SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

B.Tech., Chemical Engineering

CURRICULUM AND SYLLABUS

REGULATION – 2022

CHOICE BASED CREDIT SYSTEM

Curriculum Revision No:	00	Board of Studies recommendation date :	12.04.2024	Academic Council Approved date:	
Salient Points of the revision	01.				
	02.				
	03.				
	04.				
	05.				

SRI VENKATESWARA COLLEGE OF ENGINEERING,

(An Autonomous Institution, Affiliated to Anna University, Chennai – 600025)

REGULATIONS 2022

B.Tech., CHEMICAL ENGINEERING

CHOICE BASED CREDIT SYSTEM

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Equip students with the necessary skills and knowledge to prosper in their career in Chemical Engineering and related domains.

PEO 2: Encourage students to Pursue advanced learning and engage in research withinternationally acclaimed institutions and foster professional growth.

PEO 3: Empower students with leadership qualities to succeed in diversified fields with ethical administrative acumen and adapt to the rapid technological advancements and innovations.

PROGRAM OUTCOMES (PO's) PO

GRADUATE ATTRIBUTES

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 analyse 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 needfor 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)

1. Apply the knowledge of science and mathematics in the field of various transport processes to accomplish the contemporary needs of chemical and allied industries.

2. Execute the chemical engineering principles and modern engineering tools to conduct experiments or design a system for developing quality chemical processes by considering the cost, safety and environmental aspects.

PEO's – PO's & PSO's MAPPING:

PO's	PEOs		
	I	II	III
1.	3	3	2
2.	3	3	3
3.	3	3	3
4.	3	3	2
5.	3	3	2
6.	2	3	3
7.	2	2	3
8.	2	2	3
9.	2	2	3
10.	1	2	3
11.	3	2	2
12.	1	3	3
13.	3	3	2
14.	2	2	3

1- Slight (Low), 2- Moderate (Medium) , 3- Substantial (High)

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REGULATIONS 2022 CHOICE BASED CREDIT SYSTEM

B.Tech., CHEMICAL ENGINEERING

CURRICULUM AND SYLLABI FOR SEMESTERS

SEMESTER I

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours	Pre - requisite	Position
				L	T	P	C			
1	IP22151	Induction Program								
THEORY SUBJECTS										
2	HS22152	Communicative English (Common to all Branches)	HS	3	0	0	3	45		F
3	MA22151	Applied Mathematics I (Common to all Branches except MR)	BS	3	1	0	4	60		F
4	PH22153	Technical Physics (Common to BT and CH)	BS	3	0	0	3	45		F
5	CY22153	Technical Chemistry (Common to BT and CH & CE)	BS	3	0	0	3	45		F
6	ME22152	Basic Mechanical Engineering (Common to BT and CH)	ES	3	0	0	3	45		F
7	ME22151	Engineering Graphics (Common to BT and CH)	ES	2	0	2	3	60		F
8	HS22151	Tamil language and Heritage of Ancient Tamil Society (Common to all Branches)	MC	1	0	0	1	15		F

PRACTICAL SUBJECTS										
9	CY22161	Chemistry Laboratory (Common to all Branches)	BS	0	0	2	1	30		F
10	ME22162	Basic Mechanical Laboratory (Common to BT and CH)	ES	0	0	2	1	30		F
		TOTAL					**22**			

SEMESTER II

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours	Pre - requisite	Position
				L	T	P	C			
THEORY SUBJECTS										
11	HS22252	Technical English (Common to all Branches)	HS	3	0	0	3	45		F
12	MA22251	Applied Mathematics II (Common to all Branchesexcept MR)	BS	3	1	0	4	60		F
13	EE22251	Basic Electrical and Electronics Engineering for Chemical Engineers	ES	3	0	0	3	45		F
14	IT22251	Computer Programming and Practice (Common to AE / BT / CE / CH / ME)	ES	2	0	2	3	60		F
15	CH22201	Introduction to Chemical Engineering	PC	3	0	0	3	45		F
16	HS22251	Science and Technology in Ancient Tamil Society (Common to all branches)	MC	2	0	0	2	30		F

PRACTICAL SUBJECTS										
17	EE22111	Basic Electrical and Electronics Engineering Laboratory (Common to all Branches)	ES	0	0	2	1	30		F
18	PH22161	Physics Laboratory (Common to all Branches)	BS	0	0	2	1	30		F
		TOTAL					**20**			

SEMESTER III

SL.NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PERIODS PER WEEK**				**Total Hours**	**Pre - requisite**	**Position**
				L	**T**	**P**	**C**			
THEORY SUBJECTS										
19	MA22351	Applied Mathematics III	BS	3	1	0	4	60		F
20	CH22301	Chemical Process Calculations	PC	2	1	0	3	45		F
21	CH22302	Momentum Transfer	PC	2	1	0	3	45		F
22	CH22303	Chemical Engineering Thermodynamics I	PC	3	0	0	3	45		F
23	CH22304	Mechanical Operations	PC	2	1	0	3	45		F
24	CH22305	Mechanics of Solids for Chemical Engineering	PC	2	1	0	3	45		F
PRACTICAL SUBJECTS										
25	CH22311	Environmental Engineering Laboratory	PC	0	0	4	2	60		F
26	CH22312	Technical Analysis Laboratory	BS	0	0	4	2	60		F
		TOTAL					**23**			

SEMESTER IV

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours	Pre - requisite	Position
				L	T	P	C			
THEORY SUBJECTS										
27	MA22452	Numerical Methods (Common to CH and EE)	BS	3	1	0	4	60		F
28	CH22408	Chemical Engineering Thermodynamics II: Theory and Practice	PC	2	0	2	3	60		F
29	CH22401	Heat Transfer	PC	2	1	0	3	45		M
30	CH22402	Mass Transfer I	PC	2	1	0	3	45		F
31	CH22403	Chemical Reaction Engineering I	PC	2	1	0	3	45		F
32	CH22404	Instrumental Methods of Analysis	PC	3	0	0	3	45		M
33	GE22451	Environmental Science and Sustainability (Common to all branches)	MC	3	0	0	3	45		F
PRACTICAL SUBJECTS										
34	CH22411	Momentum Transfer Laboratory	PC	0	0	4	2	60		F
35	CH22412	Mechanical Operations Laboratory	PC	0	0	4	2	60		F
		TOTAL					**26**			

SEMESTER V

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours	Pre - requisite	Position
				L	T	P	C			
THEORY SUBJECTS										
36	CH22501	Mass Transfer II	PC	2	1	0	3	45		F
37	CH22502	Chemical Reaction Engineering II	PC	2	1	0	3	45		F

38	CH22503	Process Instrumentation Dynamics and Control	PC	2	1	0	3	45		M
39	CH22504	Chemical Process Industries	PC	3	0	0	3	45		F
40	CH22505	Process Equipment Design I	PC	2	1	0	3	45		F
41	******	Open Elective I	OE	3	0	0	3	45		M
PRACTICAL SUBJECTS										
42	CH22511	Mass Transfer Laboratory	PC	0	0	4	2	60		F
43	CH22512	Heat Transfer Laboratory	PC	0	0	4	2	60		F
		TOTAL					**22**			

SEMESTER VI

SL.NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PERIODS PER WEEK**				**Total Hours**	**Pre - requisite**	**Position**
				L	**T**	**P**	**C**			
THEORY SUBJECTS										
44	CH22601	Transport Phenomena	PC	2	1	0	3	45		F
45	CH22608	Process Modeling and Simulation: Theory and Practices	PC	2	0	2	3	60		F
46	CH22609	Process Equipment Design II: Theory and Practices	PC	2	0	2	3	60		F
47	******	Professional Elective I	PE	3	0	0	3	45		M
48	******	Professional Elective II	PE	3	0	0	3	45		M
49	******	Open Elective II	OE	3	0	0	3	45		M
PRACTICAL SUBJECTS										
50	CH22611	Chemical Reaction Engineering Laboratory	PC	0	0	4	2	60		F
51	CH22612	Process Control Laboratory	PC	0	0	4	2	60		F

52	HS22511	Interview and Career Skills Laboratory (Common to all Branches)	EEC	0	0	3	2	45		F
TOTAL							**24**			

SEMESTER VII

SL.NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PERIODS PER WEEK**				**Total Hours**	**Pre - requisite**	**Position**
				L	**T**	**P**	**C**			
THEORY SUBJECTS										
53	CH22701	Plant design and Economics	PC	3	0	0	3	45		F
54	CH22702	Professional Ethics	PC	3	0	0	3	45		F
55	******	Professional Elective III	PE	3	0	0	3	45		M
56	******	Professional Elective IV	PE	3	0	0	3	45		M
57	******	Professional Elective V	PE	3	0	0	3	45		M
58	******	Professional Elective VI	PE	3	0	0	3	45		M
59	CH22711	Industrial Training / Internship	EEC				2	4 weeks		M
TOTAL							**20**			

SEMESTER VIII

SL.NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PERIODS PER WEEK**				**Total Hours**	**Pre - requisite**	**Position**
				L	**T**	**P**	**C**			
60	CH22811	Project Work	EEC	0	0	20	10			F
TOTAL							**10**			
OVERALL CREDITS							**167**			

PROFESSIONAL ELECTIVES / VERTICALS

VERTICAL I SPECIAL ELECTIVES

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
61	SE22001*	Financial Statement Analysis (Common to all Branches)	PE	3	0	0	3	45
62	SE22002*	Introduction to Securities Market (Common to all Branches)	PE	3	0	0	3	45
63	SE22003*	Option Trading Strategies (Common to all Branches)	PE	3	0	0	3	45
64	SE22004*	Corporate Finance (Common to all Branches)	PE	3	0	0	3	45
65	SE22005*	Managerial Economics (Common to all Branches)	PE	3	0	0	3	45
66	SE22006*	Project Management (Common to all Branches)	PE	3	0	0	3	45
67	SE22007*	Mathematics for AI & ML (Common to all Branches)	PE	3	0	0	3	45

VERTICAL – II HYDROCARBON PROCESSING

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
68	CH22021	Drilling Technology and well Engineering	PE	3	0	0	3	45
69	CH22022	Natural Gas Engineering	PE	3	0	0	3	45
70	CH22023	Hydrocarbon Processing Technology	PE	3	0	0	3	45
71	CH22024	Unit Processes in Petrochemical Technology	PE	3	0	0	3	45
72	CH22025	Petrochemical Derivatives	PE	3	0	0	3	45
73	CH22026	Multi-Component Distillation	PE	3	0	0	3	45
74	CH22027	Petroleum Refinery Engineering and Design	PE	3	0	0	3	45
75	CH22028	Petroleum Process Equipment Auxiliaries	PE	3	0	0	3	45
76	CH22020	Mini Project	EEC	0	0	4	2	

VERTICAL III HSE IN PROCESS INDUSTRIES

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
77	CH22031	Fire Engineering and Explosion Control	PE	3	0	0	3	45
78	CH22032	Industrial Safety Assessment	PE	3	0	0	3	45
79	CH22033	Acts and Regulations for Health, Safety andEnvironment	PE	3	0	0	3	45
80	CH22034	Disaster Management in Process Industries	PE	3	0	0	3	45
81	CH22035	Accident Investigation and Reporting	PE	3	0	0	3	45
82	CH22036	First Aid and Safety Precautions	PE	3	0	0	3	45
83	CH22037	Safety in process industries	PE	3	0	0	3	45
84	CH22038	Process Safety Management	PE	3	0	0	3	45
85	CH22030	Mini Project	EEC	0	0	4	2	

VERTICAL IV: ENERGY ENGINEERING

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
86	CH22041	Renewable energy Resources (Common to CH, ME and MR)	PE	3	0	0	3	45
87	CH22042	Energy and Environment	PE	3	0	0	3	45
88	CH22043	Energy conservation in Utilities	PE	3	0	0	3	45
89	CH22044	Energy conversion and storage Techniques	PE	3	0	0	3	45
90	CH22045	Waste Management and Energy Recovery	PE	3	0	0	3	45
91	CH22046	Alternative energy resources	PE	3	0	0	3	45
92	CH22047	Measurement and Control for Energy systems	PE	3	0	0	3	45
93	CH22048	Energy Audit	PE	3	0	0	3	45
94	CH22040	Mini Project	EEC	0	0	4	2	

VERTICAL V: ENVIRONMENTAL ENGINEERING (Common to CH & CE)

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
95	CH22051	Industrial Waste Management	PE	3	0	0	3	45
96	CH22052	Air Pollution Management	PE	3	0	0	3	45
97	CH22053	Disaster Mitigation and Management	PE	3	0	0	3	45
98	CH22054	Global Climate Change	PE	3	0	0	3	45
99	CE22051	Municipal Solid Waste Management	PE	3	0	0	3	45
100	CE22052	Environmental Policy and Legislations	PE	3	0	0	3	45
101	CE22053	Environment, Health and Safety	PE	3	0	0	3	45
102	CE22054	Sustainability and Social Development	PE	3	0	0	3	45
103	CH22050	Mini Project	EEC	0	0	4	2	

VERTICAL VI MATERIAL TECHNOLOGY

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
104	CH22061	Materials engineering fundamentals	PE	3	0	0	3	45
105	CH22062	Surface Engineering	PE	3	0	0	3	45
106	CH22063	Frontier Materials	PE	3	0	0	3	45
107	CH22064	Biomaterials	PE	3	0	0	3	45
108	CH22065	High Temperature Materials	PE	3	0	0	3	45
109	CH22066	Particulate Processing	PE	3	0	0	3	45
110	CH22067	Polymer processing	PE	3	0	0	3	45
111	CH22068	Nano Materials and Applications	PE	3	0	0	3	45
112	CH22060	Mini Project	EEC	0	0	4	2	

VERTICAL VII PROCESS ENGINEERING

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
113	CH22071	Process Optimization	PE	3	0	0	3	45
114	CH22072	Chemical Reactor Analysis	PE	3	0	0	3	45
115	CH22073	Scale-up in Chemical Engineering	PE	3	0	0	3	45
116	CH22074	Piping Design	PE	3	0	0	3	45
117	CH22075	Chemical Process Intensification	PE	3	0	0	3	45
118	CH22076	Process Plant utilities	PE	3	0	0	3	45
119	CH22077	Computational Fluid Dynamics	PE	3	0	0	3	45
120	CH22078	Quality Control, Assurance and Reliability	PE	3	0	0	3	45
121	CH22070	Mini Project	EEC	0	0	4	2	

DIVERSIFIED VERTICAL GROUP I:

SL.NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
122	CH22081	Biochemical Engineering	PE	3	0	0	3	45
123	CH22082	Food Processing Technology	PE	3	0	0	3	45
124	CH22083	Pulp and Paper Technology	PE	3	0	0	3	45
125	CH22084	Fluidization Engineering	PE	3	0	0	3	45
126	CH22085	Design of Experiments and Parameter Estimation	PE	3	0	0	3	45
127	CH22086	Drug and Pharmaceutical Technology	PE	3	0	0	3	45
128	CH22087	Chemical process automation	PE	3	0	0	3	45
129	CH22088	Data Analytics & Machine Learning for Chemical Engineers	PE	3	0	0	3	45

LIST OF OPEN ELECTIVES

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
130	OE22301	Waste to Energy	OE	3	0	0	3	45
131	OE22302	Industrial Safety	OE	3	0	0	3	45
132	OE22303	Composite Materials	OE	3	0	0	3	45
133	OE22304	Industrial Wastewater Treatment	OE	3	0	0	3	45
134	OE22305	Fuel Cell Technology	OE	3	0	0	3	45
135	OE22306	Industrial Pollution Prevention	OE	3	0	0	3	45
136	OE22307	Solid Waste Management	OE	3	0	0	3	45
137	OE22308	Plant Utilities	OE	3	0	0	3	45
138	OE22309	Green Energy	OE	3	0	0	3	45
139	OE22310	Energy Management	OE	3	0	0	3	45

VALUE ADDED COURSES

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
140	VD22301	Chemical Engineering Plant Design	VD	2	0	0	0	30
141	VD22302	Introduction to Sustainability	VD	2	0	0	0	30
142	VD22303	MATLAB/ASPEN	VD	2	0	0	0	30
143	VD22304	Packaging Technology	VD	2	0	0	0	30
144	VD22305	Sustainable Agricultural Land Management	VD	2	0	0	0	30
145	VD22306	Waste Utilization	VD	2	0	0	0	30
146	VC22001*	Basics of Entrepreneurship Development	VD	2	0	0	0	30
147	VC22002*	Advances of Entrepreneurship Development	VD	2	0	0	0	30
148	VC22003*	Communicative German	VD	2	0	0	0	30
149	VC22004*	Communicative Hindi	VD	2	0	0	0	30
150	VC22005*	Communicative Japanese	VD	2	0	0	0	30
151	VC22006*	Design Thinking and Prototyping laboratory	VD	2	0	0	0	30

MANDATORY COURSES

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
152	MC22001*	Indian Constitution	MC	3	0	0	0	45
153	MC22002*	Essence of Indian Traditional Knowledge	MC	3	0	0	0	45
154	MC22003*	Gender Sensitization	MC	3	0	0	0	45

GENERAL ELECTIVES

SL.NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK				Total Hours
				L	T	P	C	
155	GN22001*	Introduction to NCC for Engineers	GE	2	0	2	0	60
156	GN22002*	Yoga and Physical Culture	GE	0	0	2	0	30
157	GN22003*	Introduction to Fine Arts	GE	2	0	0	0	30

* - For syllabus, refer General curriculum and syllabus

SEMESTER I

HS22152	COMMUNICATIVE ENGLISH	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Enable learners to interact fluently on everyday social contexts.
2. Train learners to engage in conversations in an academic/scholarly setting.
3. Instill confidence in learners to overcome public speaking barriers.
4. Develop learners‟ ability to take notes and in the process, improve their listening skills
5. Enhance learners‟ reading skill through reading text passages for comprehension and contemplation.
6. Improve learners‟ skills to write on topics of general interest and drafting correspondences for generalpurposes

UNIT I	**9**

Listening - short video clips - conversational scenes form movies, celebrities‟ speeches /interviews. Speaking - several ways of introducing oneself at several situations, introducing others at several situations, inviting people for several occasions, describing people and their places. Reading - short comprehension passages - making inferences, critical analysis. Writing - completing the incomplete sentences - developing hints from the given information. Grammar - Wh-Questions and Yes or No questions - Parts of speech. Vocabulary development - prefixes - suffixes - articles - countable / uncountable nouns.

UNIT II	**9**

Listening - customer care voice files, short narratives - identifying problems and developing telephone etiquettes. Speaking - speaking over skype/ whatsapp, making business calls, making self-recorded informative videos, inquiring about a concept/activity, describing a concept/activity. Reading - reading the headlines on news magazines - slogans and taglines from advertisements. Writing - free writing - writing - headlines, slogans and taglines individual inspirations. Grammar- conjunctions, idioms, phrases, quotes. Vocabulary development- guessing the meanings of words in different contexts.

UNIT III	**9**

Listening - courtroom scenes from movies, debates and talks from news channels, notes taking. Speaking- language and tone for arguments, discussion, deliberation, contemplation, expressing opinions, reacting to different situations in an alien country. Reading - language used in instruction manuals of household appliances, cookery and other basic instructions. Writing- understanding the structure of texts - use of reference words, discourse markers- coherence, rearranging the jumbled sentences. Grammar - adjectives - degrees of comparison, framing direct and indirect questions. Vocabulary development - concise approach, single word substitution.

UNIT IV	**9**

Listening - Sports commentaries, advertisements with users‟ criticisms; Speaking - for social causes, for promoting a concept, negotiating and bargaining; Reading - review of a product, movie, movement or a system; Writing - writing for advertisements, selling a product; Grammar – Tenses - Simple Past, Present and Future, Continuous - Past, Present and Future; Vocabulary Development - synonyms, antonyms and phrasal verbs.

UNIT V		9
Listening - video lectures, video demonstration of a concept; Speaking – presenting papers/concepts, delivering short speeches, discourses on health, suggesting natural home remedies, cleanliness, civic sense and responsibilities; Reading - columns and articles on home science; Writing - correspondences of requests, basic enquiry/observation and basic complaints; Grammar - modal verbs, perfect tenses - Vocabulary development - collocations.		
		TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Acquire adequate vocabulary for effective communication	**3**
CO2.	Listen to formal and informal communication and read articles and infer meanings fromspecific contexts from magazines and news papers.	**3**
CO3.	Participate effectively in informal/casual conversations; introduce themselves and theirfriends and express opinions in English.	**4**
CO4.	Comprehend conversations and short talks delivered in English.	**6**
CO5	Write short write-ups and personal letters and emails in English	**6**

REFERENCES:

1. Department of English, Anna University, Mindscapes: English for Technologists and Engineers. OrientBlack Swan, Chennai, 2017.

2. Downes and Colm,; Cambridge English for Job-hunting Cambridge University Press, New Delhi, 2008.

3. Murphy and Raymond, Intermediate English Grammar with Answers Cambridge University

4. Press, 2000. Thomson, A.J., Practical English Grammar 1& 2, Oxford, 1986.

Websites

1. http://www.usingenglish.com

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Software

1. Face 2 Face Advance – Cambridge University Press, 2014.
2. English Advance Vocabulary- Cambridge University Press.
3. IELTS test preparation – Cambridge University Press 2017.
4. Official Guide to the TOEFL Test With CD-ROM, 4th Edition.
5. Cambridge Preparation for the TOEFL TEST- Cambridge University Press**, 2017**

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1										3			3	
CO2										3			3	
CO3										3			3	
CO4										3			3	
CO5										3			3	

MA22151	APPLIED MATHEMATICS I (Common to all Branches except MR)	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

The Student should be made to:

1. Compute Eigen values and Eigen vectors and use in diagonalization and in classifying real quadraticforms.
2. Study differential calculus and its applications to relevant Engineering problems .
3. Compute derivatives using the chain rule or total differentials.
4. Understand the rotation of two dimensional geometry using definite integrals
5. Acquaint with the Mathematical tools needed in evaluating multiple integrals and their usage.

