristics.

MODULE II LEARNING

5

Learning, Memory & Study Skills: Definitions, types, principles of reinforcement, techniques for improving study skills, Mnemonics.

MODULE III PERCEPTION

5

Attention & Perception: Definition, types of attention, perception.

TOTAL : 15 PERIODS

COURSE OUTCOME

Students will be able to

CO1: perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering

CO2: exhibit team spirit with a balanced mindset.

CO3: experience th importance of life-long learning.

TEXTBOOKS

1. S. K. Mangal, "General Psychology", Sterling Publishers Pvt. Ltd.2007
2. Baron A. Robert, "Psychology", Prentice Hall of India. New Delhi 2001

REFERENCES

1. Elizabeth B.Hurlock, Developmental Psychology-A life span approach, 6th edition.
2. Feldman, Understanding Psychology, McGraw Hill, 2000.
3. Clifford Morgan, Richard King,John Scholper,"Introduction to Psychology", Tata Mcgraw Hill, Pvt Ltd 2004.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1								3						
2								2	3					
3								1				3		
Avg.								2	3			3		

1-low, 2-medium, 3-high

	FUNDAMENTALS OF NANOSCIENE	L	T	P	C
		1	0	0	1

MODULE I INTRODUCTION

Nanoscale Science and Technology- Implications for Physics, Chemistry, Biology and Engineering- Classifications of nanostructured materials- nano particles- quantum dots, nanowires-ultra-thin films-multilayered materials.

MODULE II PREPARATION METHODS

Bottom-up Synthesis-Top-down Approach.

MODULE III CHARECTERISATION TECHNIQUES

X-ray diffraction technique, Scanning Electron Microscopy, Transmission Electron Microscopy, Surface Analysis techniques.

TOTAL : 15 PERIODS

COURSE OVERVIEW

The general goal of the course is to provide an introduction to and an overview over nanotechnology. This course introduces the fundamentals of nano-scale engineering and manufacturing. Current and future applications of nanostructured materials will be reviewed with respect to their impact in commercial products and technologies

PEDAGOGY

Lecture, Exercises

EVOLUTIONAL GRADING

Tests / Quiz : 50%

Assignments / Seminar Presentations : 50%

COURSE OUTCOME

Students will be able to

CO1: perform as a leader with good ethical principles to meet societal needs in the field of chemical engineering

CO2: exhibit team spirit with a balanced mindset.

CO3: experience th importance of life-long learning.

TEXT BOOKS

1.A.S. Edelstein and R.C. Cammearata, eds., "Nanomaterials: Synthesis, Properties and Applications", Institute of Physics Publishing, Bristol and Philadelphia, 1996.

2.N John Dinardo, "Nanoscale characterization of surfaces & Interfaces", 2nd edition, Weinheim Cambridge, Wiley-VCH, 2000

REFERENCES

1.G Timp (Editor), "Nanotechnology", AIP press/Springer, 1999.

2.AkhleshLakhtakia (Editor), "The Hand Book of Nano Technology, Nanometer Structure, Theory, Modeling and Simulations". Prentice-Hall of India (P) Ltd, New Delhi, 2007.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1								3						
2								2	3					
3								1				3		
Avg.								2	3			3		

1-low, 2-medium, 3-high

AN INTRODUCTION TO ENVIRONMENTAL ETHICS											L	T	P	C
											1	0	0	1

MODULE I ETHICS AND THE ENVIRONMENT

5

Introduction, Ethics and the Environment, Environmental ethics approach and world views - Foundations for an Environmental Ethics, History and Its Pioneers, types of environmental ethics.

MODULE II ENVIRONMENTAL JUSTICE

5

Ethical Issues and Environmental Justice, Principles of Environmental Justice, Environmental Laws and Regulations.

MODULE III APPLICATION OF ETHICS IN ENVIRONMENTAL ISSUES

5

Ethical contributions to contemporary environmental issues, Environmental standard establishment and maintenance.