UNIT I	**MATRICES**	**12**

Eigen values and Eigen vectors of a real matrix – Characteristic equation –Properties of Eigen values and Eigen vectors – Statement and Applications of Cayley-Hamilton Theorem – Diagonalization of matrices– Reduction ofa quadratic form into canonical form by orthogonal transformation-Nature of quadratic forms

UNIT II	**APPLICATION OF DIFFERENTIAL CALCULUS**	**12**

Curvature and radius of Curvature– Centre curvature – Circle of curvature –Evolutes– Envelopes-Evolute as Envelope of Normals.

UNIT III	**DIFFERENTIAL CALCULUS FOR SEVERAL VARIABLES**	**12**

Limits and Continuity - Partial derivatives – Total derivatives – Differentiation of implicit functions – Jacobians and properties– Taylor's series for functions of two variables – Maxima and Minima of functionsof two variables – Lagrange's method of undetermined multipliers.

UNIT IV	**APPLICATION OF DEFINTE INTEGRALS**	**12**

Integration by Parts-Bernoulli's formula for integration- Definite integrals and its Properties- Solids of Revolution- Disk Method- Washer Method- Rotation about both x and y axis and Shell method

UNIT V	**MULTIPLE INTEGRALS**	**12**

Double integrals in Cartesian and polar coordinates – Change of order of integration – Area enclosed by planecurves - Change of variables in double integrals – Triple integrals – Volume of solids

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Solve the Eigen value problems in matrices.	**3**
CO2.	Apply the basic notion of calculus in Engineering problems and to tackle for different geometries	**3**
CO3.	Perform calculus for more than one variable and its applications in Engineering problems	**3**
CO4.	Apply definite integrals for design of three dimensional components	**3**
CO5	Evaluate multiple integral in Cartesian and polar coordinates	**3**

TEXT BOOKS:

1. Erwin Kreyszing, Herbert Kreyszing, Edward Norminton, "Advanced Engineering Mathematics", 10th Edition, John Wiley, (2015)
2. Grewal .B.S, Grewal .J.S "Higher Engineering Mathematics",43rd Edition, Khanna Publications, Delhi, (2015).

REFERENCES:

1. Bali N.P and Manish Goyal, "A Text book of Engineering Mathematics", Ninth Edition, Laxmi Publications Pvt. Ltd.,(2014).
2. Glyn James, "Advanced Modern Engineering Mathematics", 4thEdition, Pearson Education,(2016).
3. Ramana B.V, "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company, New Delhi, (2013).

Web Link:

https://home.iitk.ac.in/~peeyush/102A/Lecture-notes.pdf
https://www.sydney.edu.au/content/dam/students/documents/mathematics-learning-entre/integration-definite-integral.pdf

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	3								3	3	
CO2	3	3										3	3	
CO3	3	3	3	3								3	3	
CO4	3	3										3	3	
CO5	3	3	2	2								3	3	

PH22153	TECHNICAL PHYSICS (Common to BT and CH)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To enhance the fundamental knowledge in Physics and its applications relevant to various Streams of Engineering and Technology.

UNIT I	LASERS AND FIBER OPTICS	9

Lasers: population of energy levels, Einstein's A and B coefficients derivation – resonant cavity, optical amplification (qualitative) – Nd-YAG laser – CO_2 Laser – Dye lasers, Exceimer Lasers – Applications. **Fiber optics**: principle, numerical aperture and acceptance angle - types of optical fibres (material, refractive index, and mode) – losses associated with optical fibers–Fiber optic communication- fibre optic sensors: pressure and displacement- Endoscope.

UNIT II	QUANTUM PHYSICS	9

Black body radiation – Planck's theory (derivation)- deduction of Wien's and Rayleigh Jean's law – Compton effect: theory and experimental verification – wave particle duality – electron diffraction – concept of wave function and its physical significance – Schrödinger"s wave equation – time independent and time dependent wave equations – Finite potential wells - - particle in a one-dimensional - three dimensional potential box– Fermi distribution function – Effect of temperature on Fermi Function – Density of energy states – carrier concentration in metals.

UNIT III	CRYSTAL PHYSICS	9

Single crystalline, polycrystalline and amorphous materials – single crystals: unit cell, crystal systems, Bravais lattices, directions and planes in a crystal, Miller indices – interplanar distances- coordination number and packing factor for SC, BCC, FCC, HCP and diamond structure (qualitative) - crystal imperfections: point defects, line defects – Burger vectors, stacking faults

UNIT IV	NEW ENGINEERING MATERIALS	9

Metallic glasses: preparation, properties and applications. Shape memory alloys (SMA): Characteristics, properties of NiTi alloy, application, Nanomaterials– Preparation -pulsed laser deposition – chemical vapor deposition – Applications –Classification of Biomaterials and its applications

UNIT V	PHYSICS OF SOUND	9

Classification of Sound- decibel- Weber–Fechner law – Sabine's formula- derivation using growth and decaymethod – Absorption Coefficient and its determination –factors affecting Acoustics of buildings and their remedies.

Production of ultrasonics by magnetostriction and piezoelectric methods - Acoustic grating –Non Destructive Testing – Pulse echo system through transmission and reflection modes - A,B and C –scan displays, Medicalapplications – Sonogram.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Develop an understanding about photonics and Fiber Optic communication system	**2**
CO2.	Acquire the knowledge of Quantum mechanics	**3**
CO3.	Classify and demonstrate the fundamentals of crystals and their defects.	**3**
CO4.	Acquire the knowledge of New Engineering Materials	**2**
CO5	Enable to explore how sound is produced and propagates in material medium	**3**

TEXT BOOKS:

1. Gaur R.K. and Gupta S.L, "Engineering Physics", Dhanput Publications, 2015.
2. Shatendra Sharma and Jyotsna Sharma, "Engineering Physics", Pearson, 2006.
3. Rajendran V, "Engineering Physics", Tata McGraw Hill, 2009.
4. Arumugam M, "Materials Science", Anuradha Publications, 2015.
5. Elementary Bio physics - An Introduction – P K Srivasthava, Narosa Pub.-2005

REFERENCES:

1. David Halliday, Robert Resnick, Jearl Walker, "Principles of Physics", 10th Edition, Wiley,2015.
2. Peter Atkins and Julio De Paula, "Physical Chemistry", 10th Edition., Oxford University Press, 2014
3. Arthur Beiser, Shobhit Mahajan and Rai Choudhury S, "Concepts of Modern Physics", 7th edition, McGraw Hill Education, 2017.
4. Raghavan V, "Materials Science and Engineering", PHI Learning Pvt. Ltd., 2010
5. Pandey B.K., Chaturvedi.S. "Engineering Physics", Cengage Learning India Pvt.Ltd, 2012

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	**3**									**1**			**3**	
CO2	**3**	**2**	**2**	**2**	**3**					**1**		**2**	**3**	
CO3	**3**	**2**								**1**			**3**	
CO4	**3**	**2**	**2**	**2**	**3**	**2**	**2**			**1**		**2**	**3**	
CO5	**3**									**1**			**3**	

CY22153	TECHNICAL CHEMISTRY (Common to BT and CH & CE)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To make the student conversant with the

- Electrodes, Corrosion and Protective coatings
- Photochemical process
- Synthesis and applications of nanoparticles
- Characteristics and analysis of water
- Materials like polymers, composites and binding materials

UNIT I	**ELECTROCHEMISTRY**	**9**

Electrodes and electrochemical cells – electrode potential, standard electrode potential, single electrode potential and its determination, types of electrodes – calomel, quinhydrone and glass electrode. Nernst equation – determination of pH of a solution by using quinhydrone and glass electrode. Electrochemical series and its applications. Batteries – Primary (dry cell) and secondary batteries (Lead – acid storage battery and Lithium ionbattery) and next generation batteries.

UNIT II	**PHOTOCHEMISTRY**	**9**

Laws of photochemistry – Grotthuss-Draper law, Stark–Einstein law and Lambert Beer Law – determination iron by spectrophotometer. Quantum efficiency – Photo physical processes - internal conversion, inter-system crossing, fluorescence, phosphorescence and photo-sensitization-Quenching of fluorescence and its kinetics, Stern-Volmer relationship. Applications of photochemistry

UNIT III	**NANOCHEMISTRY**	**9**

Basics and scale of nanotechnology, different classes of nanomaterials, Distinction between molecules, nanoparticles and bulk materials; size-dependent properties. Synthesis of nanomaterials, fabrication (lithography) and its applications – Basics of nanophotonics and quantum confined materials (surface plasmon resonance).

UNIT IV	**WATER TECHNOLOGY**	**9**

Sources, impurities in water and their effects. WHO guideline and BIS guideline for drinking water. Water characteristics – Hardness – Types of hardness – Disadvantages of hard water. Boiler troubles: Scale, Sludge, Priming and Foaming, Caustic embrittlement and Boiler corrosion. Water softening methods - Internal treatment of water: Carbonate conditioning, Phosphate conditioning and Calgon conditioning - External treatment of water: Ion exchange process. Domestic water treatment. Water analysis: Hardness – determination by EDTA method, Alkalinity – determination by double indicator method, Determination of dissolved oxygen by Winkler's method and Determination of chloride by Mohr's method.

UNIT V	**MATERIALS CHEMISTRY**	**9**

Polymers: Introduction – Monomers, functionality and its significance, Free radical polymerization mechanism. Conducting polymers – mechanism of conduction in polyacetylene and applications. Composites: Definition, need for composites. Constitution – Matrix materials (Polymer matrix, metal matrix and ceramic matrix) and Reinforcement (fiber, particulates, flakes and whiskers). Properties and applications of composites materials. Hybrid composites, Binding materials and its applications

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify electrochemical cells, corrosion and fundamental aspects of batteries	**2**
CO2.	Interpret the photochemical reactions and make use of spectroscopic techniques	**2**
CO3.	Realize the structures, properties and applications of nanoparticles.	**2**
CO4.	Describe the hardness of water, the problems caused by the hard water and theirremovals methods.	**4**
CO5	Illustrate the significance of various materials like polymer, composites their composition, properties and applications.	**2**

TEXT BOOKS:

1. P.C.Jain and Monica Jain, "Engineering Chemistry", DhanpetRai& Sons, New Delhi, 17th Edition, 2018
2. .2.S.S.Dara, "A Text Book of Engineering Chemistry", S.Chand& Co. Ltd., New Delhi, 12th Edition, 2016

REFERENCES:

1. B.R. Puri, L.R. Sharma, M.S. Pathania., "Principles of Physical Chemistry" Vishal Publishing Company, 2008.
2. Sivasankar B., "Engineering Chemistry", Tata McGraw-Hill Publishing Company, Ltd., New Delhi,2008.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	**3**	**3**	**3**	**2**								**3**	**3**	
CO2	**3**	**3**				**3**	**3**					**3**	**3**	
CO3	**3**	**3**	**3**			**3**	**3**	**3**				**3**	**3**	
CO4	**3**	**3**		**2**		**3**	**3**	**3**				**3**	**3**	
CO5	**3**	**3**	**3**			**3**	**3**	**3**				**3**	**3**	

ME22152	BASIC MECHANICAL ENGINEERING (Common to BT and CH)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To teach the fundamentals of various energy resources
2. To impart the concepts in internal combustion Engines
3. To make the students to understand the working principle of refrigeration and Air conditioning systems
4. To impart the various engineering materials and their processing methods.
5. To give an awareness about the recent trends in Mechanical engineering

UNIT I	ENERGY RESOURCES	10

Classification of Energy Resources - Non-renewable and renewable energy resources. Nonrenewable energyresources – Steam power plant, Nuclear power plant, Hydroelectric power plant, Gas Turbine power plant. Diesel Power plant

Renewable Energy resources – Solar Energy, Wind Energy, Bio energy, tidal energy, fuel cells

UNIT II	INTERNAL COMBUSTION ENGINES	9

Classification, I.C. Engines parts and their function, working of 2 Stroke and 4 stroke engines. Basic terms - Indicated power, brake power frictional power, thermal efficiency, mechanical efficiency (simple problems).

UNIT III	REFRIGERATION AND AIR CONDITIONING	9

Refrigeration: Types of refrigerants and properties of good refrigerant, Refrigerating effect and unit of Refrigeration (definition). Working principle of vapor Compression refrigeration and vapor absorption refrigeration (with a sketch). Applications areas of a refrigeration system. Basic Calculations

Air Conditioning: Definition, Types, Room air-conditioning working principle (with a sketch), Applications. Calculation of Tonnage requirement based on the room size

UNIT IV	MATERIALS AND MANUFACTURING PROCESSES	10

Engineering Materials: Classification – Properties – Alloys and their applications

Manufacturing Processes – classification – Casting – Pattern, Core, Green sand Mould preparation,Investment casting

Metal Joining Process – Arc welding and Gas welding process, Soldering and Brazing – introduction

Metal forming Process – Forging, rolling, Extrusion – introduction

Metal Removal process – Lathe, Milling, Drilling

UNIT V	RECENT TRENDS IN MECHANICAL ENGINEERING	7

Hybrid and Electric vehicle – layout and Principle Additive Manufacturing – Introduction and types

Robotics – Introduction – Types of robot and applications

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the various energy resources and the principle of their operations	**2**
CO2.	Understand the principle of refrigeration and Air-conditioning	**2**
CO3.	Identify the types of IC engines and will calculate the various parameters	**4**
CO4.	Learn the various Engineering Materials and the manufacturing processes	**2**
CO5	Know the recent trends in I.C. engines and manufacturing	**2**

TEXT BOOKS:

1. Dr Sadhu Singh, Elements of Mechanical Engineering, S. Chand Publishing, 2010
2. Basant Agrawal, C.M. Agrawal. Basic Mechanical Engineering, Wiley India Pvt Ltd, 2008
3. Pravin Kumar, Basic Mechanical Engineering, 2nd Edition Pearson India, 2018
4. R.K. Rajput, Basic Mechanical Engineering, Lakshmi Publications, 2007
5. Nag, P K, Basic Mechanical Engineering, McGraw-Hill Education (India) Pvt Limited, 2011

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	**2**													
CO2	**2**													
CO3	**2**													
CO4	**2**													
CO5	**1**													

ME22151	ENGINEERING GRAPHICS	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

This course will introduce the students to build their ability to read drawings and interpret the position and form of simple geometries.

UNIT 0	CONCEPTS AND CONVENTIONS AND GEOMETRICCONSTRUCTION (NOT FOR EXAM)	2

Importance of graphics in engineering applications - Use of drafting instruments - BIS conventions and specifications - Size, layout and folding of drawing sheets - Lettering and dimensioning

UNIT I	CONICS, CYCLOIDAL CURVES AND INVOLUTES	10

Geometric construction - Curves used in engineering practices: Conics - Construction of ellipse, parabola and hyperbola by eccentricity method - Drawing of tangents and normal to the above curves - Construction of cycloid, epicycloid and hypocycloid- Drawing of tangents and normal to the above curves. Construction of involutes of square, pentagon and circle - Drawing of tangents and normal to the above involutes.

UNIT II	PROJECTION OF POINTS, LINES AND PLANESURFACES	12

Orthographic projection – principles- Principal planes - First angle projection-projection of points. Projection of straight lines (only First angle projections) inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method.

Projection of planes (polygonal and circular surfaces) inclined to one of the principal planes and perpendicular to other by rotating object method.

UNIT III	PROJECTION OF SOLIDS	12

Projection of simple solids like prisms, pyramids, cylinder, cone when the axis is inclined to one of the principal planes and parallel to the other by rotating object method. Projections of hollow prism and hollow cylinder with centrally drilled hole or square through its ends by rotating line method - axis is inclined to one of the principal planes and parallel to the other.

UNIT IV	BLOCK FLOW DIAGRAM USING CAD	12

Introduction to Computer Aided Drafting hardware - Overview of application software -2D drafting commands (AutoCAD) for simple shapes - Block flow diagrams - Dimensioning.

UNIT V	ORTHOGRAPHIC AND ISOMETRIC VIEWS USING CAD	12

Introduction to tolerance - Annotation in CAD - Isometric views - Orthographic views - 3D Modelling basics - 3D to 2D conversion.

TOTAL:60 (30L +30P) PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	***Construct*** conic sections and as per drawing standards.	**3**
CO2.	***Obtain*** orthographic projections of lines and plane surfaces and simple solids invarious positions.	**3**
CO3.	***Obtain*** projections of simple and hollow solids.	**3**
CO4.	***Employ*** the CAD software for drafting and modelling of simple components	**3**
CO5	***Construct*** 2D views from 3D models using CAD software.	**3**

TEXT BOOKS:

1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House,53rd Edition, 2019.
2. Dhananjay M. Kulkarni, A.P. Rastogi, Ashoke K. Sarkar, "Engineering Graphics with AutoCAD",PHI Learning Private Ltd., 2009.
3. Venugopal K. and Prabhu Raja V., "Engineering Drawing +AutoCAD", New Age International (P) Limited, 6th edition, 2022

REFERENCES:

1. Dhananjay A Jolhe, "Engineering Drawing with an Introduction to AutoCAD", Tata McGraw-Hill Publishing Company Limited., 2008
2. Parthasarathy N. S. and Vela Murali, "Engineering Graphics", Oxford University, Press, New Delhi,2015.
3. Shah M.B., and Rana B.C., "Engineering Drawing", Pearson Education India, 2nd Edition, 2009.
4. Natrajan K.V., "A Text Book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2018.

WEB RESOURCES:

1. Block flow diagram - https://media.ed.ac.uk/media/1_u4r3az7t
2. AutoCAD tutorials - https://www.thesourcecad.com/autocad-tutorials/
3. https://nptel.ac.in/courses/112105294
4. https://nptel.ac.in/courses/112103019

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1										**1**				
CO2										**2**				
CO3										**2**				
CO4					**2**				**1**	**3**				
CO5					**2**				**1**	**3**				

HS 22151	தமிழ் மொழியும் தமிழர் மரபும் **Tamil Language and Heritage of Ancient Tamil Society** ***(Common to all branches)***	L	T	P	C
		1	0	0	1

பாடத்தின் நோக்கங்கள் :

- தமிழ் மொழியின் தோற்றம் பற்றியும், திணை கருத்துக்கள் வாயிலாக வாழ்வியல் முறைகளை பற்றியும் கற்றுக் கொள்வார்கள்.
- .இந்திய தேசிய சுதந்திர இயக்கத்தில் தமிழர்களின் பங்களிப்பு மற்றும் தமிழர்களின் மேலாண்மை முறைகளை பற்றியும் கற்றுக் கொள்வார்கள்.

அலகு 1 **UNIT I**	**தமிழுக்கும் தொழில் நுட்ப கல்விக்கும் உள்ள தொடர்பு**	**3**

மொழி மற்றும் பாரம்பரியம்:: இந்தியாவில் உள்ள மொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழில் செம்மொழி இலக்கியம் - உ.வே. சுவாமிநாத ஐயர்., ஆறுமுக நாவலர் ஆகியோரின் பங்களிப்பு - தொழில் நுட்ப கல்வியில் தமிழ்

LANGUAGE AND HERITAGE: Language families in india – Dravidan Languages – Tamil as a Classical language – Classical Literature in Tamil – Contribution of U. Ve. Saminathaiyar. Arumuka Navalar – Importance of Tamil language in technical education.

அலகு 2 **UNIT II**	**திணை கருத்துக்கள்**	**9**

திணை கருத்துக்கள் : - ஐந்து வகை நிலங்கள், தமிழர்களின் தாவரங்கள் மற்றும் விலங்கினங்கள், கடவுள்கள், தொழில்கள் , வாழ்க்கை முறை, பண் , கூத்து , உணவு முறை - தொல்காப்பியம் மற்றும் சங்க இலக்கியங்களில் இருந்து அகம் மற்றும் புறம் கருத்து - தமிழ் அறம் கருத்து - சங்க காலத்தில் கல்வி மற்றும் எழுத்தறிவு - பண்டைய நகரங்கள் மற்றும் சங்க காலத்தில் துறைமுகங்கள் - சங்க காலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - சோழ மன்னர்களின் வெளிநாட்டு வெற்றிகள்.

.Thinai concepts : -Five types of lands, animals, Gods, occupation, life styles, music, dance , food style, Floara and Fauna of Tamils - Agam and puram concept from Tholkappiyam and Sangam Literature – Aram concept of Tamil – Education and Literacy during Sangam Age – Ancient cities and Ports of Sangam Age – Export and Import during Sangam Age - Overseas Conquest of Choloas.

அலகு 3 **UNIT III**	**தமிழரின் மரபு**	**3**

இந்திய தேசிய சுதந்திர இயக்கம் மற்றும் இந்திய கலாச்சாரத்திற்கு தமிழர்களின் பங்களிப்பு:- சுப்ரமணிய பாரதி, வாஞ்சிநாதன், சுப்பிரமணிய சிவா, வீரபாண்டிய கட்டபொம்மன், வா.. **உ** சிதம்பரம் பிள்ளை, தீரன் சின்னமலை, மருது பாண்டிய சகோதரர்கள், பூலி தேவர், திருப்பூர் குமரன், வீர மங்கை வேலுநாச்சியார்.

தமிழர் இலக்கியங்களில் மேலாண்மை கருத்துக்கள் (கி. மு. 500 முதல் கி. பி 200 வரை) – அகநானூறு, புறநானூறு, திருக்குறள் ஆகியவற்றில் மேலாண்மைக் கருத்துகள்...

Contribution of Tamils to Indian National Freedom Movement and Indian Culture : Contributions of Subramanya Bharathi, Vanchinathan, Subramaniya Siva, Veerapandiya Kattabomman, V O Chidambaram Pillai, Dheeran Chinnamalai, The Maruthu Pandiyar, Puli Thevar, Tiruppur Kumaran, Veera Mangai Velunachiyar.

Management in tamil literature (From 500 B.C to 200 A.D) – Agananooru, Puranaanooru and thirukkural.

TOTAL: 15 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

பா .வெ . எண் CO'S	பாடத்திட்டத்தின் வெளிப்பாடு STATEMENT	RBT LEVEL
CO1.	மாணவர்கள் தமிழ் மொழி தோற்றம் பற்றி தெரிந்து கொள்வார்கள் Students will learn about the origin of the Tamil language	**1**
CO2.	தமிழர்களின் வாழ்வியல் முறைகளை தெரிந்து கொள்வார்கள் They will know the ways of life of Tamils.	**2**
CO3.	தமிழர்களின் சுதந்திர போராட்ட வீரர்களை பற்றியும், மேலாண்மை முறைகளை பற்றியும் தெரிந்து கொள்வார்கள் They will know about the freedom fighters of Tamils and the management of Tamils	**2**

பாட நூல்கள்:

TEXT BOOKS:

பொன். முத்துகுமாரன் (2002), **"தமிழ் மரபு"**, காந்தளகம், 68, அண்ணா சாலை, சென்னை 600 002

பி. டி ஸ்ரீனிவாச ஐயங்கார் ***(தமிழக்கமும் திறனாய்வும்)*** புலவர் கா. கோவிந்தன் (1988), "**தமிழர் வரலாறு (முதல் பகுதி)**", திருநெல்வேலி தென்னிந்திய சைவ சித்தாந்த நூற்பதிப்பு கழகம் ,154, TTK சாலை, சென்னை 18.

டாக்டர் கே கே பிள்ளை (2009), **"தமிழக வரலாறு மக்களும் பண்பாடும்**", உலக தமிழாராய்ச்சி நிறுவனம், தரமணி , சென்னை 600113

முனைவர். ச. இராஜேந்திரன் (2004), "**தமிழில் சொல்லாக்கம்**", தஞ்சாவூர் தமிழ் பல்கலைக் கழகம் வெளியீடு

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1			3		3	3	2		3			2		
CO2			3	2	3	3		1	3					
CO3			3	2	3	3	2		3			2		

CY22161	CHEMISTRY LABORATORY	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

The objective of the Chemistry Laboratory is to acquaint the students with the basic phenomenon/conceptsof chemistry, the student face during course of their study in the industry and engineering field.

1. To appreciate the need and importance of water quality parameters for industrial and domestic use.
2. To gain the knowledge on electrochemical instrumentation techniques like potential and current measuring used in electrochemistry applications
3. To impart knowledge on separation of components using paper chromatography.
4. To enhance the thinking capability about polymer and properties like molecular weight.

LIST OF EXPERIMENTS (Minimum 8 Experiments)

1. Determination of DO content of water sample by Winkler‟s method.
2. Determination of strength of given hydrochloric acid using pH meter
3. Determination of strength of acids in a mixture using conductivity meter
4. Estimation of iron content of the water sample using spectrophotometer (phenanthroline/thiocyanatemethod)
5. Determination of total, temporary & permanent hardness of water by EDTA Method.
6. Estimation of iron content of the given solution using potentiometer.
7. Determination of alkalinity in water sample.
8. Determination of Single electrode potential.
9. Separation of components from a mixture of red and blue inks using Paper chromatography.
10. Determination of molecular weight of polymer by using Ostwald's/Ubbelohde viscometer

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

Common apparatus: Pipette, Burette, conical flask, porcelain tile, dropper (each 30 Nos.)

1.	Iodine flask	30 Nos
2.	pH meter	5 Nos
3.	Conductivity meter	5 Nos
4.	Spectrophotometer	5 Nos
5.	Oswald/UbbelohdeViscometer	30 Nos

TOTAL: 15 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Distinguish hard and soft water, solve the related numerical problems on water,purification and its significance in industry and daily life.	**3**
CO2.	Interpret the knowledge of instruments to measure potential and current relatedparameters	**2**
CO3.	Demonstrate the basic principle for separation of components using paper chromatography	**3**
CO4.	Evaluate the molecular weight of polymer using Ostwald's/Ubbelohde viscometer.	**3**

REFERENCES:

1. Daniel R. Palleros, "Experimental organic chemistry" John Wiley & Sons, Inc., New York 2001
2. Furniss B.S. Hannaford A.J, Smith P.W.G and Tatchel A.R., "Vogel"s Textbook of practical organicChemistry", LBS Singapore 1994.
3. Jeffery G.H., Bassett J., Mendham J.and Denny vogel"s R.C, "Text book of quantitative analysis chemical analysis", ELBS 5th Edn. Longman, Singapore publishers, Singapore, 1996.
4. Kolthoff I.M., Sandell E.B. et al. "Quantitative chemical analysis", Mcmillan, Madras 1980.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	**3**	**2**				**3**	**3**	**3**	**1**		**1**	**2**		**3**
CO2	**3**	**2**	**1**			**3**	**3**	**3**						**3**
CO3	**3**					**3**	**3**					**2**		**3**
CO4	**3**			**1**		**3**	**3**	**3**						**3**
CO5	**3**	**2**				**3**	**3**	**3**	**1**		**1**	**2**		**3**

ME22161	BASIC MECHANICAL ENGINEERING LABORATORY (Common to AE, BT, CH)	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

To provide an exposure and hands on experience to the students on various basic mechanical Engineering processes.

LIST OF EXPERIMENTS

1. Welding - Butt joint and lap joint using Electric Arc and Gas welding.
2. Machining – Turning and facing using Centre Lathe.
3. Sheet metal work – Making of a cylinder using GI sheet and finishing using rivets.
4. Drilling and Tapping – Drilling of holes precisely and making internal threads by Tapping forvarious sizes.
5. Casting – Mould preparation using simple solid pattern and casting.
6. Plumbing – Making household pipeline PVC pipes, valves, taps, couplings, unions, reducers, elbows.
7. Fuel testing – Determination of Flash point and Fire point of fuels.
8. Refrigeration and Air Conditioning – Determination of Coefficient of Performance (COP) of refrigeration and air conditioning systems.
9. Automation – Basic pneumatic circuit using single and double acting cylinder.
10. 3D printing –Demonstration of printing of simple solids using Additive Manufacturing/3D printing

TOTAL: 30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	***Fabricate*** components by various manufacturing processes.	3
CO2.	***Prepare*** pipeline for a given application.	3
CO3.	***Evaluate*** the ignition properties of fuels	5
CO4.	***Determine*** the efficiency of refrigeration and air conditioning Systems	2
CO5	***Understand*** the principles of low-cost automation using pneumatic circuits.	2
CO6	***Understand*** the principle of additive manufacturing/3D printing	2

TEXT BOOKS:

1. Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.

2. Jeyapoovan T., Saravanapandian M. & Pranitha S., "Engineering Practices Lab Manual", VikasPublishing House Pvt.Ltd, 2006.

3. Bawa H.S., "Workshop Practice", Tata McGraw Hill Publishing Company Limited, 2007.

4. Rajput. R.K., "Thermal Engineering", Laxmi Publications, Tenth Edition, 2017

5. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.

6. Anthony Esposito, Fluid Power with Applications, Pearson Education, 7th edition, 2009.

7. Mechanical engineering practices lab manual, SVCE, 2022.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2													3
CO2	2													3
CO3	2													3
CO4	2													3
CO5	1				2									3
CO6	1				2									3

SEMESTER II

HS22152	TECHNICAL ENGLISH	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Enable learners to define and understand technical communication and scientific writing.
2. Expose learners to the technicalities of seminar presentation, group discussion, and public speaking.
3. Develop learners‟ writing skills for scientific and documenting purposes.
4. Improve learners‟ ability to draft correspondences for business purposes.
5. Cultivate learners‟ ability to holistically understand the nuances of job interviews and recruiting process

UNIT I		9

Listening - AV files pertaining to manufacturing processes of products, scientific documentaries; Speaking -syllable division and word stress, intonation, sharing opinions; Reading - news articles related to science and technology; Writing - definitions, instruction, recommendation, data interpretation, resume; Grammar - tenses and their aspects, sentence connectors – discourse markers, sequential words, active and passive voice, subject-verb agreement.

UNIT II		9

Listening - AV pertaining to marketing strategies, peer reading and pronunciation; Speaking- turn taking, sharing opinions; conducting and attending a meeting, understanding the nuances of spoken communication among internal audience and external audience; Reading - analytical documents, descriptive documents; Writing - fliers, brochures, resume - letter of application, checklists; Grammar - modal verbs, clauses - typesand uses, conditional clauses, articles.

UNIT III		9

Listening - AV related to how to use components, scientific description, Speaking - speaking for motivation and initiation, speaking at a seminar presentation; Reading - scientific journals, papers; Writing - Technical descriptions - process description, purpose and function, PowerPoint, Google forms, user manuals; Grammar - phrasal verbs, prepositions, technical and scientific affixes.

UNIT IV		9

Listening - scientific debates, crisis management; Speaking - handling conflicts, speaking about the loss of benefits, progress or decline of business, identifying the connotative meanings, Reading- documented evidences of uses and functions of a product, review of a product, Writing - memos, follow-up letters, reports - proposal, project, progress reports, sales reports, reports on industrial visits, executive summary. Grammar - reported speech and tag questions, sentence structure - comparative, imperative, cause and effect, infinitive of result.

UNIT V		9
Listening - AV of Group discussions, panel discussions, face to face interviews for recruitment purposes; Speaking- speaking at group discussions, interviewing a personality, answering at the interviews; Reading - WebPages of top notch engineering companies, Writing - blogging, e-mails, letter of complaint, minutes of the meeting; Grammar - one word substitution, collocations, better word/sentence substitution (rephrasing the content/improvising ideas).		
TOTAL:45 PERIODS		

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the nuances of technical communication and scientific writing	**3**
CO2.	Present papers and give seminars	**6**
CO3.	Discuss in groups and brainstorm	**6**
CO4.	Draft business correspondences and write for documenting purposes	**6**
CO5	Face job interviews with confidence	**6**

Websites

1. http://www.usingenglish.com
2. http://www.uefap.com3
3. https://owl.english.purdue.edu/owl/
4. www.learnenglishfeelgood.com/esl-printables-worksheets.html

Software

1. Face 2 Face Advance – Cambridge University Press, 2014.
2. English Advance Vocabulary- Cambridge University Press.
3. IELTS test preparation – Cambridge University Press 2017.
4. Official Guide to the TOEFL Test With CD-ROM, 4th Edition.
5. Cambridge Preparation for the TOEFL TEST- Cambridge University Press**,** 2017.

REFERENCES:

1. Department of English, Anna University. *Mindscapes: English for Technologists and Engineers.*
Orient Blackswan, Chennai. 2012.
2. Downes, Colm, *Cambridge English for Job-hunting*, Cambridge University Press, New Delhi. 2008.
3. Murphy, Raymond, *Intermediate English Grammar with Answers*, Cambridge University Press 2000.
4. Thomson, A.J., *Practical English Grammar 1 & 2*, Oxford, 1986.
5. Herbert A J, *The Structure of Technical English*, Longman, 1965.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1										3			3	
CO2										3			3	
CO3										3			3	
CO4										3			3	
CO5										3			3	

MA22251	APPLIED MATHEMATICS – II (Common to all except Marine Engineering)	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

The Student should be made to:

1. Acquire the concepts of vector calculus needed for problems in all engineering disciplines and compute different types of integrals using Green's, Stokes' and Divergence theorems.
2. Skilled at the techniques of solving ordinary differential equations that model engineering problems.
3. Extend their ability of using Laplace transforms to create a new domain in which it is easier to handle the problem that is being investigated.
4. Explain geometry of a complex plane and state properties of analytic functions.
5. Understand the standard techniques of complex variable theory so as to apply them with confidencein application areas such as heat conduction, elasticity, fluid dynamics and flow of electric current.

UNIT I	VECTOR CALCULUS	12

Gradient, divergence and curl - Directional derivative - Vector identities – Irrotational and solenoidal vector fields - Line integral over a plane curve – Surface integral - Area of a curved surface - Volume integral – Green's theorem in a plane, Gauss divergence theorem and Stokes'theorem (excluding proofs) – Verification and application in evaluating line, surface and volume integrals.

UNIT II	ORDINARY DIFFERENTIAL EQUATIONS AND ITS APPLICATIONS	12

Differential equations of first order – Equations of the first order and first degree – Linear equations – Higher order linear differential equations with constant coefficients - Method of variation of parameters – Cauchy's and Legendre's linear equations - Simultaneous first order linear equations with constant coefficients – Applications of Linear differential equations – Oscillatory electrical circuit – Deflection of beams

UNIT III	LAPLACE TRANSFORM	12

Conditions for existence - Transform of elementary functions - Transforms of unit step function and impulse functions – Basic properties – Shifting theorems - Transforms of derivatives and integrals of functions - Derivatives and integrals of transforms - Initial and final value theorems - Transform of periodic functions. Inverse Laplace transforms - Convolution theorem – Application to solution of linear ODE of second order with constant coefficients using Laplace transformation techniques

UNIT IV	ANALYTIC FUNCTIONS	12

Analytic functions - Necessary and sufficient conditions (Cauchy-Riemann equations) - Properties of analytic function - Harmonic conjugates - Construction of analytic functions - Conformal mapping – Mapping by functions $W = Z + C$, CZ, $1/Z$, Z^2 – Joukowski‟s transformation- Bilinear transformation

UNIT V	COMPLEX INTEGRATION	12

Cauchy‟s integral theorem - Cauchy‟s integral formula - Taylor‟s and Laurent‟s series expansions - Singularpoints - Residues - Cauchy‟s Residue theorem – Application of residue theorem for evaluation of real integrals – Use of circular contour and semi-circular contour

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Interpret the fundamentals of vector calculus and execute evaluation of line, surfaceand volume integrals using Gauss, Stokes and Green‟s theorems.	**3**
CO2.	Solve first order linear, homogeneous differential equations and use series solutionmethod to solve second order differential equations.	**3**
CO3.	Determine the methods to solve differential equations using Laplace transforms andInverse Laplace transforms	**3**
CO4.	Explain Analytic functions and Categorize transformations	**3**
CO5	Perform Complex integration to evaluate real definite integrals using Cauchy integraltheorem and Cauchy's residue theorem.	**3**

TEXT BOOKS:

1. Erwin Kreyszing, Herbert Kreyszing, Edward Norminton, "Advanced Engineering Mathematics",10Edition, John Wiley, (2015).
2. Grewal .B.S, Grewal .J.S "Higher Engineering Mathematics",43rd Edition, Khanna Publications,Delhi, (2015).

REFERENCES:

1. Dass, H.K., and RajnishVerma, "Higher Engineering Mathematics", S.Chand Private Ltd., 2011.
2. Ramana B.V, "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company, NewDelhi, (2013).
3. Bali N. P and Manish Goyal, "A Text book of Engineering Mathematics", 9th edition, Laxmi Publications(p) Ltd., 2014.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	**3**	**3**										**3**	**3**	
CO2	**3**	**3**	**2**									**3**	**3**	
CO3	**3**	**3**	**2**									**3**	**3**	
CO4	**3**	**3**										**3**	**3**	
CO5	**3**	**3**										**3**	**3**	

EE22251	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING FOR CHEMICAL ENGINEERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basic concepts used in Electrical circuits and the principles of measuringinstruments and sensors
- To introduce the fundamentals of power semiconductors devices and its applications.
- To study the different types of electrical machines and its starting methods.
- To study basics of Industrial Electrical Drives.
- To impart knowledge of application of electrical drives using modern control strategy in chemical process industries

UNIT I	ELECTRICAL CIRCUITS & MEASURMENTS	9

Ohm‟s Law – Kirchoff‟s Laws – Steady State Solution of DCCircuits (Mesh current analysis only) – Introduction to AC Circuits – Single Phase and Three Phase Balanced Circuits. Principle of measurement - Error Analysis, Static and dynamic characteristics of instruments – sensors – Temperature, Pressure, Flow and Level measurement.

UNIT II	SEMICONDUCTOR DEVICES	9

PN Junction Diode and Zener Diode - Static Characteristics, SCR, MOSFET - Static and Switching Characteristics, Applications of Power semiconductor devices - Uncontrolled Rectifiers, Phase controlled Rectifiers, DC Choppers, Concept of PWM in MOSFET

UNIT III	ELECTRICAL MACHINES	9

Construction and working of DC machines – types, Characteristics, Starting and braking of DC Motors. Construction and working of AC Induction motors – Slip-Torque Characteristics, Starting methods

UNIT IV	INDUSTRIAL ELECTRICAL DRIVES	9

Basic Elements – Types of Electric Drives – Factors influencing the choice of electrical drives – Heating and Cooling curves – classes of duty - Maintenance of electrical drive systems - Industrial Hazards andSafety Measures.

UNIT V	APPLICATION OF ELECTRIC DRIVES (Block Diagram Representation Only)	9

Conventional and Solid State speed control of DC Motors - Conventional and Solid state speed control of AC Drive systems - Inverters, AC Voltage controllers, Slip power recovery schemes - Block diagram of different chemical process units - Computer based control of DC and AC Drive systems.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply basic electrical laws for the electrical circuits and understand sensors and measurement principles	**3**
CO2.	Analyze the characteristics of various semiconductor devices and develop circuitsfor an application.	**4**
CO3.	Analyze and select electrical machines for drive applications based on characteristics.	**4**
CO4.	Identify the structure and types of Electrical drives for specific applications.	**3**
CO5	Apply control methods for Electrical Machine and Drives in chemical processindustries	**3**

TEXT BOOKS:

1. Nagrath.I.J. &Kothari.D.P, "Electrical Machines", Tata McGraw-Hill,1998
2. Mittle V.N, Arvind Mittal "Basic Electrical Engineering", Tata McGraw Hill (India), 2ndEdition,2013
3. Gopal.Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House,2001
4. Vedam Subrahmaniam, "Electric Drives (concepts and applications)", Tata McGraw- Hill, 2011
5. P.S.Bimbra "Power Electronics" Khanna Publishers, third Edition,2003

REFERENCES:

1. Muthusubramanian R, Salivahanan S and Muraleedharan K A, "Basic Electrical, Electronics Engineering", Tata McGraw Hill, 2013.
2. J.Nagrath and D.P. Kothari, "Basic Electrical Engineering", Tata McGraw Hill ((India),3rd Edition, 2010.
3. M.H.Rashid, „Power Electronics: Circuits, Devices and Applications", Pearson Education, Third Edition, New Delhi, 2004 .
4. Mehta V K, "Principles of Electronics", S.Chand& Company Ltd, 2010.
5. Pillai.S.K "A first course on Electric drives", Wiley Eastern Limited, 1998.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	1		1					3		
CO2	3	3	3	3	1		1					3		
CO3	3	3	3	2			1					3	2	
CO4	3	3	2	2		2	2					3	3	2
CO5	3	3	2	2			1					3	3	

IT22251	COMPUTER PROGRAMMING AND PRACTICE (Common to AE/BT/CV/CH)	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

To know the basics of algorithmic problem solving
To learn programming using a structured programming language.
To implement programs with basic features of C.

UNIT I	FUNDAMENTALS OF COMPUTING	6 + 3

Computing Devices – Identification of Computational Problems – Algorithms – Building Blocks of Algorithms - Pseudocodes and Flowcharts- Notion of memory, addresses, variables, instructions, execution of instructions- Operating system commands, file editing, compiling, linking, executing a program. Introduction to different programming languages.

Suggested Activities: Practical - Use of operating system commands and file editing operations

UNIT II	BASICS OF C	6+9

Data types - constants, variables - operators - expressions - basic input/output. Statements and blocks - Selection - if-else construct - iteration - while - for constructs.

Suggested Activities

Practical Demonstration of programs using data types, operators and basic input/output.Demonstration of programs using if else, else-if, switch, Demonstration of programs using, while, for do-while, break, continue

UNIT III	ARRAYS AND STRINGS	6+6

Array, declaration, initialization. Multi dimensional arrays. Strings and character arrays, string operations on arrays

Suggested Activities Practical

Demonstration of programs using arrays and operations on arrays, Demonstration of programs implementing string operations on arrays

UNIT IV	FUNCTIONS AND STRUCTURES	6+6

Functions, definition, call, arguments, call by value. Call by reference. Recursion, Introduction to structures and unions.

Suggested ActivitiesPractical

Demonstration of programs using functions,. Demonstration of programs using recursion, Demonstration of programs using Structures and Unions

UNIT V	POINTERS AND FILE HANDLING IN C	6+6

Introduction to Pointers- pointers to basic variables, pointers and arrays. Pointers to strings Dynamic Memory Allocation, Files - binary, text - open, read, write, random access, close. Preprocessor directives

Suggested Activities

Practical Demonstration of programs using pointers, Demonstration of programs using files

TOTAL:L30+P30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the model of a computer, software design methodologies, and represent solutions to computational problems as algorithms	**3**
CO2.	Analyze the problem scenarios and develop C programs using sequential, conditional, and iterative constructs	**4**
CO3.	Appraise problem scenarios and develop C programs using complex storage structures	**4**
CO4.	Design modularized solutions for larger problems	**3**
CO5	Inspect the storage structure in a computer and design C programs to access permanent storage	**4**

TEXT BOOKS:

1. PradipDey, Manas Ghosh, " Programming in C ", First Edition, Oxford University Press, 2018.
2. R G Dromey, "How to Solve it using Computer", Pearson,2006.

REFERENCES:

1. Kernighan,B.W and Ritchie,D.M, "The C Programming language", Second Edition, Pearson Education, 2015.
2. Yashavant P. Kanetkar. "Let Us C", BPB Publications, 2011.
3. Byron S Gottfried, "Programming with C", Schaum"s Outlines, Third Edition, Tata McGrawHill, 2010
4. ReemaThareja, "Programming in C", 2nd ed., Oxford University Press, 2016

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	3	3	2	2	1	0	1	3	2	0	2	0	1
CO2	2	3	2	2	2	1	0	1	3	2	0	2	0	1
CO3	2	3	2	2	2	1	0	1	3	2	0	2	0	1
CO4	3	3	2	2	2	1	0	1	3	2	0	2	0	1
CO5	1	1	1	1	2	1	0	1	3	2	0	2	0	1

CH22201	INTRODUCTION TO CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Introduce and outline of the concepts of Chemical Engineering

UNIT I	OVERVIEW OF CHEMICAL ENGINEERING	9

Historical overview of Chemical Engineering; Chemical Engineering in day to day life; Greatest achievements in the field of Chemical Engineering, Paradigm shifts in Chemical Engineering; Opportunities and Future prospects of Chemical Engineering.

UNIT II	BASICS OF CHEMICAL ENGINEERING	9

Units and dimensions, Dimensional Analysis – Rayleigh's and Buckingham Pi methods, Gas calculations, First and Second law of Thermodynamics, Chemical Kinetics – Reaction rates and Reactor types.

UNIT III	MOMENTUM TRANSFER	9

Introduction: Nature of fluids, Concepts of Fluid flow, Properties of Fluid Flow, Pumps and Measuring devices –Variable and constant head meters.

UNIT IV	HEAT TRANSFER	9

Modes of Heat Transfer: Conduction, Convection and Radiation, Heat Transfer Equipments - Heat Exchanger and evaporators.