TOTAL : 15 PERIODS

COURSE OUTCOMES

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

CO1 : Understand the philosophical and ethical views as they relate to the environment.

CO2 : Identify the ethical issues, analyse environmental laws and justice.

CO3 : Examine applications of ethics in environmental issues.

REFERENCES

1. Environmental Ethics, Andrew Light and Holmes Rolston III, eds. Blackwell Publishing, 2003.
2. The Economy of the Earth: Philosophy, Law, and the Environment, 2nd edition, Mark Sagoff. Cambridge University Press, 2008

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1							1	2						
2								3						1
3								2						1
Avg.														

1-low, 2-medium, 3-high

CORPORATE SOCIAL RESPONSIBILITIES											L	T	P	C
											1	0	0	1

MODULE I CORPORATE SOCIAL RESPONSIBILITY

6

Corporate Social Responsibility- Definition, concept, linkages to development Growth of CSR-historical & contemporary perspectives, National & International scenario Factors influencing growth of CSR in societies- ideological, socio-economic, legal & environmental perspectives Government initiatives for promoting CSR Impact of globalization & liberalization on CSR initiatives

MODULE II CSR DEVELOPMENT

CSR & Development: -CSR activities-nature, types, impact on development programmes- CSR& development organisations-relationships, functioning & impact on organisational functioning Stakeholders' participation & perspectives about CSR

Pedagogy

Lecture, Exercises

Evaluation and Grading

Exercises ... 50%

Case Studies ... 50%

TOTAL : 15 PERIODS

COURSE OUTCOMES

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

CO1 : Understand the key characteristics of Corporate Social Responsibility (CSR) in the context of present-day management

CO2 : Apprise regarding business decision-making by ethical values and respect for people communities and the environment

CO3 : Become aware of creating a strategic plan that enables an organization to reach out its internal and external stakeholders with consistent messages

REFERENCES

1.Grayson D., Hodges A. (2004). Corporate Social Responsibility- Seven Steps to Make Corporate Social Responsibility Work for Your Business. UK: Greenleaf Publishing Limited

2.Narang R.K. (2009). Corporate Social Responsibility-Replicable Models on Sustainable Development. New Delhi: The Energy & Resources Institute.

3.William B Werther, Jr, David Chandler, 2010 Strategic Corporate Social Responsibility, Stakeholders in a Global Environment, Second Edition, SAGE Publications, New Delhi

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1							2	1	3		3	3		3
2							2	2	3		2	3		3
3							2	1	3		3	3		3
Avg.							2	1.33	3		2.67	3		3

1-low, 2-medium, 3-high

ENERGY MATERIALS, DEVICES AND SYSTEMS											L	T	P	C
											1	0	0	1

MODULE I NANOMATERIALS FOR ENERGY CONVERSION AND STORAGE **8**

Advanced materials and devices for energy storage: Carbon Nano-Tubes (CNT), fabrication of CNTs, CNTs for hydrogen storage, CNT-polymer composites, ultra capacitor, Polymer membranes for fuel cells, PEM fuel cell, Acid/alkaline fuel cells, Batteries.

MODULE II ENERGY CONVERSION AND STORAGE DEVICES **7**

Device fabrication technologies, fundamentals of solar cells, recent advances in photovoltaics, spectral response and IV characterization.

TOTAL : 15 PERIODS

COURSE OUTCOMES

After the course completion, students will be able to

CO1 : Understand the recent technologies in energy storage

CO2 : Analyze various devices and mechanism for energy conversion from renewable sources

CO3 : Develop novel materials for energy conversion and storage application

Pedagogy

Lecture, Presentation, Assessment

Evaluation and Grading

Literature review	...	20%
Presentation	...	30%
Assessment	...	50%

REFERENCES

1. Robert F. P. Advanced Semiconductor Fundamentals, 2nd Edition, Pearson,2002
2. Duncan W. B., Dermot O., and Richard I. W. Energy Materials, 1st Edition, Wiley,2011.
3. Christoph B. Ullrich S. and Vladimir D. Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technologies, 2nd Edition, Wiley?VCH,2014.
4. San P. J. and Pei K. S.Nanostructured and Advanced Materials for Fuel Cells, 1st Edition, CRC Press,2013
5. Daniel C. and Besenhard J. O. Handbook of Battery Materials, 1st Edition Wiley? VCH,2011

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3													
2		2												
3		2	2			1								
Avg.														