UNIT V	MASS TRANSFER	9

Diffusion - Absorption, Adsorption, Humidification and dehumidification, Mass Transfer Equipments –Absorbers, strippers and Dryers.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyze the history and future prospects of Chemical Engineering.	4
CO2.	Apply the basic Chemical Engineering Principles.	3
CO3.	Construct the Concepts of Momentum Transfer.	3
CO4.	Explore the Heat Transfer concepts and understand the working principle of Heattransfer equipments.	3
CO5	Explain the Mass Transfer operations and its role in Chemical process industries.	3

TEXT BOOKS:

1. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", 6th Edition, TataMcGraw Hill,1997.
2. Ghosal, S.K, Sanyal S.K. and Dutta.S, "Introduction to Chemical Engineering" TMHPublications, New Delhi, 1998.
3. Dryden, C.E., "Outlines of Chemicals Technology", Edited and Revised by Gopala Rao, M. and M.Sittig,2nd Edition, Affiliated East-West press, 1993.
4. Randolph Norris Shreve, George T. Austin, "Shreve"s Chemical Process Industries", 5thedition, McGraw Hill, 1984.

REFERENCES:

1. McCabe, W.L., Smith, J. C. and Harriot, P. "Unit operations in Chemical Engineering", McGraw HillEducation, 7th Edition, 2017 ISBN-13: 978- 8184959635.
2. Pushpavanam, S, "Introduction to Chemical Engineering", PHI Learning Private Ltd, New Delhi, 2012, ISBN 13: 978-8120345775.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	1	1		1		2		1		2	2	2
CO2	2	2	1	1		1		2		1		2	2	2
CO3	3	2	2	2		2	1	2		1		3	3	3
CO4	3	2	2	2		2	1	2		1		3	3	3
CO5	3	2	2	2		2	1	2		1		3	3	3

HS22251	அறிவியல் மற்றும் தொழில் நுட்பத்தில் தமிழ் **Science and Technology in Ancient Tamil Society** (Common to all branches)	L	T	P	C
		2	0	0	2

பாடத்தின் நோக்கங்கள் :

- அறிவியலில் தமிழின் பயன்பாடு பற்றி தெரிந்து கொள்வார்கள்.
- தொழில்நுட்பத்தில் தமிழ் பாரம்பரியத்தின் தாக்கம் பற்றி அறிந்து கொள்வார்கள்

அலகு 1 **UNIT I**	**அறிவியல் தமிழ்** **SCIENTIFIC TAMIL**	**5**

கருவி உருவாக்கம் - ஆராய்ச்சி மேம்பாடு - கல்வி வளர்ச்சி - அறிவியல் தமிழ் சொற்கள் உருவாக்கம்.
Tool Development - Research Development - Educational Development - Scientific Tamil words Creation.

அலகு 2 **UNIT II**	**தொழில் நுட்பத்தில் தமிழ்** Tamil in technology	**25**

வடிவமைப்பு மற்றும் கட்டுமான தொழில்நுட்பம் : சங்க காலத்தில் கட்டுமானப் பொருட்கள் - சோழர்களின் பெரிய கோவில்கள் மற்றும் பிற வழிபாட்டு தலங்கள் - பல்லவர்களின் சிற்பங்கள் மற்றும் கோவில்கள் (**மாமல்லபுரம்**) - நாயக்கன் கால கோவில்கள் (**மதுரை மீனாட்சி அம்மன் கோவில்**), திருமலை நாயக்கர் மஹால், செட்டி நாட்டு வீடுகள்.

Design and Construction Technology : Building materials in Sangam age – Great temples of Cholas and other workship places – Sculptures and Temples of Pallavas (**Mamallapuram**) – Temples of Nayakas period (**Madurai Meenakshi amman temple**), Thirumalai Navakar Mahal, Chetti Nadu Houses.

உற்பத்தி தொழில்நுட்பம் : கப்பல் கட்டும் கலை, உலோகவியல் ஆய்வுகள், தங்கம், தாமிரம், இரும்பு பற்றிய அறிவு - தொல்பொருள் சான்றுகள் - சுட்டக் களிமண் மணிகள், சங்கு மணிகள், எலும்பு மணிகள்.

Manufacturing Technology : Art of Ship building, Metallurgical studies, Knowledge about Gold, Copper, Iron – Archeological evidences – Terracotta beads, Shell beads, Bone beads.

விவசாயம் மற்றும் நீர்ப்பாசன தொழில்நுட்பம் : அணைகள், ஏரிகள், குளங்கள், மதகுகள், சோழர் கால குமுழி தூம்பு ஆகியவற்றின் முக்கியத்துவம் - கால்நடை பராமரிப்பு , கால்நடைகளின் பயன்பாட்டிற்காக வடிவமைக்கப்பட்ட கிணறுகள். விவசாயம் மற்றும் வேளாண் செயலாக்கம் - கடல் பற்றிய அறிவு - மீன்பிடித்தல், முத்து குளித்தல், சங்கு சேகரித்தல்.

Agriculture and Irrigation Technology: Dams, Tank, ponds, sluice, Significance of Kumuzhi Thoompu of Cholas period- Animal Husbandry, Wells designed for cattle use. Agriculture and Agro processing, - Knowledge about Sea – Fisheries, Pearl, Conche diving.

தமிழ் கணினி: அறிவியல் தமிழ் வளர்ச்சி - தமிழ் கணினி , தமிழ் புத்தகங்களின் டிஜிட்டல் மயமாக்கல் , தமிழ் டிஜிட்டல் நூலகம் , தமிழ் மென்பொருள் உருவாக்கம் - தமிழ் மெய்நிகர் அகாடமி - சொற்குவை திட்டம்.

Tamil Computing : Development of Scientific Tamil – Tamil Computing, Digitization of Tamil books, Tamil Digital Library, Development of Tamil Softwares – Tamil virtual Academy – Sorkuvai project.

தமிழின் எதிர்காலமும் தகவல் தொழில்நுட்பமும்- உலகமயமாக்கலும் தகவல் தொழில் நுட்பமும் - கணினிக்கு தமிழ் கற்று கொடுத்தல் - தமிழ் மொழித் தொழில் நுட்பத்தில் வளங்கள்.

Future of Tamil and Information Technology- Globalization and Information Technology-Teaching Tamil for Computer-Resources in Tamil Language Technology.

TOTAL: 30 PERIODS

பாடநெறி முடிவுகள் :COURSE OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	பாடத்திட்டத்தின் வெளிப்பாடு STATEMENT	RBT LEVEL
CO1.	அறிவியலில் தமிழ் மொழியின் பயன்பாடு பற்றி தெரிந்து கொள்வார்கள்	2
CO2.	பல்வேறு தொழில்நுட்பத்தில் தமிழ் மொழியின் தாக்கம் பற்றி அறிந்து கொள்வார்கள்	2

பாட நூல்கள்:TEXT BOOKS:

டாக்டர், வா.செ .குழந்தைசாமி (1985), " அறிவியல் தமிழ் " , பாரதி பதிப்பகம் , 126/108, உஸ்மான் சாலை , தியாகராய நகர் , சென்னை 600017

சுப. திண்ணப்பன், (1995), "கணினியும் தமிழ் கற்பித்தலும்", புலமை வெளியீடு, 38-B மண்ணத்நதோட்டத் தெரு, ஆழ்வார்பேட், சென்னை 600018

மு. பொன்னவைக்கோ, (2003), "வளர் தமிழில் அறிவியல் – இணையத்தமிழ்", அனைத்திந்திய அறிவியல் தமிழ்க்கழகம், தஞ்சாவூர் 615 005.

துரை. மணிகண்டன், (2008), "இணையமும் தமிழும்", நல் நிலம் பதிப்பகம், 7-3, சிமேட்லி சாலை, தியாகராய நகர், சென்னை 600 017.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2			2	2							2		
CO2	2	1	1	2	2	1			1	1	1	2		

EE22111	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

1. To provide exposure to the students with hands on experience in basic of Electrical and Electronicswiring connection and measurements.

2. To introduce the students to Electrical Machines and basic laws of Electrical Circuits.

LIST OF EXPERIMENTS

1. Wiring – Residential house wiring and Stair case wiring.
2. (a) AC Analysis- Measurement of electrical quantities–voltage, current, power, and power factor usingRLC.
(b) Study of three phase system.
3. Energy conservation - Measurement and comparison of energy for incandescent lamp and LED lamp.
4. (a) Identification of circuit components (Resistor, Capacitor, Diode and BJT) and soldering practice.
(b) Signal Measurement- Measurement of peak to peak, RMS, average, period, frequency of signals using CRO.
5. (a) VI Characteristics of Solar photovoltaic panel.
(b) Design of Solar PV Array and Battery sizing for Residential solar PV system.
6. Design a 5V/12V Regulated Power Supply using FWR and IC7805/IC7812.
7. DC Analysis- Verification of Ohm's Law and Kirchhoff's Laws.
8. Study of Transformer and motor characteristics.

TOTAL: 30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO's	STATEMENT	RBT LEVEL
CO1.	Wiring of basic electrical system and measurement of electrical parameters.	**4**
CO2.	Verify the basic laws of Electric circuits and select various Electrical Machines.	**4**
CO3.	Construct electronic circuits and design solar photovoltaic system.	**4**
CO4.	Apply the concept of three-phase system.	**4**
CO5	Construct a fixed voltage regulated power supply.	**4**

REFERENCES:

1. Mittle V.N, Arvind Mittal, "Basic Electrical Engineering", Tata McGraw Hill (India), 2nd Edition, 2013. Sedha R.S., "A Text Book of Applied Electronics", S.Chand& Co., 2014.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	3					2			2		3
CO2	3	3	3	3					2			2		3
CO3	3	3	3	3					2			2		3
CO4	3	3	3	3					2			2		3
CO5	3	3	3	3					2			2		3

PH 22161	PHYSICS LABORATORY Common to all Branches	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES: To introduce different experiments to test basic understanding of physics concepts applied in optics, thermalphysics and properties of matter.

LIST OF EXPERIMENTS: (Any EIGHT Experiments)

1. a) Determination of Wavelength, and particle size using Laser.
   b) Determination of acceptance angle in an optical fiber.
2. Determination of velocity of sound and compressibility of liquid – Ultrasonic Interferometer.
3. Determination of wavelength of mercury spectrum – spectrometer grating.
4. Determination of thermal conductivity of a bad conductor – Lee‟s Disc method.
5. Determination of Young's modulus by Non uniform bending method.
6. Determination of specific resistance of a given coil of wire – Carey Foster‟s Bridge.
7. Determination of Rigidity modulus of a given wire -Torsional Pendulum
8. Energy band gap of a Semiconductor
9. Determine the Hysteresis loss of a given Specimen
10. Calibration of Voltmeter & Ammeter using potentiometer

TOTAL: 30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyze the physical principle involved in the various instruments; also relate the principle to new application. materials.	**4**
CO2.	Comprehend the Experiments in the areas of optics, mechanics and thermal physics to nurture the concepts in all branches of Engineering.	**3**
CO3.	Apply the basic concepts of Physical Science to think innovatively and also improve the creative skills that are essential for engineering	**3**
CO4.	Evaluate the process and outcomes of an experiment quantitatively and qualitatively	**3**
CO5	Extend the scope of an investigation whether or not results come out as expected	**3**

REFERENCES:

Physics Laboratory practical manual", 1st Revised Edition by Faculty members, 2018.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	3	2				3	1		2		3
CO2	3	3		3		2			3	1		2		3
CO3	3	3	2	3	2	2			3	1		2		3
CO4	3	3		3					3	1		2		3
CO5	3	3		3	2				3	1		2		3

SEMESTER III

MA22351	APPLIED MATHEMATICS III	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

The student should be

- Competent in solving applications of ordinary differential equations using analytical methods to obtaintheir exact solutions.
- Find the solution of 1st & higher order PDEsusing analytical methods.
- Introduce Fourier series analysis which is central to many applications in engineering apart from its use insolving boundary value problems.
- Acquire the knowledge of using Fourier series techniques in Boundary value problems.
- Achieve an understanding of the basic concepts of the Fourier transform and Z-transform techniques andits application in Engineering.

UNIT I	APPLICATIONS OF ORDINARY DIFFERENTIAL EQUATIONS	9+3

Applications of Differential Equations of First Order-Geometrical Applications-Orthogonal Trajectories-Physical Applications-Application of Linear Differential Equations-Simple Harmonic Motions-Deflection of Beams- Applications of Simultaneous Linear Differential Equations.

UNIT II	PARTIAL DIFFERENTIAL EQUATIONS	9+3

Formation of partial differential equations – Singular integrals - Solutions of standard types of first order partialdifferential equations - Lagrange‟s linear equation – Linear homogeneous partial differential equations of second and higher order with constant coefficients.

UNIT III	FOURIER SERIES	9+3

Dirichlet‟s conditions – General Fourier series – Odd and even functions – Half range sine series – Half rangecosine series –Parseval‟s identity – Harmonic Analysis.

UNIT IV	BOUNDARY VALUE PROBLEMS	9+3

Classification of PDE – Method of separation of variables - Solution of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (Cartesian and polar coordinates).

UNIT V	FOURIER AND Z -TRANSFORMS	9+3

Fourier transform pair – Fourier sine and cosine transforms – Properties (without proof) – Convolution theorem – Parseval‟s identity. Z- Transforms – Elementary properties – Inverse Z - transform (using partial fraction) –Convolution theorem – Solution of difference equations using Z - transform.

TOTAL(L:45+T:15):60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Develop skills in dealing with problems on ordinary differential equations and applyknowledge of LDE to solve the problems in Chemical engineering.	**4**
CO2.	Classify, formulate and solve the first order and second order linear, non-linear partial differential equations and apply the knowledge of partial differential equations to solve the engineering problems.	**3**
CO3.	Achieve an understanding of the basic concepts of periodic function and method ofsolving problems in Fourier series.	**4**
CO4.	Analyze and evaluate various partial differential equations such as wave equation,one- and two-dimensional heat flow equations.	**4**
CO5	Develop the skill of conversion between time domain to frequency domain using theconcept of Fourier Transforms and Z-transform.	**4**

TEXT BOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10 th Edition, Wiley India, 2011.
2. Grewal. B.S., "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, Delhi 2017.
3. Narayanan.S., Manicavachagom Pillay.T.K and Ramanaiah. G "Advanced Mathematics for EngineeringStudents" Vol. II & III, S.Viswanathan Publishers Pvt. Ltd. 1998.

REFERENCES:

1. Bali.N.P and Manish Goyal, "A Textbook of Engineering Mathematics", 7th Edition, Laxmi PublicationsPvtLtd , 2007.

2. Glyn James, "Advanced Modern Engineering Mathematics", 4th Edition, Pearson Education, 2011.

3. Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Publishing CompanyLtd., New Delhi, 2012.

4. LurryC.Andrews, "Special Functions of Mathematics for Engineers", 2nd Edition, McGraw Hill International Edition, 1992.

WEB LINKS:

1. Engg Mathematics-3 - APPLICATION OF ORDINARY DIFFERENTIAL EQUATIONS - 111 3 Applicationof Ordinary - Studocu .

2. FS_PDES_2016.dvi (ox.ac.uk)

3. Introduction to Fourier Series (purdue.edu)

4. Applications of Partial Differential Equations (nitk.ac.in)

COURSE ARTICULATION MATRIX														
CO	**PO**												**PSO**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	2	2	1	1	1	2	3	3	3	3
CO2	3	3	3	3	2	2	2	2	1	3	3	3	3	3
CO3	3	3	3	3	2	1	1	1	1	2	2	3	3	3
CO4	3	3	3	3	2	2	2	2	1	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	1	3	3	3	3	3

CH22301	CHEMICAL PROCESS CALCULATIONS	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

- To impart knowledge on the basic fundamentals of process calculations.
- To enable the students to perform material balances on various unit operations and processes.
- To enable the students to understand the concepts and calculations associated with gases and othercombustion operations in industry which involves two phases.
- To enable the students to perform energy balance calculations on various unit operations and processes.
- To impart knowledge on unsteady state material and energy balances and enable the students to solveproblems using process simulators.

UNIT I	UNITS AND DIMENSIONS	9

Base and derived Units - Conversion of units and conversion factors, Dimensional consistency Composition of Mixture and solutions - calculations of pressure, volume and temperature using ideal gas law. Use of partial pressure and pure component volume in gas calculations, applications of real gas relationship in gas calculations.

UNIT II	MATERIAL BALANCE WITH AND WITHOUT CHEMICALREACTIONS	9

Stoichiometric principles, Application of material balance to unit operations like distillation, evaporation, crystallisation, drying etc., multicomponent systems species analysis and Degree-of-Freedom Analysis Material balance with chemical reaction - Limiting and excess reactants - recycle - bypass and purging - Unsteady state material balances.

UNIT III	HUMIDITY AND SATURATION	9

Basic of humidity and application of psychrometric chart - Use of humidity in condensation and drying –application of air water systems - cooling tower, types and basic calculations.

UNIT IV	ENERGY BALANCE WITH AND WITHOUT CHEMICALREACTIONS	9

Heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible heat and latent heats, evaluation of enthalpy. Standard heat of reaction, heats of formation, combustion, solution, mixing etc., calculation of standard heat of reaction - Effect of pressure and temperature on heat of reaction -Energy balance for systems with and without chemical reaction - Unsteady state energy balances.

UNIT V	FLUE GAS ANALYSIS	9

Determination of Composition by Orsat analysis of products of combustion of solid, liquid and gas fuels - Calculation of excess air from Orsat technique, Combustion processes – Flue gas analysis, Ultimate and Proximate analyses of coal. Application of Process simulators and excel solver tool in energy and material balance problems.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Interpret the data presented in different unit systems and apply various gas laws tocalculate the unknowns in a given system.	4
CO2.	Develop knowledge on various unit operations and unit processes and analyze thematerial balances for steady and unsteady state chemical systems.	4
CO3.	Discuss humidification operations and its applications for known systems.	3
CO4.	Perform and analyze energy balance calculations for steady and unsteady state chemical processes.	4
CO5	Explicate various methods used for analyzing combustion processes and demonstratethe ability to understand process simulators.	4

TEXT BOOKS:

1. David M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", Eighth Edition, Prentice Hall of India, New Delhi, 2012
2. Bhatt B.I. and Vora S.M., "Stoichiometry", Second Edition, Tata McGraw Hill, New Delhi, 2004
3. Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, JohnWiley & Sons, New York, 2005

REFERENCES:

1. Hougen O A, Watson K M and Ragatz R A, "Chemical process principles" Part I, Second Edition, CBSpublishers, 1976.
2. Venkatramani. V, Anatharaman. N and Meera Shariffa Begam "Process Calculations" Prentice Hall of India, New Delhi, 2011.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	2	2	1	1	1	2	3	3	3	3
CO2	3	3	3	3	2	2	2	2	1	3	3	3	3	3
CO3	3	3	3	3	2	1	1	1	1	2	2	3	3	3
CO4	3	3	3	3	2	2	2	2	1	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	1	3	3	3	3	3

CH 22302	MOMENTUM TRANSFER	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES: To impart to the student knowledge on fluid properties, fluid statics, dynamic characteristics for through pipesand porous medium, flow measurement and fluid machineries

UNIT I	FUNDAMENTALS OF FLUID AND FLUID FLOW	9

Fluid – properties of fluid – Continuum concept of fluid – Newton's law of viscosity, pressure and temperature dependence – classification of fluids – Newtonian fluid – Non-Newtonian fluid and their classification. Classification of fluid flow – Incompressible and Compressible flow – Steady, Unsteady, Uniform and Non – Uniform flow. Flow visualization – streamline, pathline, streak line, velocity and stress field.

UNIT II	FLUID STATICS AND FLUID KINEMATICS	9

Fluid statics – Pressure concept, Hydrostatic equilibrium, Manometer and their types. Fluid flow - Differential analysis of fluid motion – Conservation of mass – Equation of continuity and Equation of motion – Euler's equation, Bernoulli equation and with correction for fluid friction – correction for pump work, Navier- Stokes Equations and Applications

UNIT III	FLOW THROUGH CONDUITS, FIXED ANDFLUIDIZED BEDS	9

Reynolds number, experiment and significance, Hagen Poiseuelle equation and Darcy-Weisbach equation; internal flow - flow through pipes and conduits – Moody diagram – friction factor – friction factor chart – head loss due to friction, sudden expansion and contraction. External flows - Flow over a sphere – friction andpressure drag - flow through fixed and fluidized beds - Kozeny Carman equation – Blake Plummer equation and Ergun equation.

UNIT IV	TRANSPORTATION OF FLUIDS	9

Flow measurement –classification flow measuring devices – Principle and working of Orifice meter, Venturi meter, Pitot tube and Rotameter. Brief introduction to non-conventional methods: Laser Doppler velocimetry, Particle image velocimetry, ultrasonic flow meters, electromagnetic flow meters. Valves, Types and characteristics of Valves; Pumps – Classification and working of Centrifugal pumps and Reciprocating pumps, Centrifugal pump: Cavitation and priming – performance characteristics – Net positive suction head – factors influencing selection of pump. Introduction to compressors, fans and blowers.

UNIT V	TURBULENCE AND SIMILARITY	9

Introduction to turbulence: Structure of turbulence, visualization of turbulence, Reynolds decomposition. Fundamental dimension of quantities, dimensional homogeneity – dimensional analysis: Physical significanceof dimensionless numbers, Geometric – Kinematic and Dynamic Similarity

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyze the fluid properties and flow behaviour of fluids.	**3**
CO2.	Apply various equations governing fluid statics and fluid kinematics.	**4**
CO3.	Discuss the pressure drop during the flow of fluids through different physical systems like pipes, valves, fixed and fluidized beds.	**4**
CO4.	Analyze several machineries used to transport the fluid and theirperformance including the flow measurements.	**3**
CO5	Compare the fluid flow characteristics during the turbulent conditions usingthe analogies.	**4**

TEXT BOOKS:

1. McCabe W.L, Smith, J C and Harriot. P "Unit Operations in Chemical Engineering", McGraw Hill,Seventh Edition, 2005.
2. White, F.M., "Fluid Mechanics ", McGraw-Hill Inc., Seventh Edition, 2011.

REFERENCES:

1. Robert W. Fox and Alan T. McDonald, "Introduction to Fluid Mechanics" John Wiley & Sons, Inc,Fifth Edition, 2009.
2. Noel de Nevers, "Fluid Mechanics for Chemical Engineers ", McGraw-Hill, Third Edition, 2005.
3. J. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall (1999).
4. R. B. Bird, W. L. Stewart and E. L. Lightfoot, Transport Phenomena (Second edition), WileySingapore (2002).
5. M. M. Denn, Process Fluid Mechanics, Prentice Hall (1980).

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	3	3	3	2	1	1	2	2	1	1	3	3
CO2	3	3	2	3	3	3	2	1	2	2	1	3	3	3
CO3	3	3	2	3	3	3	2	1	2	2	1	3	3	3
CO4	3	2	2	3	3	2	2	1	2	2	1	3	3	3
CO5	3	3	3	3	3	3	3	1	2	2	1	3	3	3

CH22303	CHEMICAL ENGINEERING THERMODYNAMICS – I	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To apply the principles and application of first and second law of thermodynamics, and phase equilibria.

UNIT I	INTRODUCTION	9

Introduction- scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat, Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V,T processes; Mass and energy balances for open systems

UNIT II	SECOND LAW OF THERMODYNAMICS	9

Statements of the second law; Heat engines, Carnot's theorem, Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law, Entropy balance for open systems;Calculation of ideal work, Lost work

UNIT III	PVT BEHAVIOUR OF FLUIDS	9

Phases, phase transitions, PVT behaviour; description of materials – Ideal gas law, vanderWaals, virial, and cubic equations of state; Reduced conditions & corresponding states theories; correlations in description of material properties and behaviour. Heat effects-latent heat, sensible heat, standard heats of formation, reaction, and combustion

UNIT IV	THERMODYNAMIC PROPERTIES OF PURE FLUIDS	9

Thermodynamic property of fluids- Helmholtz free energy, Gibb's free energy, Thermodynamic property relations- Maxwell relations, Residual properties,2-phase systems, graphs, Thermodynamic property diagrams – P-H, H-T, T-S, H- S and Thermodynamic property diagrams with its constructions.

UNIT V	REFRIGERATION AND LIQUIFACTION, COMPRESSOR WITH INTERCOOLING	9

Application of thermodynamics to flow processes-pumps, compressors, and turbines. Thermodynamic analysis of steam power plants; Rankine cycle; Internal combustion engine, Otto engine; Diesel engine; Jet engine. The Carnot refrigerator; Vapour-compression cycle; Absorption refrigeration cycle. Compressors, Types of Compressors with design calculation. Thermodynamic analysis of steam power plants; Liquefaction processes.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply concepts of heat, work and energy conversion and mass and energy balances to close and open systems	**3**
CO2.	Envisage the entropy changes in a wide range of processes and determine the reversibility or irreversibility of a process from such calculations.	**3**
CO3.	Evaluate the properties of non-ideal gases.	**4**
CO4.	Illustrate the inter relations between measurable and non measurable properties.	**4**
CO5	Examine the process of liquefaction, refrigeration and different power cycles	**4**

TEXT BOOKS:

1. M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, Seventh edition, McGraw-Hill International Edition,2005.

REFERENCES:

1. K. V. Narayanan, A Textbook of Chemical Engineering Thermodynamics, Prentice Hall of India,2001
2. B. G. Kyle, Chemical and Process thermodynamics. Second Edition., Prentice Hall of India,2000
3. M J Moran, H N Shapiro, D Boettner and M B Bailey, Principles of Engineering Thermodynamics, 8th Edition, Wiley, 2000

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	2	2	1	2	2	-	2	2	1	3	3
CO2	3	3	3	3	3	2	2	-	-	2	1	1	3	3
CO3	3	2	2	2	2	1	1	1	1	2	2	1	3	3
CO4	3	3	3	3	3	-	1	-	1	2	2	2	3	3
CO5	3	3	3	3	3	1	1	-	1	2	-	2	3	3

CH22304	MECHANICAL OPERATIONS	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES: To learn characterization of solids, size reduction, techniques of solid – fluid separation, mixing and conveying ofsolids.

UNIT I	PARTICLE CHARACTERIZATION AND MEASUREMENT	9

Particle shape and size, different ways of expression of particle size, shape factor, sphericity. Mixed particle size analysis, standard screens, Differential and cumulative size analysis, specific surface of mixture of particles, number of particles in a mixture. Screens, ideal and Actual screens, Effectiveness of screen, Standard Screen Series, sub sieve analysis – air permeability method.

UNIT II	PARTICLE SIZE REDUCTION AND SIZE ENLARGEMENT	9

Introduction – types of forces used for comminution, Criteria for comminution, Characteristics of comminuted products, Laws of size reduction, Work Index, Energy utilization, methods of operating crushers – Free and choke feeding, open circuit grinding, Closed circuit grinding, wet and dry grinding, Equipment‟s for size reduction & its operation– Jaw crusher, Roll crusher, Hammer mill, Ball mill, Fluid energy mill. Principles and importance of Size enlargement.

UNIT III	PARTICLE SEPARATION (GAS-SOLID AND LIQUID-SOLID SYSTEM)	9

Mechanics of particle motion, Equation for one dimensional motion of particles through a fluid in gravitational and centrifugal field, Terminal velocity, drag coefficient, Motion of spherical particles in Stoke‟s region, Newton's region, and Intermediate region, Criterion for settling regime, Hindered settling, Modification of equation for hindered settling. Equipment's for particle separation and its operation – Gravity settling, double cone classifier, rake classifier and surface area estimation for thickener. Centrifugal separation principle -cyclones and hydro cyclones.

UNIT IV	FILTRATION AND FILTRATION EQUIPMENTS	9

Theory of filtration, Batch and continuous filters, Flow through filter cake and filter media, compressible and incompressible filter cakes, filter aids. Filtration equipment's - selection, operation and optimum cycle of operation, Principle of operation – plate and frame filter press, leaf filter, bag filter, electrostatic precipitator.

UNIT V	MIXING AND PARTICLE HANDLING	9

Mixing and agitation - Mixing of liquids (with or without solids), mixing of powders, selection of suitable mixers, power requirement for mixing. Storage of solids - Bunkers, silos, bins, and hoppers. Principles in transportation ofsolids in bulk – Conveying – belt, bucket and pneumatic.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Applying the basic knowledge on the solid handling characteristics and mixed particle size analysis through screening.	3
CO2.	Examine the various comminution equipment's for size reduction operations and to understand the principles of size enlargement techniques	4
CO3.	Make use of various solid separation techniques through settling and basic knowledge on such equipment design.	3
CO4.	Analyse the various types of filtration process in mineral processing industries.	4
CO5	Apply knowledge to practice various mixing processes and particles storage & conveying.	3

TEXT BOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill, 1997.
3. Foust, A. S., Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., "Principles of Unit Operations", 2nd Edn., John Wiley & Sons, 1994.
4. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. II, 4th Edn., Asian Books Pvt. Ltd., India,1998.

REFERENCES:

1. 1. Hiroaki Masuda , KoHigashitani and Hideto Yoshida, Powder Technology Handbook, 4th Edition. Taylor &Francis, 2006
2. Christie J. Geankoplis, Transport processes and unit operations, Prentice Hall, 2018.
3. Sunggyu Lee, Kimberly H. Henthorn, Particle Technology and Applications, CRC Press, 2017.
4. Martin Rhodes, Introduction to Particle Technology, Second Edition, John Wiley & Sons, 2008.
5. Unit Operations-I, Fluid Flow & Mechanical Operation, K.A Gavhane, Nirali Prakashan, 2016.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	2	2	2	3	1	2	3	1	3	3	3
CO2	3	3	2	3	3	3	1	2	3	3	1	3	3	3
CO3	3	3	2	2	2	2	3	1	2	3	1	3	3	3
CO4	3	3	2	3	3	3	1	2	3	3	1	3	3	3
CO5	3	3	2	1	2	3	3	1	2	3	1	3	3	3

CH22305	MECHANICS OF SOLIDS FOR CHEMICAL ENGINEERING	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

- To learn fundamental concepts of stress, strain and deformation of solids with applications to bars, beams,columns, thin cylinders and spherical shells.
- To know the mechanism of load transfer in beams, the induced stress resultants and deformations underaxial and transverse loading.
- To analyze the forces and stresses on pressure vessel.

UNIT I	STRESS, STRAIN AND DEFORMATION OF SOLIDS	9

Stress and strain - tension, compression, reaction forces and shear stresses in simple and compound bars- Hooke‟s law –Thermal stresses - Relationship among elastic constants and Poisson‟s ratio – Stress strain diagrams for engineering materials – Factor of safety.

UNIT II	TRANSVERSE LOADING ON BEAMS	9

Beams – support conditions – types of Beams - forces on solids and supports – transverse loading on beams - shearforce and bending moment in beams - analysis of cantilevers, simply supported beams and over hanging beams with reaction force - relationships between loading, S.F. and B.M. In beams - S.F.& B.M. diagrams – Location of
point of contraflexure and maximum B.M.

UNIT III	DEFLECTION OF BEAMS	9

Double integration method, Macaulay‟s method, Moment-Area theorems and conjugate beams method for computation of slopes and deflections in simply supported and cantilever beams.

UNIT IV	STRESSES IN BEAMS & COLUMNS	9

Theory of simple bending – assumptions and derivation of bending equation - analysis of bending stresses inbeams under transverse loading – loads carrying capacity of beams – proportioning beam sections - shear stress distribution in beams - determination of shear stress distribution in symmetrical and unsymmetrical sections with reaction force.Columns: Euler‟s theory of long columns and critical loads for columns with different end conditions.

UNIT V	DESIGN OF PRESSURE VESSELS	9

Codes & Standards, Vessels operating at low temperatures and elevated temperatures, design conditions and stress, design of shell and its components, supports, stress from local loadsand thermal gradients, thermal stresses in cylindrical shell. Features of high pressure vessels – solid walled vessel, vessel closures, jackets.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Recognize the fundamental concepts of stress and strain in mechanics of solids andstructures.	**3**
CO2.	Apply the knowledge on types of beams and loads and investigate the shear forceand bending moment diagrams.	**3**
CO3.	Utilizing various techniques to infer the deflection of beams.	**3**
CO4.	Develop the models to analyze the principle stresses in beams and columns.	**3**
CO5	Apply the knowledge of principle stresses to design the pressure vessels.	**3**

TEXT BOOKS:

1) R. K. Bansal, Strength of Materials, Fifth Edition, Laxmi Publications, 2012.
2) R. C. Hibbeler, Mechanics of Materials, Sixth Edition, Pearson Education, Inc., 2005
3) E. P. Popov, Engineering Mechanics of Solids, Prentice Hall, 1998.
4) F. P. Beer, E. R. Johnston (Jr.) and J.T. DeWolf, Mechanics of Materials, Tata McGraw Hill, 2005.
5) M. V. Joshi, Process Equipment Design, Macmillan, 1976.

REFERENCES:

1) S. H. Crandall, N. C. Dahl, and T. J. Lardner, An Introduction To The Mechanics Of Solid, 2nd Ed., TataMcGraw Hill, 2008.
2) S. P. Timoshenko, Strength of Materials, Vols. 1 & 2, CBS Publishers, 1986.
3) H. Shames and J. M. Pitarresi, Introduction to Solid Mechanics, Prentice Hall of India, 2003.
4) J. M. Gere, Mechanics of Materials, Thomson Brooks/Cole, 2006.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2	2	1	2	2	2	2	1	3	3	3	3
CO2	3	2	2	2	1	2	2	2	2	3	3	3	3	3
CO3	3	2	2	2	1	3	2	2	3	3	2	3	3	3
CO4	3	2	3	3	1	3	3	2	2	2	3	3	3	3
CO5	3	3	3	3	1	3	2	3	2	3	3	3	3	3

CH22311	ENVIRONMENTAL ENGINEERING LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES: At the end of the course, the student will be aware of the standard procedures for quantification of qualityparameter of wastewater, soil and air.

LIST OF EXPERIMENTS:

1. Estimation of the Total Solids for a given sample of water.
2. Permeability determination of solid sample.
3. Direct shear test in cohesionless soil.
4. Determination of chromium traces in tannery effluents.
5. Determination of the metal concentration in solid samples.
6. Determination of viscosity of oil samples using Brookfield Viscometer.
7. Determination of pH range of indicator solutions.
8. Determination of the COD of the given liquid sample.
9. Determination of the BOD of the given liquid sample.
10. Determination of total coliforms in water.
11. Determination of corrosion rate of the given sample.
12. Determination of air quality for indoor and outdoor environments.

*Minimum 10 experiments shall be performed

LIST OF EQUIPMENTS

1. COD Digester
2. Atomic Absorption Spectroscopy
3. Brookfield Viscometer
4. Dissolved Oxygen meter
5. Conductivity meter
6. Carbon dioxide (CO_2) sensor
7. Constant head permeameter
8. Shear box assembly

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyse the characteristics of waste water using standard procedures.	**4**
CO2.	Conduct tests to determine the permeability and shear strength of soils.	**3**
CO3.	Characterise metals affected by corrosion.	**4**
CO4.	Analyse the air quality present in the surrounding environment.	**4**
CO5	Perform coliform analysis.	**3**

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2	3	1	3	3	3	3	3	2	3	3	3
CO2	3	2	1	3	1	3	3	2	3	3	2	3	3	3
CO3	3	2	1	3	1	3	3	2	3	2	2	3	3	3
CO4	3	2	1	3	1	3	3	3	3	3	2	3	3	3
CO5	3	2	1	3	1	3	3	1	3	3	2	3	3	3

CH22312	TECHNICAL ANALYSIS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES: To learn basic principles involved in estimation and characterization of industrially important materials

LIST OF EXPERIMENTS:

I. Soap Analysis
- a. Estimation of total fatty acid
- b. Estimation of percentage alkali content

II. Oil Analysis
- a. Estimation of free acid
- b. Determination of Saponification value
- c. Determination of iodine value

III. Cement Analysis
- a. Estimation of Silica content
- b. Estimation of mixed oxide content
- c. Estimation of calcium oxide content
- d. Estimation of calcium oxide by rapid method

IV. Coal Analysis
- a. Estimation of Sulphur present in coal
- b. Ultimate analysis of coal
- c. Proximate analysis of coal

V. Analysis of Bleaching Powder
- a. Estimation of available chlorine

VI. Analysis of Glycerol
- a. Estimation of purity of glycerol

VII. Analysis of fuels
- a. Flash point
- b. Fire point
- c. Cloud point
- d. Pour point

Aniline point.

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Estimate the alkali and total fatty acid content of soap.	2
CO2.	Determine the acid value, iodine value and cloud & pour point of oil.	3
CO3.	Apply the principle of gravimetry to estimate the quantity of analyte.	3
CO4.	Determine the purity of glycerol	2
CO5	Analyze the available chlorine and residual chlorine in water sample	3
CO6	Analyze sulphate and turbidity in water sample.	2

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1	1	1	1		3	3	2	2			1		
CO2	1	1	1			3	3	2	2					
CO3	1	1	1	1		3	3	2	2					
CO4	1	1	1	1										
CO5	1	1	1	1		3	3	2	2			1		
CO6	1	1	1	1		3	3	2	2					

SEMESTER IV

MA22452	NUMERICAL METHODS (Common to CH & EE)	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

The Student should be made to:

- Learn the solution of algebraic, transcendental equations, system of linear equations
- Understand the concept of Interpolation and approximation.
- Learn how to apply numerical differentiation and Integration
- Familiarize in solving IVP
- Understand how to solve BVP in ODE and PDE

UNIT I	SOLUTION OF EQUATIONS AND EIGEN VALUE PROBLEMS	12

Introduction to computation software for numerical methods solution of algebraic and transcendental equations – Newton Raphson method- Solution of linear system of equations - Gauss elimination method – Pivoting - Gauss Jordan method, Solution of Tri-diagonal system of equations – Gauss Seidel iterative method - Matrix Inversion by Gauss Jordan method - Eigen values of a matrix by Power method and Jacobi Method for symmetric matrix. Solving equations and Eigen value problems using computational tools.

UNIT II	INTERPOLATION AND APPROXIMATION	12

Finite difference operators and its relations - Interpolation with equal intervals – Newton's forward andbackward difference formulae - Interpolation with unequal intervals - Lagrange's interpolation – Newton's divided difference interpolation. Interpolation and Approximation using computational tools

UNIT III	NUMERICAL DIFFERENTIATION AND INTEGRATION	12

Approximation of derivatives using interpolation polynomials - Numerical integration using Trapezoidal, Simpson's 1/3 rule, Romberg's Method - Two point and three-point Gaussian quadrature formulae – Evaluation of double integrals by Trapezoidal and Simpson's 1/3 rules. Application of computational tools for numerical differentiation and integration.

UNIT IV	INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIALEQUATIONS	12

Single Step methods – Taylor's series method, Modified Euler's method – Fourth order Runge Kutta methodfor solving first order equations, second order equations and simultaneous first order equations - Multi step methods – Milne's and Adams- Bash forth predictor corrector methods for solving first order equations. Solving Initial value problems using computational tools.

UNIT V	BOUNDARY VALUE PROBLEMS	12

Finite difference solution of ODE. Finite difference techniques for the solution of two-dimensional Laplace‟s and Poisson‟s equations on rectangular domain – One dimensional heat flow equation by explicit and implicit (Crank Nicholson) methods – One dimensional wave equation by explicit method. Solving Boundary value problems using computational tools.

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Have the fundamental knowledge of solving an algebraic or transcendental equation, linear system of equations.	**2**
CO2.	Appreciate the numerical techniques of interpolation in various intervals	**3**
CO3.	Apply the numerical techniques of differentiation and integration for engineering problems.	**3**
CO4.	Solve initial value problems using an appropriate numerical technique.	**3**
CO5	Solve boundary value problems using finite difference method.	**3**

TEXT BOOKS:

1) Grewal. B.S., Numerical Methods in Engineering & Science with Programs in C, C++ & MATLAB,Khanna Publishers, 11th Edition, New Delhi, 2013.
2) Jain M.K., Iyengar. S.R.K., and Jain. R.K, Numerical Methods for Scientific and EngineeringComputation, New Age International Publishers, New Delhi, 2015.
3) Chapra. S.C., and Canale.R.P., Numerical Methods for Engineers, Tata McGraw Hill,7th Edn, NewDelhi, 2015.

REFERENCES:

1) Sankara Rao. K., Numerical methods for Scientists and Engineers, Prentice Hall of India, 3rd Edition,New Delhi, 2007.
2) Gerald. C. F., and Wheatley. P. O., Applied Numerical Analysis, Pearson Education, Asia, New Delhi,2009.
3) Venkataraman. M.K. Numerical Methods in Science and Engineering, National Publishers, 2001.
4) Kandasamy. K., Thilagavathy. K., and Gunavathi. K., Numerical Methods, S. Chand & Company Ltd.,New Delhi, 2008.
5) Sastry, S.S., "Introductory Methods of Numerical Analysis", Prentice Hall of India, 2010.

WEBLINKS

1. https://nptel.ac.in/courses/111/107/111107105/
2. https://nptel.ac.in/courses/111/107/111107063/

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2									2		
CO2	3	3	2									2		
CO3	3	3	2											
CO4	3	3	2	2										
CO5	3	3	2	2										

CH22401	HEAT TRANSFER	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

- To enable the students to learn the fundamental concepts of heat transfer conduction, convection, radiation, boiling, evaporation, and condensation.

To use these fundamentals in typical engineering applications in heat transfer equipments like evaporator and heat exchangers.

UNIT I	HEAT TRANSFER BY CONDUCTION	9

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, spheres - Heat conduction through a series of resistances - Thermal conductivity measurement; effect of temperature on thermal conductivity; Heat transfer in extended surfaces.

UNIT II	HEAT TRANSFER BY CONVECTION	9

Concepts of heat transfer by convection - Natural and forced convection, Buckingham Pi Theorem, Dimensional analysis in heat transfer, heat transfer coefficient for flow through a pipe, flow past flat plate, and flow through packed beds. Application for developing semi - empirical non- dimensional correlation for convection heat transfer.

UNIT III	HEAT TRANSFER WITH PHASE CHANGE	9

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, Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling and film boiling.

UNIT IV	EVAPORATION AND RADIATION HEAT TRANSFER	9

Theory of evaporation - single effect and multiple effect evaporation Thermal design calculation for single and multiple effect evaporation. Radiation heat transfer - Black body radiation, Emissivity, Stefan - Boltzman law, Plank‟s law, radiation between surfaces – Concepts of shape factor, Heat exchange between grey bodies – Radiation exchange between non-black surfaces, radiation shields.

UNIT V	DESIGN OF HEAT EXCHANGERS	9

Classification of heat exchangers - overall and individual film coefficients heat transfer coefficient and fouling factor - Concepts of LMTD, and NTU methods - plate heat exchangers; use of correction factor charts; heat exchangers effectiveness; - Chart for different configurations - Fouling factors.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Impart knowledge on the various modes of heat transfer and apply conduction heat transfer concept	**3**
CO2.	Apply convective heat transfer concept to fluids without phase change	**3**
CO3.	Develop the ability to model and analyze heat transfer processes with phase change	**4**
CO4.	Apply the concepts of evaporation to estimate steam economy, capacity of singleand multiple effect evaporators	**3**
CO5	Apply thermal analysis of heat exchanger using LMTD and NTU method and designheat exchanger	**4**

TEXT BOOKS:

1) Binay K. Dutta, "Heat Transfer Principles and applications" Prentice Hall of India Pvt.Ltd.
2) Holman, J. P., „Heat Transfer", Eighth Edition., Tata McGraw Hill, 1997
3) Coulson, J.M. and Richardson, J.F., "Chemical Engineering", Vol. I, Fourth Edition., Asian Books Pvt. Ltd., India, 1998.

REFERENCES:

1. Kern, D.Q., "Process Heat Transfer ", McGraw-Hill, 1999
2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", Seventh Edition., McGraw-Hill, 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	2	3	1	1	3	2	2	2	3	3	3
CO2	3	3	2	2	3	1	1	3	2	2	2	3	3	3
CO3	3	3	2	2	3	1	1	3	2	2	2	3	3	3
CO4	3	3	2	2	3	1	1	3	2	2	2	3	3	3
CO5	3	3	2	2	3	1	1	3	2	2	2	3	3	3

CH22402	MASS TRANSFER I	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

1. To understand the diffusion mechanism in fluids and solids.
2. To understand the role of mass transfer coefficients in design calculations.
3. To understand the mechanism of humidification operations.
4. To understand the drying operations used in chemical and allied industries.
5. To design a crystallizer for a suitable purpose.