1-low, 2-medium, 3-high

SURFACE ENGINEERING OF NANOMATERIALS											L	T	P	C
											1	0	0	1

MODULE I SURFACE ENGINEERING – FUNDAMENTALS

7

Fundamentals of surface engineering, physical modifications, chemical modifications, Application of surface engineering to nanomaterials.

MODULE II SURFACE ENGINEERING – METHODS

8

Deposition and surface modification methods, Advanced coating practices, characterization of nano coatings, thin films for surface engineering, microencapsulation, applications and current trends in surface engineering of nanomaterials.

TOTAL : 15 PERIODS

COURSE OUTCOMES

After the course completion, students will be able to

CO1 : Understand the fundamentals of surface engineering

CO2 : Analyze the performance enhancement of the surface engineered materials

CO3 : Identify appropriate technique for modification of nanomaterial to improve its properties

Pedagogy

Lecture, Presentation, Assessment

Evaluation and Grading

Literature review	...	20%
Presentation	...	30%
Assessment	...	50%

REFERENCES

- Gabor A. Somorjai, Yimin Li, Introduction to Surface Chemistry and Catalysis, John Wiley & Sons, New Jersey, 2010.
- HaraldIbach, Physics of Surfaces and Interfaces, Springer-Verlag, Berlin, 2006.
- Pankaj Vadgama, Surfaces and interfaces for biomaterials, First Edition, CRC Press, Boca Raton, 2005.
- Peter J. Blau, Friction Scienceand Technology- From concepts to applications, Second Edition, CRC Press, Boca Raton, 2009
- B. Bhusan, Modern Tribology Handbook, CRC Press, Boca Raton, 2005.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	2													
2		2												
3			1	2		1								
Avg.														

1-low, 2-medium, 3-high

	RESEARCH SKILLS	L	T	P	C
		1	0	0	1

MODULE I INTRODUCTION

5

What is Research and What makes a Good Research Question? - What is Literature Review and Why Do We Need to Do One? - Why are Planning and Management Skills Important for Research?

MODULE II STEPS IN RESEARCH WORK

5

When should I begin research? - How much time is required? - How do I select a research advisor? - How do I select a research topic? - What are the benefits of research? - How do I register for research programme?

MODULE III PUBLISHING REASRCH WORK

5

How to write a research / review article? - How to write abstract, introduction, methodology, results and discussion - How to format tables and figures? - Ethical issues in scientific publishing - How to avoid plagiarism? - Determining authorship - Submission of Manuscript - Monitoring Peer Review - Acceptance and post publication process.

TOTAL : 15 PERIODS

COURSE OUTCOMES

After completion of the course, students are able to

CO1 : Understand the concept of performing research, literature survey procedure and skills for pursuing research.

CO2 : Identify the research topic, advisor, time span, benefits of research and admission procedure.

CO3 : Write a research article and publishing it in a suitable journal and making presentations.

Evaluation and Grading

Literature Survey (Assignment)	-	30%
Presentation	-	40%
Review Article Writing	-	30%

TEXT BOOKS

1. J.W. Creswell, Research Design: Qualitative, Quantitative and Mixed Methods Approaches, SAGE Publications, Inc., 4th Ed., 2014.
2. N. William, Research Methods, Routledge; 2nd Ed., 2017.
3. C.R. Kothari, Research Methodology Methods and Techniques, New Age Publications, New Delhi, 2009.

CO-PO & PSO MAPPING

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1				2						3				1
2				3				2		3				1
3				3				2		3				1
Avg.				2.67				1.33		3				1

1-low, 2-medium, 3-high