UNIT I	DIFFUSION	9

Molecular diffusion in gases and liquids, measurement and calculation of diffusivities, steady state diffusionin multicomponent mixtures. Diffusion in solids, molecular and Knudsen diffusion in porous solids, unsteady state diffusion in solids.

UNIT II	MASS TRANSFER COEFFICIENTS	9

Eddy diffusion, concept of mass transfer coefficients, theories of mass transfer, different transport analogies, application of correlations for mass transfer coefficients, inter phase mass transfer, relationship between individual and overall mass transfer coefficients. NTU and NTP concepts, Stage-wise and differential contractors.

UNIT III	HUMIDIFICATION	9

Humidification – Equilibrium, humidification operations; theory and types of cooling tower, dehumidifiers and humidifiers using enthalpy transfer unit concept.

UNIT IV	DRYING	9

Drying Theory and Mechanism, Drying Characteristics, Estimation of Drying time, drying rate curve, Classification of Driers, Through circulation driers design, Design of driers, Description and Application of Driers, Analysis of continuous driers.

UNIT V	CRYSTALLISATION	9

Crystallization - Equilibrium, classification of crystallizers, mass and energy balance; kinetics of crystallization – nucleation and growth; design of batch crystallizers; population balance model and design of continuous crystallizers.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply the principles of diffusion in measuring diffusivity.	**3**
CO2.	Calculate different types of Mass transfer co-efficient and identify the relation between them.	**3**
CO3.	Apply mass transfer concepts in designing humidification units.	**3**
CO4.	Calculate rate of drying using Mass transfer concepts.	**3**
CO5	Apply mass transfer concepts in designing crystallization units.	**3**

TEXT BOOKS:

1. Treybal, R.E., "Mass Transfer Operations", Third Edition, McGraw-Hill, 1981.
2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", Seventh Edition., McGraw-Hill, 2005.
3. Geankoplis, C.J., "Transport Processes and Separation Process Principles Includes Unit Operations", Fourth Edition, Prentice Hall Inc., New Jersey, 2003

REFERENCES:

1. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II, Fourth Edition, Asian Books Pvt. Ltd., India, 1998
2. Foust A.S, "Principles of Unit Operations", Second Edition, John Wiley, 2008
3. Seader J.D & Henley E.J, "Separation Process Principles", Second Edition, John Wiley, 2006.
4. E.L. Cussler, "Diffusion, Mass Transfer in Fluid Systems", Second Edition, Cambridge University Press, 1997

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3		1									3	3
CO2	3	3		2									3	3
CO3	3	3		3		2	2	2				2	3	3
CO4	3	3		3		2	2	2				2	3	3
CO5	3	3	2	3		2	2	2				2	3	3

CH22403	CHEMICAL REACTION ENGINEERING I	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

- To study the kinetics of chemical reactions and the analysis of kinetic data
- To design a suitable reactor for single and multiple reaction schemes
- To study the non-isothermal operation of reactors
- To impart knowledge on residence time distribution studies in non-ideal flow reactors

UNIT I	KINETICS AND ANALYSIS OF EXPERIMENTAL KINETIC DATA	9

Overview of Chemical Reaction Engineering - Kinetics of homogeneous reactions - Elementary and Non-elementary reactions - Theories on reaction rates - Temperature dependence of rate constants- Activation Energy and Arrhenius Equation - Kinetics of Bio-Chemical Reactions: Michaelis Menton model; Auto-catalytic reactions. , Analysis of experimental kinetics data, integral and differential analysis.

UNIT II	IDEAL REACTOR DESIGN FOR HOMOGENEOUS SINGLE REACTIONS	9

Performance equations for ideal batch, Plug flow, Back-mix flow and semi batch reactors for isothermal condition, Size comparison of single reactors, Multiple-reactor systems, Recycle reactor.

UNIT III	MULTIPLE REACTIONS	9

Parallel reactions of different orders: Yield and selectivity, Product distribution and design for single and multiple reactors - Series reactions: first-order reactions and zero-order reactions.

UNIT IV	TEMPERATURE EFFECTS FOR SINGLE AND MULTIPLE REACTIONS	9

Thermal stability of reactors and optimal temperature progression for first order reversible reactions – Equilibrium conversion - Adiabatic and heat regulated reactors, Multiple Steady States in Continuous Stirred Tank Reactor (CSTR) - Design of non-isothermal reactors.

UNIT V	NON – IDEAL FLOW REACTORS	9

Concept of residence time distribution (RTD), Measurement and moments of RTD, RTD in batch reactors, Plug Flow Reactor and CSTR. Zero Parameter Model: One parameter model: Tanks in series model and Dispersion Model.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyze kinetic data and determine the rate of the reaction.	**4**
CO2.	Design ideal reactors for homogeneous reactions	**6**
CO3.	Evaluate reactor systems to carry out multiple reactions and recommend reactor/combination of reactors for the yield of desired product.	**5**
CO4.	Discuss the temperature effects and design non-isothermal reactors	**6**
CO5	Develop mathematical models for conversion in non-ideal flow reactors	**6**

TEXT BOOKS:

1) H.S. Fogler,Elements of Chemical Reaction Engineering, Prentice Hall of India Ltd., 2016.
2) O. Levenspiel,Chemical Reaction Engineering,Wiley Eastern Ltd., 2006.

REFERENCES:

1) J.M. Smith, Chemical Engineering Kinetics,McGraw Hill, 1981.
2) Keith, J. Laidler, Chemical Reaction kinetics, Pearson Education Asia,2004.
3) G. F. Froment, K. B. Bischoff and J. De Wilde, Chemical Reactor Analysis and Design, John Wiley&Sons, 1979.
4) M.E.Davis, R.J.Davis,Fundamentals of Chemical Reaction Engineering**,** McGraw Hill, 2003.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	3	3	3			1	1	1	3	3
CO2	3	3	3	3	3	3	3			1	1	1	3	3
CO3	3	3	3	3	3	3	3			1	1	1	3	3
CO4	3	3	3	3	3	3	3			1	1	1	3	3
CO5	3	3	3	3	3	3	3			1	1	1	3	3

CH22404	INSTRUMENTAL METHODS OF ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To enable the students to acquire knowledge in the field of various instruments which are used in the analysis of products in various chemical industries.

UNIT I	FUNDAMENTALS OF SPECTRAL ANALYSIS	9

Spectral Analysis: principle, electromagnetic radiation-regions, properties and interaction with matter, classification of instrumental methods based on physical properties; Colorimetric analysis: Beer-Lambert's Law, Instrumentation, Real Limitations, Apparent Chemical Deviations, Application, Nesslerimetry and Duboscq colorimetry, Estimation of inorganic ions such as Ni and Nitrite by Colorimetry; UV-Visible and IR spectroscopy: Instrumentation and application, Solvent effects, Various electronic transitions involved in organic molecules, Characterization, Chromophore concept, Effects of auxochromes and effects of conjugation on the absorption maxima, Modes of molecular vibrations, Mull and Pressed Pellet Technique; Woodward-Fischer rules for the calculation of absorption maxima.

UNIT II	ELECTROMETRIC METHODS	9

Conductometric Titrations: Instrumentation, Types, Limitations, Specific-Equivalent-Molecular conductance, Advantages& Application; Potentiometric Titrations: Instrumentation, Types, Advantages & Application; Measurement of pH: Instrumentation, Calibration method, Applications; Ion selective electrodes and types: Electrode setup - Applications; Amperometric titrations: Principle, instrumentation, Application.

UNIT III	IMPORTANT SPECTROSCOPIC METHODS OF ANALYSIS	9

Atomic Absorption Spectroscopy (AAS): Principle, Instrumentation, absorbance-concentration relationship, Interference and Applications; Emission Spectroscopy: Flame Photometry and Inductively coupled Plasma Atomic Emission spectroscopy (ICP-AES)- Principle, Instrumentation, Advantages& Applications;Polarimetry: Principle, Instrumentation and Applications; Refractometry: Principle, Snell's law, Instrumentation, Types and Applications; Nephlometry and Turbidimetry: Principle, Instrumentation and Applications.

UNIT IV	MAGNETIC RESONANCE SPECTROSCOPY & MASSSPECTROMETRY	9

Absorption spectrum-emission spectrum; Magnetic resonance spectroscopy: Theory of NMR, environmental effect on NMR spectra, Modes of Nuclear Spin, Chemical shift, NMR spectrometers, applications of 1H and 13C NMR, Application; Molecular Mass Spectrum: Ion sources, Mass spectrometer, applications of molecular mass spectrometry, Electron Paramagnetic Resonance (EPR) – g values, instrumentation and applications.

UNIT V	X-RAY METHODS AND SURFACE MICROSCOPY	9

Mosley law, Continuous and Discontinuous spectra, X-ray instrumentation, X-ray detection and measurement, The Laue method of analysis, Bragg"s law, Diffraction of X-rays, Production and detection of X-rays – Debye Scherrer method. Study of surfaces: Scanning electron Microscopy, Transmission Electron Microscopy (TEM), Energy Dispersive X-ray (EDX) microanalyzer, Scanning probe microscopes,Scanning Tunnelling Microscope (STM) and Atomic Force Microscope (AFM).

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply knowledge on the fundamental concepts and various terms in electromagnetic radiations and absorption spectroscopy.	**3**
CO2.	Arrive at the knowledge in the various analytical instruments which are based on electrical property of compounds.	**4**
CO3.	Obtain familiarity on various properties of liquid materials and the instruments used to measure these properties	**3**
CO4.	Investigate the applications of spectroscopic techniques in Chemical Industry.	**4**
CO5	Analyze the modern techniques which are used in nanoscience.	**3**

TEXT BOOKS:

1) D.A.Skoog, D.M.West, F.J.Holler and S.R.Crouch, "Fundamentals of Analytical Chemistry", NinthEdition, Brooks / Cole, Cenage Learning, 2014.
2) B.K.Sharma, "Instrumental Methods of Chemical Analysis", Twenty Eighth Edition, Goel PublishingHouse, 2012.

REFERENCES:

1) H.H.Willard, I.I.Merritt, J.A.Dean and F.A.Settle, "Instrumental Methods of Analysis", SeventhEdition, Pearson Education, 2002.
2) H.Kaur, "Instrumental Methods of Chemical Analysis", Eighth Edition, Pragati Prakashan Publishers,2012.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1	1	1	3	2	1	1	1	1	1	2	2	2
CO2	3	1	3	2	3	-	-	1	1	1	-	2	1	1
CO3	2	2	3	1	3	2	-	-	1	-	-	1	1	1
CO4	2	1	1	1	1	1	1	-	1	-	1	2	1	1
CO5	3	3	1	1	3		2	1	1	1	1	1	2	2

CH22408	CHEMICAL ENGINEERING THERMODYNAMICS II:THEORY AND PRACTICE	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES: Determine thermodynamic properties of gaseous mixtures, Solutions and also to evaluate heat effectsinvolved in industrial chemical processes

UNIT I	SOLUTION THERMODYNAMICS	6+6

Fundamental property relation, Chemical potential, Partial properties, The ideal gas mixture model, The idealsolution model, Excess properties.

Practical - Prediction of Heat of solution by solubility method.

UNIT II	APPLICATIONS OF SOLUTION THERMODYNAMICS	6+6

Activity coefficient, Excess Gibbs Energy, Models for the excess Gibbs energy, Property changes of mixing, Heateffects of mixing process. Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity.

Practical – Vapour liquid equilibrium studies of an Ideal Binary system

UNIT III	PHASE EQUILIBRIUM	6+6

Application of phase rule - vapour-liquid equilibrium, phase diagrams for homogeneous systems and for systems with a miscibility gap - effect of temperature and pressure on azeotrope composition - liquid-liquid equilibrium - ternary liquid-liquid equilibrium.

Practical – Prediction of azeotropic composition and VLE data by vanlaar model

UNIT IV	CORRELATION AND PREDICTION OF PHASE EQUILIBRIA	6+6

Activity coefficient-composition models - thermodynamic consistency of phase equilibria - application of the correlation and prediction of phase equilibria in systems of engineering interest particularly to distillation and liquid extraction processes.

Practical – Validating Thermodynamic consistency test using othmer VLE still

UNIT V	CHEMICAL REACTION EQUILIBRIA	6+6

Standard free energy change and reaction equilibrium constant - evaluation of reaction equilibrium constant -prediction of free energy data - calculation of equilibrium compositions for homogeneous chemical reactors.

Practical – Determination of equilibrium constant

TOTAL:L 30+P 30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify the partial Molar property of solutions upon mixing.	**3**
CO2.	Envisage the equilibrium between phases in multicomponent systems and Excess propertyof solutions.	**4**
CO3.	Explore and generate the phase diagram data to find the effect of temperature and pressureon azeotropic conditions.	**4**
CO4.	Apply knowledge on various models used to evaluate the equilibrium data to test thethermodynamic consistency.	**4**
CO5	Identify and calculate the equilibrium constant for various systems	**4**

TEXT BOOKS:

M. Smith, H.C. Van Ness and M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, Seventh edition, McGraw-Hill International Edition,2005.

REFERENCES:

1. K. V. Narayanan, A Textbook of Chemical Engineering Thermodynamics, Prentice Hall of India,2001
2. B. G. Kyle, Chemical and Process thermodynamics. Second Edition., Prentice Hall of India,2000
3. M J Moran, H N Shapiro, D Boettner and M B Bailey, Principles of Engineering Thermodynamics, EighthEdition, Wiley

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3	3	1	2	3	2	2	2	1	3	3
CO2	3	3	3	3	3	1	2	2	2	2	1	1	3	3
CO3	2	2	2	2	2	1	2	2	2	1	2	1	3	3
CO4	3	3	3	3	3	2	2	3	2	1	2	1	3	3
CO5	3	3	3	3	3	1	2	1	1	1	2	2	3	3

GE22451	ENVIRONMENTAL SCIENCES AND SUSTAINABILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To study the nature and facts about environment, energy flow in an ecosystem and biodiversity.
2. To study the various types, causes of pollution, its control and solutions to environmental problems.
3. To study and understand the various types of renewable sources of energy and its applications.
4. To know the importance of sustainability management and practices
5. To learn the importance of zero waste concept and green engineering for environmental management.

UNIT I	ENVIRONMENT AND BIODIVERSITY	9

Definition, scope and importance of environment – need for public awareness. Eco-system and Energy flow– food chains, food webs and ecological pyramids, ecological succession. Biodiversity- types- genetic, species and ecosystem diversity– values of biodiversity, India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: fragmentation and habitat loss, poaching of wildlife, human-wildlife conflicts – endangered and endemic species of India –conservation of biodiversity: In-situ and ex-situ.

UNIT II	ENVIRONMENTAL POLLUTION	9

Definition, causes, effects and preventive measures of air, water and soil pollutions. Marine and thermal pollution - causes, effects and control measures. Light and noise pollution-effect on flora and fauna. Nuclear pollution- Sources, effects and control measures. Disposal of radioactive wastes (Nuclear hazards). Pollution case studies. Role of an individual in prevention of pollution. Solid, hazardous and E-waste management. Occupational health and safety management system (OHASMS). Environmental protection, Environmental protection acts, categorization of spices according to IUCN.

UNIT III	RENEWABLE SOURCES OF ENERGY	9

Energy resources: Growing energy needs, Non renewable resources – types, uses. Energy management and conservation - New energy sources, Need of new sources - geo suitability of establishing renewable energy sources, different types new energy sources. Applications of hydrogen energy, ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal energy. Role of an individual in conservation of energy.

UNIT IV	SUSTAINABILITY AND MANAGEMENT	9

Development, GDP, Sustainability- concept, needs and challenges-economic, social and aspects of sustainability-from unsustainability to sustainability-millennium development goals, and protocols, Sustainable Development Goals-targets, indicators and intervention areas - Principles of green chemistry, Climate change-Global, Regional and local environmental issues and possible solutions-case studies - Role of non-governmental organization, Concept of carbon credit, carbon footprint - Environmental management in industry-A case study,

UNIT V	SUSTAINABILITY PRACTICES	9

Zero waste and R concept, circular economy, ISO 18000 series, material life cycle assessment, environmental impact assessment. Wasteland reclamation, Sustainable habitat: green buildings, green materials, energy efficiency and energy audit, sustainable transports. Energy cycles, carbon cycle, emission and sequestration, Green engineering: sustainable urbanization- socio-economical and technological change. Rain water harvesting, watershed management, environmental ethics: Issues and possible solutions.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Describe the importance of ecosystems, biodiversity and its conservation.	3
CO2.	Classify the different types of pollution, their effects and control measures.	4
CO3.	Implement the energy management and conservation.	4
CO4.	Describe the sustainable development, its importance and social issues like climate change	3
CO5	Recognize the importance of zero waste concept, circular economy, EIA and Green engineering for environmental management.	4

TEXT BOOKS:

1.AnubhaKaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 7th Edition, NewAge International Publishers,2022.

2.Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016.

3. Gilbert M.Masters, 'Introduction to Environmental Engineering and Science', 2nd edition,Pearson Education, 2004.

4.Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Pearson.2011.

5.Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design anddevelopment, CL Engineering, 2015.

6Environment Impact Assessment Guidelines, Notification of Government of India, 2006.

7 Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.

REFERENCES:

1.R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38

2.Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House,Mumbai, 2001.

3.Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.

4.Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 3rd edition, 2015.

5.Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient BlackswanPvt. Ltd. 3rd edition,2021.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3					3	3							
CO2	3					3	3							
CO3	3	1	1			3	3							
CO4	3					3	3	3				1		
CO5	3					3	3	3				1		

CH22411	MOMENTUM TRANSFER LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

- The students will learn experimentally to calibrate flow meters
- Find pressure loss for fluid flows across various pipes beds
- Determine Performance characteristics of different types of pumps.

LIST OF EXPERIMENTS:

1) Calibration of Orifice and Venturimeter
2) Calibration of Rotameter
3) Calibration of V-Notch
4) Efflux time test rig – Open drum orifice and draining time
5) Flow through straight pipe
6) Flow through annular pipe
7) Flow through helical coil
8) Flow Through spiral coil
9) Losses in pipe fittings and valves
10) Performance characteristics of Centrifugal pump
11) Performance characteristics of Reciprocating pump
12) Performance characteristics of Gear pump
13) Pressure drop studies in packed column
14) Hydrodynamics of fluidized bed
15) Drag coefficient of solid particle
16) Velocity Measurement using Pitot Tube
17) Reynolds Experiment

***Minimum of 10 Experiments to be offered**

LIST OF EQUPMENTS:

1) Orificemeter
2) Venturimeter
3) Rotameter
4) V-Notch
5) Efflux time test rig
6) Straight pipe

7) Annular pipe
8) Helical coil
9) Spiral coil
10) Fittings and valves
11) Centrifugal pump
12) Reciprocating pump
13) Gear pump
14) Packed column
15) Fluidized bed
16) Drag Column
17) Pitot Tube
18) Reynolds Experiment

TOTAL: 30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Demonstrate practical understanding of various theoretical fluid flow properties	3
CO2.	Utilize basic flow and pressure measurement techniques for fluid flow	3
CO3.	Demonstrate practical understanding of friction losses in internal flows	3
CO4.	Discuss the differences among measurement techniques, their relevance and applications	3
CO5	Compare the results of analytical models with the actual behavior of real fluid flows	3

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	1	1	2	1	1	3	1	2	1	3	3
CO2	3	2	1	3	2	2	1	1	2	1	2	1	3	3
CO3	2	3	2	2	1	2	1	1	2	2	2	1	3	3
CO4	3	3	3	2	2	2	2	2	3	2	1	2	3	3
CO5	2	3	2	3	2	2	2	1	1	1	2	1	3	3

CH22412	MECHANICAL OPERATIONS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES: To enable the students to develop a sound working knowledge on different types of crushing equipment andseparation studies using different mechanical filters and separators

LIST OF EXPERIMENTS

1. Screen Effectiveness
2. Size Analysis
3. Jaw Crusher
4. Ball mill
5. Roll Crusher
6. Drop weight crusher
7. Leaf filter
8. Plate and Frame Filter press
9. Batch Sedimentation Test
10. Sub- Sieve Analysis - Beaker decantation
11. Cyclone separator
12. Air Elutriator
13. Air Permeability
14. Mixing Index

*Minimum 10 experiments shall be performed

LIST OF EQUIPMENTS

1. Gyratory Sieve shaker & Sieves
2. Air Permeability apparatus.
3. Jaw Crusher
4. Ball Mill
5. Roll Crusher
6. Drop Weight Crusher
7. Leaf filter
8. Plate and Frame Filter Press
9. Cyclone Separator
10. Air Elutriator

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply knowledge of various mechanical operations	3
CO2.	Analyse the practical importance of crushing, grinding and size separation ininorganic process industry	4
CO3.	Relate the theoretical and practical concepts used in industry	4
CO4.	Evaluate the working of equipment used for mechanical operations.	5
CO5	Develop the skill to operate filter, screens, sedimentation tank, crusher, mill.	6

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2	3	2	1	2	1	1	1	1	1	3	3
CO2	3	3	3	3	3	1	2	1	1	2	1	1	3	3
CO3	3	3	2	2	2	1	1	1	1	1	2	2	3	3
CO4	2	2	3	2	1	1	1	1	1	3	2	2	2	2
CO5	3	3	3	3	2	1	1	1	1	3	2	2	2	2

SEMESTER V

CH22501	MASS TRANSFER II	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

To provide the basic principles on thermodynamics and mass transfer

UNIT I	ABSORPTION	9

Gas Absorption and Stripping – Equilibrium; material balance; limiting gas-liquid ratio; tray tower absorber - calculation of number of theoretical stages, tray efficiency, tower diameter; determination of height of packing using HTU and NTU calculations

UNIT II	DISTILLATION	9

Vapour liquid equilibria - Raoult's law, vapor-liquid equilibrium diagrams for ideal and non-ideal systems, enthalpy concentration diagrams. Principle of distillation - flash distillation, differential distillation, steam distillation, multistage continuous rectification, Number of ideal stages by Mc.Cabe - Thiele method, Total reflux, minimum reflux ratio, optimum reflux ratio. Introduction to azeotropic and extractive distillation- Introduction to Multicomponent distillation.

UNIT III	LIQUID-LIQUID EXTRACTION	9

Liquid - liquid extraction - solvent characteristics-equilibrium stage wise contact calculations for batch and continuous extractors- differential contact equipment-spray, packed and mechanically agitated contactors and their design calculations-packed bed extraction with reflux. Pulsed extractors, centrifugal extractors.

UNIT IV	LEACHING	9

Leaching-Theory, Mechanism, Types of leaching, Solid - Liquid equilibria- Introduction to Batch and continuous extractors- Equipments and industrial applications.

UNIT V	ADSORPTION AND OTHER SEPARATION PROCESS	9

Adsorption - Types of adsorption, nature of adsorbents, adsorption equilibria, effect of pressure and temperature on adsorption isotherms, Adsorption operations - stage wise operations, steady state moving bed and unsteady state fixed bed adsorbers, break through curves. Solid membranes; concept of osmosis; reverse osmosis; electro dialysis; ultrafiltration.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply mass and energy balances to analyze absorption processes.	4
CO2.	Apply distillation principles and analyze complex distillation problems to identify appropriate solutions.	4
CO3.	Apply liquid-liquid extraction principles and analyze Engineering problems	4
CO4.	Apply mass and energy balances to analyze solid-liquid extraction processes.	4
CO5	To analyze various types of adsorption equipment and apply Membrane Separation Fundamentals.	4

TEXT BOOKS:

1. R. E.Treybal, Mass Transfer Operations, Third Edition, McGraw Hill, New Delhi, 1983.
2. W.L. McCabe, J. Smith and P. Harriot, Unit Operations in Chemical Engineering, Seventh Edition, Tata McGraw Hill, India, 2014.
3. C. J. Geankopolis, "Transport Processes in Chemical Operations", Fourth Edition., Prentice Hall of India, New Delhi, 2004

REFERENCES:

1. M. Coulson and J. F. Richardson, "Chemical Engineering.", Vol - II, Fifth Edition., Pergamon Press, New York, 2002
2. N. Anantharaman and K.M.Meera Sheriffa Begum, "Mass Transfer Theory and Practice", Prentice Hall of India Pvt. Ltd., New Delhi, 2013.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3			2	2	2	2	2		3	3	3
CO2	3	3	3			2	2	2	2	2		3	3	3
CO3	3	3	2			2	2	2	2	2		3	3	3
CO4	3	3	2			2	2	2	2	2		3	3	3
CO5	3	3	2			2	2	2	2	2		3	3	3

CH22502	CHEMICAL REACTION ENGINEERING – II	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

To enable the students to learn the heterogeneous noncatalytic and catalytic reactions and reactors.

UNIT I	CATALYSIS	9

Catalysis: Nature of catalysis, methods of evaluation of catalysis, factors affecting the choice of catalysts, promoters and inhibitors. Catalyst preparation. Adsorption isotherms, surface area and pore-volume distribution, catalyst poison, mechanism and kinetics of catalyst, deactivation.

UNIT II	HETEROGENEOUS REACTIONS	9

Rate equations for heterogeneous reactions, rates of adsorption and desorption, surface reaction analysis of rate equation and rate controlling steps.

UNIT III	GAS-SOLID CATALYTIC REACTIONS	9

Diffusion within catalyst particle, effective thermal conductivity, mass and heat transfer within catalyst pellets, effectiveness factor, internal and external transport processes, non-isothermal systems, effectiveness factor, Thiele Modulus, fixed bed reactors.

UNIT IV	GAS-SOLID NON-CATALYTIC REACTIONS	9

Models for explaining kinetics, volume and surface models, controlling resistances and rate controlling steps, time for complete conversion for single and mixed sizes, fluidized and static reactors.

UNIT V	GAS-LIQUID REACTIONS	9

Absorption combined with chemical reactions; mass transfer coefficients and kinetic constants; application of film, penetration and surface renewal theories; Hatta number and enhancement factor for first order reaction, tower reactor design. Design of multiphase reactors: Fluidized bed reactor, trickle bed reactor and slurry reactor.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Estimate the catalyst properties and characterization	3
CO2.	Evaluate the rate equations for heterogeneous reactions.	4
CO3.	Analyze the role of transport effects in isothermal heterogeneous reactions	4
CO4.	Determine an optimal model and predict the rate limiting step for heterogeneous reactions	4
CO5	Employ a qualitative discussion of absorption involved reactions based on mass transfer theories, identifying the nature of reactions.	4

TEXT BOOKS:

1) Levenspiel, O., "Chemical Reaction Engineering ", Third Edition, John Wiley, 2014.
2) Smith J.M., "Chemical Engineering Kinetics ", 3rd Edition, McGraw-Hill, New York, 2014.

REFERENCES:

1) Fogler. H. S. "Elements of Chemical Reaction Engineering ", 4th Edition, Prentice Hall of India, 2010.
2) Froment G.F & K.B. Bischoff, "Chemical Reaction Analysis and Design", 3rd Edition, John Wiley and Sons, 2011.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2			3	3	2	2	3		3	3	3
CO2	3	3	3			3	3	2	2	3		3	3	3
CO3	3	3	3			3	3	2	2	3		3	3	3
CO4	3	3	3			3	3	2	2	3		3	3	3
CO5	3	2	2			3	3	2	2	3		3	3	3

CH22503	PROCESS INSTRUMENTATION DYNAMICS AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

This course will enable the students to compute the response of various control strategies for different process dynamics.

UNIT I	PRINCIPLES OF MEASUREMENT	9

Introduction to measurement and instrumentation - Transducer function and types – Static and Dynamic characteristics of measuring devices – Types and principle of temperature transmitter – Types and principle of pressure transmitter - Types and principle of level transmitter - Types and principle of flow transmitter

UNIT II	TRANSIENT RESPONSE OF OPEN LOOP SYSTEM	9

Introduction to process control – Review of Laplace transforms principles – Transfer function for chemical system- Standard input functions – Transient response and characteristic of first and second order system – Linearization of nonlinear system

UNIT III	DEVELOPMENT OF FEEDBACK CONTROL SYSTEM	9

Feedback control, Elements of control system and development of block diagram - Controller types and transfer function – Principles of pneumatic and electronic controller – Pneumatic control valves and transfer function – Transportation lag.

UNIT IV	ANALYSIS OF CLOSED LOOP SYSTEM	9

Closed loop system, Servo and regulator mechanism problems – reduction of feedback control loop – dynamic response of closed loop system; Stability analysis: Routh test and Root locus diagram.

UNIT V	FREQUENCY RESPONSE ANALYSIS AND ADVANCED CONTROL SYSTEM	9

Introduction to frequency response – frequency response characteristic – Bode diagram – Bode stability criterion – Phase margin and gain margin – Tuning of controller setting : Ziegler-Nichols and Cohen-Coon method; Advanced control systems : principle and applications of cascade, ratio and feed forward control

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify various measuring instruments and transmitters used in process industries	3
CO2.	Illustrate the response of first and second order systems	3
CO3.	Apply the principle and describe the types of controllers and control elements for different applications.	3
CO4.	Analyze the closed loop control systems to determine the transient response, offset and their stability	4

CO5	Assess the frequency response of closed loop systems and describe the advanced control strategies	4

TEXT BOOKS:

1. Singh S K, Industrial Instrumentation and control, 3rd Ed., Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2013.

2. Donald R. Coughanowr, "Process Systems Analysis and Control", 3ed Ed, McGraw Hill, New York, 2013.

REFERENCES:

1.Stephanopoulos S.G, "Chemical Process Control: An Introduction to Theory and Practice", 1st Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2012

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3	3	3	3	2	2	3	2	3	3	2
CO2	3	3	2	2	3	3	3	2	2	2	3	3	3	2
CO3	3	3	2	3	2	3	2	2	2	2	3	3	3	2
CO4	3	3	2	3	3	3	3	2	2	2	3	3	3	2
CO5	3	3	2	3	3	3	3	2	2	2	2	3	3	2

CH22504	CHEMICAL PROCESS INDUSTRIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To gain knowledge on various aspects of production engineering and understand the practical methods of production in a chemical factory

UNIT I	**Alkalies and Acids**	9

Alkalies : Chlor - alkali Industries: Manufacture of Soda ash, Manufacture of caustic soda and chlorine, common salt. Acids: Mining of sulphur and manufacture of sulphuric acid. Manufacture of hydrochloric acid.

UNIT II	**Fertilisers**	9

Nitrogen industries: ammonia, nitric acid, urea. Phosphorus industries: Phosphorus, Phosphoric acid, Super Phosphate. Potassium Industries: Potassium chloride, Potassium Sulphate. Bio-fertilizers, pesticides, herbicides. Applications of fertilisers

UNIT III	**Gases, Cement, Glasses, and Paints**	9

Fuel Gases: Producer gas, Water gas, Coke oven gas, Natural gas, Liquefied natural gas. Industrial gases: Carbon dioxide, hydrogen, nitrogen and oxygen. Cement: Types and manufacture of Portland cement. Glasses: Types and Manufacture of glasses. Manufacture of paints and Pigment.

UNIT IV	**Natural Products processing**	9

Pulp: Methods of production, Comparison of pulping processes. Paper: Types of paper products, raw materials, methods of production. Sugar: Methods of production, by products of the Sugar industry. Oils and Fats: Nature of Vegetable oils and animal fats, hydrogenation of oils and fatty acids. Processing of soap and detergents. Manufacture of rubbers and allied products.

UNIT V	**Petroleum , Petrochemical and Explosives**	9

Petroleum: Petroleum Refinery products. Petroleum Conversion processes: Pyrolysis, Cracking and Reforming. Petrochemicals: Methanol, acetylene and ethylene. Chemicals from Aromatics: Benzene, Toluene and Xylene. Explosives: Types of explosives, Industrial explosives, Manufacture of nitroglycerine and dynamite.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Outline about the manufacture of various alkalies and acids.	2
CO2.	Understand the production of fertilisers and its applications.	2
CO3.	Infer the manufacture of Industrial gases, Cement, Glasses, and Paints.	2
CO4.	Impart the knowledge on pulp, paper, sugar, oils, fats, soap and rubber manufacture processes.	2
CO5	Illustrate the manufacturing process in petrochemicals and explosives	2

TEXT BOOKS:

1) "Shreve's Chemical Process Industries Handbook", Fifth Edition, McGraw-Hill 1998.
2) Dryden's "Outlines of Chemical Technology", Edited and Revised by Gopala Rao. M. and M.Sittig, Second edition, Affiliated East-West press, 1993

REFERENCES:

1) "Kent and Riegel's Handbook of Industrial Chemistry and Biotechnology", Springer, 11th Edition, 2007
2) "Chemical Process Technology and Simulation", Srikumar Koyikkal, PHI Learning Ltd 2013

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2	0	0	3	3	3	2	3	3	3	3	3
CO2	2	2	2	0	0	3	3	3	2	3	3	3	3	3
CO3	2	2	2	0	0	3	0	3	2	3	3	3	3	3
CO4	2	2	2	0	0	3	3	3	2	3	3	3	3	3
CO5	2	2	2	0	0	3	3	3	2	3	3	3	3	3

CH22505	PROCESS EQUIPMENT DESIGN I	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

1. To impart the basic knowledge on the unfired pressure vessels at process industries.
2. To access the high-pressure vessel design from operational point of view.
3. To understand the importance of storage vessel design and construction at onsite.
4. To apply basic textbooks methods to preliminary design valves and common industrial equipment at Oil & Gas industry

UNIT I	DESIGN & ANALYSIS OF PRESSURE VESSEL	**12**

Codes and Standards: Unfired Pressure Vessel. Design- L/D ratio, head and thickness. Design stress: due to static and dynamic loads, elastic instability. Combined stress and theories of failures and scenarios, fatigue, brittle fracture, creep, temperature effects, radiation effect, effect on fabrication methods

UNIT II	HIGH PRESSURE VESSEL AND FIXTURES & SUPPORTS	**9**

Codes and Standards: Jacketed Vessel, Capacity, Nozzle and closures.
Flanges: Types, Flange face and Standard flanges – design. Vessel support: Saddle supports, skirt supports, bracket supports.

UNIT III	STORAGE VESSELS	**9**

Codes & Standards, Storage of fluids: storage of non-volatile fluids, storage of volatile fluids, storage of gases, design of rectangular tanks, design of tanks, nozzles and mountings, large capacity storage tanks

UNIT IV	VALVES, & FLUID MOVERS	**9**

Valves: Type and selection. Safety valves: Types and selection.
Pumps: Type, selection, performance curves, pump efficiency, NPSH, Head calculations, and power calculation.
Compressors: Type, selection, performance curves, Head calculations, and power calculations. Drivers for moving equipments

UNIT V	COMMON INDUSTRIAL EQUIPMENT DESIGN	**6**

Design of Knockout Drum, Cyclone Separator, Thickener

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Analyse the integrity of pressure vessels and access its failure.	4
CO2.	Exemplify the analysis of high pressure operated pressure vessels	3
CO3.	Analyse the design parameters of storage vessel construction	3
CO4.	Evaluate the specifications of valves and prime movers used in process industries	3
CO5	Design the common process equipment at process industries.	3

TEXT BOOKS:

1. J.M.Coulson, J.Richardson, "Chemical Engineering", Vol. 6, Asian Books Printers, Fourth edition 2005.
2. M.V. Joshi, V.V. Mahajan, "Design of Process Equipment Design", Third edition, McMillan India, 1996.

REFERENCES:

1. Indian Standard Specifications IS-803, 1962; IS-4072, 1967; IS-2825, Indian Standards Institution, New Delhi. 1969
2. R.H.Perry, "Chemical Engineers Handbook", Seventh Edition, McGraw Hill, 2004.
3. Suresh C.Maidargi ,"Chemical Process Equipment Design & Drawing, Volume 1, PHI Learning Ltd., 2015.
4. Brownell and Young, "Process Vessel Design", Wiley Eastern, 2009.
5. Ray Sinnott, Gavin Towler, Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design, Butterworth-Heinemann, 2007.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	1	1	3	2	2	3	3	2	3	3	3
CO2	3	3	2	1	1	3	2	2	3	3	2	3	3	3
CO3	3	3	2	1	1	3	2	2	3	3	2	3	3	3
CO4	3	3	2	1	1	3	2	2	3	3	2	3	3	3
CO5	3	3	2	1	1	3	2	2	3	3	2	3	3	3

CH22511	MASS TRANSFER LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

Exemplify the applications of mass transfer to different types of chemical engineering unit operations.

LIST OF EXPERIMENTS:

1. Simple Distillation
2. Steam Distillation
3. Tray Dryer
4. Liquid-Liquid Extraction
5. Diffusivity Measurement (Liquid-Air)
6. Packed Column Distillation
7. Cooling Tower
8. Diffusivity Measurement (Solid-Air)
9. Leaching Studies
10. Vapor Liquid Equilibrium
11. Rotary Dryer
12. Gas Liquid Absorption
13. Surface Evaporation
14. Batch Crystallizer

***Minimum of 10 Experiments to be offered**

LIST OF EQUPMENTS:

1. Simple distillation setup
2. Steam distillation setup
3. Tray dryer
4. Liquid-liquid extractor
5. Diffusivity Apparatus
6. Packed column
7. Cooling tower
8. Vapour Liquid equilibrium Setup
9. Rotary dryer
10. Absorption column
11. Batch Crystallizer Setup

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Demonstrate theoretical concepts for data analysis and interpretation	4
CO2.	Exemplify the experimental techniques related to mass transfer operations	4
CO3.	Perceive the various mass transfer operations with process equipments like distillation, extraction, diffusivity and drying principles	4
CO4.	To formulate the idea of the different types of interface operations.	4
CO5	Develop experimental skills and confidence in handling the equipments.	4

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2			3	3	3	2	2	3	2		3	3
CO2	3	2		3	1	3	2	2	2	3	1	2	3	3
CO3	2	2		3	2	3		2	1	2	1		3	3
CO4	1	1	2	1	1	3	2	2	1	1	1	2	3	3
CO5	1	2	2			3	2	2	3	3			3	3

CH22512	HEAT TRANSFER LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

To enable the students to develop a sound working knowledge on different types of heat transfer equipments.

LIST OF EXPERIMENTS:

1) Transient heat conduction with constant temperature
2) Transient heat conduction with constant heat flux
3) Determination of heat transfer coefficient in natural convection
4) Determination of heat transfer coefficient in forced convection
5) Determination of Stefan Boltzmann constant.
6) Determination of emissivity of a surface.
7) Shell and tube heat exchanger performance
8) Efficiency of double pipe heat exchanger
9) Performance of helical coil heat exchanger
10) Fin efficiency on bare and finned exchangers
11) Performance of open pan evaporation
12) Economy of single effect evaporator
13) Performance of Vertical and Horizontal condenser operations
14) Heat transfer through packed bed
15) Heat Transfer studies in Jacketed vessel

***Minimum of 10 Experiments to be offered**

LIST OF EQUPMENTS:

1) Conduction with Constant Heat Flux apparatus
2) Conduction with Constant Temperature setup
3) Natural convection apparatus
4) Forced Convection apparatus
5) Stefan Boltzmann apparatus

6) Emissivity measurement Setup
7) Shell and Tube Heat exchanger
8) Double Pipe Heat Exchanger
9) Helical coil heat exchanger
10) Bare and finned exchangers
11) Open Pan Evaporator
12) Single effect evaporator
13) Vertical and Horizontal condenser
14) Packed bed column setup
15) Boilers
16) Jacketed vessel

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Experiment with different modes of the heat transfer	3
CO2.	Compare the various heat exchangers performances	4
CO3.	Distinguish the theoretical models with real time experimentation	4
CO4.	Examine the application of heat transfer in various processes.	4
CO5	Analyze various methods for improvement of heat transfer efficiency.	4

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3		2	2	1	3	3		3	3	3
CO2	3	3	3	3		2	2	1	3	3		3	3	3
CO3	3	3	3	3		2	2	1	3	3		3	3	3
CO4	3	3	3	3		2	2	1	3	3		3	3	3
CO5	3	3	3	3		2	2	1	3	3		3	3	3

SEMESTER VI

CH22601	TRANSPORT PHENOMENA	L	T	P	C
		2	1	0	3

COURSE OBJECTIVES:

To enable students to relate the concepts of heat, mass and momentum transfer.

UNIT I	**FUNDAMENTALS OF TRANSPORT PHENOMENA**	**9**

Importance of Transport Phenomena; Analogous nature of transfer processes; Conservation laws; Newtonian and Non-Newtonian fluids- Rheological models; Transport properties of gases and liquids- theories, pressure and temperature effects

UNIT II	**SHELL MOMENTUM BALANCES AND VELOCITY DISTRIBUTION IN LAMINAR FLOW:**	**9**

Shell balance and boundary conditions; Momentum flux and velocity distribution in falling film, circular tube, annulus and two adjacent immiscible fluids; creeping flow around a Sphere. Equations of Continuity and Equation of Motion

UNIT III	**SHELL ENERGY BALANCES AND EQUATIONS OF CHANGE**	**9**

Heat Conduction with Electrical, Nuclear and Viscous Heat Sources; Heat Conduction - Composite Walls and Cooling Fin; Use of equations of change to solve tangential flow in an annulus with viscous Heat Generation and Transpiration cooling

UNIT IV	**SHELL MASS BALANCE AND CONCENTRATION DISTRIBUTIONS IN SOLIDS AND LAMINAR FLOW**	**9**

Diffusion - Stagnant Gas Film, Heterogeneous and Homogeneous Chemical Reactions, Falling Liquid Film (Gas Absorption); Diffusion andChemical Reaction inside a Porous Catalyst

UNIT V	**ANALOGIES OF TRANSPORT PROCESS**	**9**

Development and applications of analogies between momentum, heat and mass transfer- Reynolds, Prandtl, Von Karman and Chilton-Colburn analogies.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Comprehend the analogous nature of Transport processes; Gain insight about different rheological models andtransport properties of fluids	3
CO2.	Apply the shell momentum balance approach to determine momentum flux and velocity distribution; understandequations of continuity and motion	3
CO3.	Discover the change to solve heat transfer problems; Develop shell balance approach for conduction andconvection	3
CO4.	Develop solutions for homogeneous and heterogeneous chemical reactions by applying shell mass balance	3
CO5	Interpret the analogy between the transport processes	4

TEXT BOOKS:

1.Bird R.B., Stewart W.E. and Lightfoot E.N, "Transport Phenomena", 2nd Edition, John Wiley & Sons, USA, 2007

REFERENCES:

1.Brodkey Robert S. and Hershey Harry C., "Transport Phenomena - A united approach", 1st Edition, Brodkey Publications, United State of America, 2003.
2.Welty J.R., Wicks C. E. and Wilson R. E., "Fundamentals of Momentum, Heat and Mass Transfer", 5th Edition, John Wiley & Sons Inc, United State of America, 2007

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3	2	3	3	3	3	2	3	2	3	3
CO2	3	3	2	3	3	2	2	3	3	2	2	3	3	3
CO3	3	3	2	3	3	2	3	3	3	2	2	3	3	3
CO4	3	3	2	3	3	2	3	2	2	2	3	3	3	3
CO5	3	3	3	3	3	2	2	3	2	2	2	3	3	3

CH22608	PROCESS MODELING AND SIMULATION: THEORY AND PRACTICES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

To understand fundamental principles of process simulation, including the underlying theories and mathematical models used to simulate various engineering processes.

UNIT I	INTRODUCTION AND PARAMETER ESTIMATION	12

Introduction to process modeling and simulation, tools of simulation, approaches of simulation, planning of calculation in a plant simulation. Parameter estimation techniques in theoretical as well as numerical models.

Practice: Thermodynamic property estimations using property estimation and property analysis;

UNIT II	MODELS AND THEIR CLASSIFICATION	12

Models, need of models and their classification, models based on transport phenomena principles, alternate classification of models, population balance, stochastic, and empirical models, unit models – Case study.

UNIT III	MODELS OF HEAT TRANSFER EQUIPMENTS	12

Development of detailed mathematical models of evaporators, use of Newton Raphson method for solving evaporator problems.

Practice: Simulation of mixer, splitter, heat exchanger and reactive distillation column;

UNIT IV	MODELS OF SEPARATION PROCESSES	12

Separation of multicomponents mixtures by use of a single equilibrium stage, flash calculation under isothermal and adiabatic conditions. Tridiagonal formulation of component material balances and equilibrium relationships for distillation, absorption and extraction of multicomponents.

Practice: Simulation an ideal binary distillation column

UNIT V	MODELS OF REACTORS	12

Classification of fixed bed reactor models, one dimensional and two dimensional fixed bed reactor models, fluidized bed reactor models, bioreactor models.

Practice: Comparing the conversion efficiency of various reactors; Simulation of methane combustion reaction.

TOTAL: (L 30 + P 30) 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply simulation tools to estimate the properties of compounds by Equation of state.	3
CO2.	Analyze different types of models and their classification.	4
CO3.	Ability to develop mathematical models describing heat transfer phenomena in equipment such as heat exchangers and evaporators.	4
CO4.	Ability to analyze separation process performance based on model simulations and experimental data, including sensitivity analysis, optimization, and comparison with theoretical predictions.	4
CO5	Ability to formulate mathematical models describing the behavior of reactors, including mass and energy balances, reaction kinetics.	4

TEXT BOOKS:

1. Denn M. M., "Process Modeling", Longman, 1986.
2. Holland C. D., "Fundamentals and Modeling of Separation Processes", Prentice Hall., 1975.

REFERENCES:

1. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", 2nd Ed., McGraw Hill, 1990.
2. Najim K., "Process Modeling and Control in Chemical Engineering", CRC, 1990

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3	3	2	2	1	3	3	2	3	3	3
CO2	3	3	3	3	3	2	2	1	3	3	2	3	3	3
CO3	3	3	3	3	3	2	2	1	3	3	2	3	3	3
CO4	3	3	3	3	3	2	2	1	3	3	2	3	3	3
CO5	3	3	3	3	3	2	2	1	3	3	2	3	3	3

CH22609	PROCESS EQUIPMENT DESIGN II: THEORY AND PRACTICES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

1. To build strong foundation of parameters and properties used for preliminary design.
2. To impart the knowledge on thermal design of process equipment governed by heat transfer principles.
3. To impart the knowledge on preliminary design of process equipment governed by mass transfer principles.
4. To emphasize the culture of vigilance that needs to be incorporated while operating the process equipment at industries.

UNIT I	DESIGN BASIS, DESIGN DATA AND FLUID PROPERTIES	10

Sources of information on manufacturing processes, General sources of physical properties, Accuracy required of engineering data, Prediction of physical properties. Flow of fluids: Properties and units, pipeline networks, optimum pipe diameter, non-newtonian liquids.
Practice: Piping and Instrumentation Diagram: Codes & Symbols: IS 3232

UNIT II	HEAT TRANSFER EQUIPMENT – NO PHASE CHANGE	12

Heat Exchangers: Basic design procedure and theory, Overall heat-transfer coefficient, Fouling factors, Shell and tube exchangers: Mean temperature difference, general design considerations, Tube-side heat-transfer coefficient and pressure drop (single phase), Shell-side heat-transfer and pressure drop (single phase).
Practice: Aspen Plus Exchanger Design Rating exercise – I.

UNIT III	HEAT TRANSFER EQUIPMENT – INVOLVING PHASE CHANGE	12

Condensers: Heat-transfer fundamentals, Condensation outside horizontal tubes, Condensation inside horizontal tubes, Condensation of steam, Mean temperature difference, Pressure drop in condensers.
Reboilers: Boiling heat-transfer fundamentals, Pool boiling, Convective boiling, Design of forced-circulation reboilers.
Practice: Aspen Plus Exchanger Design Rating exercise – II.

UNIT IV	SEPARATION COLUMNS	15

Continuous distillation: Basic principles, Design variables in distillation, Design methods for binary systems, Concepts of multicomponent distillation.
Packed columns: Types of packing, Packed-bed height, Prediction of the height of a transfer unit (HTU), Column diameter (capacity), Column internals, Wetting rates.
Solvent extraction: Type of extraction, Liquid-liquid extraction, Extraction equipment Extractor design, Extraction columns.
Practice: Aspen Plus Column Internals exercise

UNIT V	SAFE OPERATION CONSIDERATIONS	11

Instrumentation and control objectives, Automatic-control schemes, Plant location and site selection, Site layout, Plant layout, Utilities, Environmental considerations.
Practice: Exercises involving Aspen HYSYS.

TOTAL: (L 30 + P 30) 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply the knowledge on the importance of design information and data and analyze its sensibility.	3
CO2.	Evaluate the basics of process design of heat transfer equipments.	4
CO3.	Design the thermal parameters for Condenser and Reboiler operation.	4
CO4.	Illustrate the process design of separating columns for facilitating mass transfer	3
CO5	Evaluate the concepts of piping and instrumentation diagram and site selection for establishing safe operating conditions	4

TEXT BOOKS:

1. J.M.Coulson, J.Richardson, "Chemical Engineering", Vol. 6, Asian Books Printers, Fourth edition 2005.
2. James R. Couper, James R. Fair & W. Roy Penney, "Chemical Process Equipment - Selection and Design", Published by Butterworth-Heinmann, 2007.

REFERENCES:

1. R.H.Perry, "Chemical Engineers Handbook", Seventh Edition, McGraw Hill, 2004.
2. S B Thakore, B I Bhatt, "Introduction to Process Engineering and Design", Tata McGraw Hill, 2007.
3. B.C.Bhattacharyya, "Introduction to Chemical Equipment Design", CBS Publishers & Distributors, New Delhi, 2003
4. User Manual, Aspen Plus, HYSYS and Aspen EDR.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	1	1	3	2	3	3	2	1	2	3	3
CO2	3	3	2	1	1	3	2	3	3	2	1	2	3	3
CO3	3	3	2	1	1	3	2	3	3	2	1	2	3	3
CO4	3	3	2	1	1	3	2	3	3	2	1	2	3	3
CO5	3	3	2	1	1	3	3	3	3	2	1	2	3	3

CH22611	CHEMICAL REACTION ENGINEERING LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

To design reactor and identify type of reactor by suiting chemical kinetics and using information from thermodynamics, heat and mass transfer and economics.

LIST OF EXPERIMENTS:

1. Kinetic studies in a Batch reactor
2. Determination of rate constant of a saponification reaction in a Semi Batch reactor
3. Kinetic studies in a Plug flow reactor
4. Determination of rate constant of a saponification reaction in a CSTR
5. Kinetic studies in a Packed bed reactor
6. Determination of rate constant of a saponification reaction in a CSTR followed by a PFR
7. Kinetic studies in Sonochemical reactor
8. RTD studies in a PFR
9. RTD studies in a Packed bed reactor
10. RTD studies in a CSTR
11. Study of temperature dependence of rate constant using CSTR.
12. RTD Studies of reactors in series
13. Demonstration of photochemical reaction
14. Demonstration of heterogeneous reaction (catalytic / noncatalytic)

***Minimum of 10 Experiments to be offered**

LIST OF EQUPMENTS:

1. Batch Reactor
2. Semi batch reactor
3. Plug flow reactor- 2 (KINETICS + RTD)
4. CSTR - 2 (KINETICS + RTD)
5. Combined reactor system
6. Packed bed reactor - 2 (KINETICS + RTD)
7. Sonochemical reactor
8. Photochemical reactor
9. Series reactor systems (CSTR, PBR)
10. Heterogeneous reactor setup
11. Temperature dependent reactor system

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Implement theoretical concepts in relevant practical experiments of Reaction Engineering.	3
CO2.	Gain the skill to solve practical problems on chemical reactions.	3
CO3.	Gain practical knowledge on homogeneous and heterogeneous reactions.	3
CO4.	Identify the concept of RTD in different reactors.	3
CO5	Design different types of reactors.	4

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	3		2		3	3	2	3	3	3
CO2	3	3	3	3	3				3	3	3	3	3	3
CO3	2	2	3	3	3				3	3	3	3	3	3
CO4	3	3	2	2	3				3	3	3	3	3	3
CO5	3	3	3	3	3				3	3	3	3	3	3

CH22612	PROCESS CONTROL LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

To study open loop, closed loop control system and its tuning experimentally

LIST OF EXPERIMENTS

1) Open loop study of first order system
2) Open loop study of second order system
3) Response of Non-Interacting level System
4) Response of Interacting level System
5) Characteristics of different types of control valves
6) Closed loop study on a level system
7) Closed loop study on a flow system
8) Closed loop study on a pressure system
9) Closed loop study on a thermal system.
10) Closed loop response of ratio control system
11) Tuning of a level system
12) Digital simulation of linear system
13) Closed loop study on a CSTR
14) Study of distributed control system

*Minimum 10 experiments shall be performed

LIST OF EQUPMENTS:

1) First order system
2) Second order system
3) Interacting Tank system
4) Non-Interacting Tank system
5) Different types of control valves for Characteristics study
6) Closed loop level Trainer
7) Closed loop Temperature Trainer
8) Closed loop flow Trainer
9) Closed loop Pressure Trainer
10) Closed loop CSTR setup
11) Level control system tuner
12) Digital simulation of linear system setup
13) Distributed control system

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify the transient response of an instrument and control valve for a forcing input	3
CO2.	Make use of the simulation to study open and closed loop responses	3
CO3.	Develop closed loop response of different processes for set point changes.	3
CO4.	Experiment with advanced controllers to study closed loop response of processes	3
CO5	Analyse controller settings for open loop systems	4

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3		3		2	2	3		3	3	2
CO2	3	3	2	3		3		2	2	3		3	3	2
CO3	3	3	2	3		3		2	2	3		3	3	2
CO4	3	3	2	3		3		2	2	3		3	3	2
CO5	3	3	2	3	1	3		2	2	2		3	3	2

HS22511	INTERVIEW AND CAREER SKILLS LABORATORY (COMMON TO ALL BRANCHES)	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES:

1. Build confidence and develop learners' language proficiency.
2. Better learners' performance in competitive examinations.
3. Improve learners' employability skills.
4. Develop entrepreneurship skills.
5. Expose learners to the use of professional English.

UNIT I	LISTENING AND SPEAKING SKILLS	12

Conversation Skills – types small talk, face to face and telephonic, formal and informal conversations – skills in presenting ideas and collating information during conference calls (one –to one and technical group / team) – academic and workplace situations – conversing with faculty/visiting faculty / guests / officials / employers and employees – group discussion – etiquette and dos and don'ts, turn taking –presentation skills – seminars and projects using digital tools; mock interview – etiquette and dos and don'ts – audio-visual interface for enhancement of listening and speaking skills. IELTS and TOEFL (Listening related exercises)

UNIT II	READING / SPEED READING, CRITICAL THINKING AND WRITING SKILLS	12

Reading Comprehension – general and scientific texts/articles/case studies from different or relevant fields of study for analysis and critical thinking; employability skills – writing job applications – cover letter accompanying résumé – types of business letters and email writing and etiquette; writing reports – statement of purpose – writing articles for publication style and format – creating blogs or company profiles – speed reading of voluminous reports / documents and exacting necessary information anD abstract preparation including dissemination. IELTS and TOEFL(Reading related exercises)

UNIT III	ENGLISH FOR PROFESSIONAL EXAMINATIONS	12

Sentences, paragraphs and reading comprehension – vocabulary building – general and technical terms – contextual meaning – spelling – subject specific words – usage and user specific terminology. IELTS and TOEFL(Grammar and verbal exercises)

UNIT IV	ENTREPRENEURSHIP SKILLS	9

Introduction to entrepreneurship - fundamentals of entrepreneurial skills - developing leadership qualities and team work;– marketing strategies microcosmic and macrocosmic levels of product sales and survey – sector / industry appraisal and appreciation (review and understanding state of the nation / economy / environment / sector reports published) interaction and understanding the role of multilateral financial / institutional / industrial agencies such as World Bank, ADB, UNDP, CII - Influencing in Business Meetings - Active Listening and responding - Role-play - Strengthening – Negotiating/ Argumentative and Persuasive Skills - Defend a character/idea or attack it. - Networking Skills - engaging strangers in a conversation - introducing themselves, making small talk.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Develop approaches for mastering international English language tests such as IETLS and TOEFL, as well as national-level competitive exams.	
CO2.	Make presentations and participate in Group Discussions.	
CO3.	Face interviews with confidence and develop strategies for negotiating job offers.	
CO4.	Build effective resumes, cover letters and professional emails to enhance job application success.	
CO5	re strategies for scaling and growing entrepreneurial ventures.	

REFERENCES:

1. *Business English Certificate Materials*, Cambridge University Press.
2. *Graded Examinations in Spoken English and Spoken English for Work* downloadable materials from Trinity College, London.
3. *International English Language Testing System Practice Tests*, Cambridge University Press.
4. *Interactive Multimedia Programs on Managing Time and Stress*.
5. *Personality Development* (CD ROM), Times Multimedia, Mumbai.

WEB SOURCES:

http://www.slideshare.net/rohitjsh/presentation on group discussion
http://www.washington.edu/doit/TeamN/present_tips.html
http://www.oxforddictionaries.com/words/writingjobapplications
http://www.kent.ac.uk/careers/cv/coveringletters.html
http://www.mindtools.com/pages/article/newCDV_34.html

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1										3				
CO2										3				
CO3										3				
CO4										3				
CO5										3				

SEMESTER VII

CH22701	PLANT DESIGN AND ECONOMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To design a chemical process plant and also analyzing the cost

UNIT I	**FUNDAMENTALS OF ENGINEERING DESIGN AND ENGINEERING FLOW DIAGRAMS**	**9**

General overall design considerations, Anatomy of chemical engineering projects, Process design codes, Standard sources of information, Plant location, Plant layout, Plant operation and control, Importance of laboratory development to pilot plant, scale up methods. Introduction to block, process flow, Logic, Information flow diagrams. Preparation of PID, trip and interlock systems, MOC and valve selection, color code of pipeline, Equipment datasheets, Layout engineering (Plot Plan).

UNIT II	**MATERIALS-HANDLING EQUIPMENT & OPTIMUM DESIGN**	**9**

Basic concepts-Piping in fluid transports processes- Pumping of fluids-Compression and expansion of fluids-Compression and expansion of fluids- Agitations and mixing of fluids-Flow measurement- Storage & containment of fluids-Transport of solids-handling of solids. Economic aspects and optimum design, practical considerations in design and engineering ethics, Break-even analysis, Optimum production rates in plant operation.

UNIT III	**PLANT DESIGN, PROCESS DESIGN CASE STUDIES**	**9**

Plant design case studies for any one of the chemical, petrochemical and polymer products: process synthesis, development of process flow diagram, mass and energy balance, P& ID diagram, use of process design software's such as COMSOL, ASPEN HYSYS, Technical project report writing

UNIT IV	**INTEREST, INVESTMENT COSTS & ESTIMATION AND PROFITABILITY**	**9**

Time Value of money; capital costs and depreciation, amortization, estimation of capital cost, manufacturing costs and working capital, capital budgeting and project feasibility. Estimation of project profitability, sensitivity analysis; investment alternatives; replacement policy; forecasting sales; inflation and its impact.

UNIT V	**ECONOMIC BALANCE AND QUALITY CONTROL**	**9**

Economic decisions in Chemical Plant - Economics of size - Essentials of economic balance –Economic balance approach, economic balance for insulation, evaporation, heat transfer.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify various flow diagrams, drawings, standards and codes involved in process design.	3
CO2.	Impart insights into the design of equipment pertaining to materials handling and optimum design of process.	3
CO3.	Classify the process design software and its applicability in industries.	3
CO4.	Apply techniques for finding project profitability, investment alternative and replacement.	3
CO5	Perform cash flow calculations, balance sheet and income statement and understand analysis of performance	3

TEXT BOOKS:

1. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Soemantri Widagdo, "Product and Process Design Principles: Synthesis, Analysis and Design", Third Edition, John Wiley & Sons, 2014
2. Guidelines for Engineering Design for Process Safety, Second Edition, Centre for Chemical Process Safety (CCPS), 2012
3. Peters, M. S. and Timmerhaus, C. D. RE West, "Plant Design and Economics for Chemical Engineers", Fourth Edition, McGraw Hill, 2008.
4. Herald Knottz and Heinz Weihrich, "Essentials of Management", Tata McGraw Hill Education Pvt. Ltd., 2010

REFERENCES:

1. James R. Cooper, "Process Engineering Economics", Marcel Delkker Inc, New York, 2003
2. Coulson, J.M., Richardson J.E. and Sinnott R.K., "Chemical Engineering", Vol. VI, Pergamon Press, 1991.
3. B.M.Suryavanshi, S.P.Singh and M.R.Joshi, "Process Economics and Project Engineering", NiraliPrakashan, First Edition, 2002.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3				2	2	2	3	3	3	3	3	3
CO2	3	3				2	2	2	3	3	3	3	3	3
CO3	3	3				2	2	2	3	3	3	3	3	3
CO4	3	3				2	2	2	3	3	3	3	3	3
CO5	3	3				2	2	2	3	3	3	3	3	3

CH22702	PROFESSIONAL ETHICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To understand and create awareness on ethical and social responsibility of an engineer and to solve ethical dilemma while discharging duties in professional life.

UNIT I	**HUMAN VALUES**	**9**

Morals, values and ethics, Integrity, Work ethics, Service learning, Civic virtue, Respect for other. Living peacefully, Caring, Sharing, Honesty, Courage, Valuing time, Cooperation. Commitment, Empathy, Self-confidence, Character, Spirituality. Introduction to Yoga and meditation for professional excellence and stress management.

UNIT II	**ENGINEERING ETHICS**	**9**

Senses of engineering Ethics, Variety of moral issues, Types of inquiry, Moral dilemmas, Moral autonomy, Kohlberg's theory, Gilligan's theory. Consensus and controversy, Models of professional roles, Theories about right action, Self-interest, Customs and religion, Uses of ethical theories. Ethics in Process safety.

UNIT III	**ENGINEERING AS SOCIAL EXPERIMENTATION**	**9**

Engineering as experimentation, Engineers as responsible experimenters, Codes of ethics, A balanced outlook on law.

UNIT IV	**ETHICS IN PROFESSIONAL SAFETY**	**9**

Process safety, Assessment of safety and risk, Risk benefit analysis and reducing risk. Ethical Reasoning, Professional Practice in Engineering, Commitment to Safety, Central Professional Responsibilities of Engineers, Workplace rights and responsibilities, Responsibility of engineer for Environmental protection and Bioethics.

UNIT V	**RIGHTS AND RESPONSIBILITIES IN ETHICS**	**9**

Respect for authority, Collective bargaining, Confidentiality, Conflicts of interest. Occupational crime, Professional rights, Employee rights, Rights and Responsibilities: Regarding Intellectual Property Rights (IPR), Engineers as Expert Witnesses and Advisors: Moral Leadership , Moral leadership, Code of conduct, Corporate social responsibility

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify the human values in the society.	3
CO2.	Select engineering ethics in the responsibilities and rights of the society.	3
CO3.	Build engineering ethics as social experimentation	3
CO4.	Apply overall knowledge of ethics in professional safety	3
CO5	Plan rights and responsibilities of professionals in the society	3

TEXT BOOKS:

1) Ethics in Engineering, Mike W. Martin and Roland Schinzinger, Tata McGraw Hill, New Delhi, 2003.
2) Engineering Ethics, Govindarajan M, Natarajan S, Senthil Kumar V. S, Prentice Hall of India, New Delhi, 2004.

REFERENCES:

1) Engineering Ethics,Charles B. Fleddermann, Pearson Prentice Hall, New Jersey, 2004..
2) Business Ethics: Decision Making for Personal Integrity and Social Responsibility, Laura P. Hartman and Joe Desjardins, Mc Graw Hill education, India Pvt. Ltd., New Delhi 2013.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1				3	3	3	3	2		3	3	3
CO2	3	1				3	3	3	3	2		3	3	3
CO3	3	1				3	3	3	3	2		3	3	3
CO4	3	1				3	3	3	3	2		3	3	3
CO5	3	1				3	3	3	3	2		3	3	3

SEMESTER VIII

CH22811	PROJECT WORK	L	T	P	C
		0	0	20	10

COURSE OBJECTIVES:

The objective of the project is to make use of the knowledge gained by the student at various stages of the degree course.

GUIDELINES:

Each student is required to submit a report on the project assigned to him by the department. The report should be based on the information available in the literature or data obtained in the laboratory/industry. Students, in addition to the home problem will be permitted to undertake industrial/ consultancy project work, outside the department, in industries/Research labs for which proportional weightage will be given in the final assessment.

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Demonstrate a sound technical knowledge of their selected project topic.	**4**
CO2.	Analyze literature to learn the technical advancements in the selected topic.	**4**
CO3.	Undertake problem identification, formulation and solution.	**4**
CO4.	Design engineering solution to complex problems utilizing a systematic approach	**4**
CO5	Estimate the cost analysis for the optimized solution	**4**

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3

PROFESSIONAL ELECTIVES / VERTICALS

VERTICAL – II HYDROCARBON PROCESSING

CH22021	DRILLING TECHNOLOGY AND WELL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To learn and gain expertise in the key areas of design of drilling wells and its operation management.

UNIT I	**DRILLING GEOLOGY, OIL AND GAS MIGRATION**	**9**

Rock Strengths and Stresses, Hydrostatic Pressure Forced by a Fluid. Rock Properties, Primary Migration, Reservoir Rock, Seal Rock and Secondary Migration. Reservoir Drives, Problems Related Fluids in the Reservoir.

UNIT II	**PLANNING AND DRILLING OF WELL**	**9**

Well Proposal, Gathering Data, Designing the Well, Drilling the Well and Testing the Well. Planning of Well, Hole and Casing Sizes and Drilling the Well. Selecting a suitable Drilling Rig, Classification of Drilling Rig, Rig Systems and Equipments.

UNIT III	**DRILL BITS AND DRILLING FLUIDS**	**9**

Roller Cone Bits, Fixed Cutter Bits and Cone Bits. Optimizing Drilling Parameters- Grading the Dull Bit and Bit Selection. Functions of Drilling Fluid, Basic Mud Classification Designing the Drilling Fluid

UNIT IV	**DIRECTIONAL DRILLING, CASING, CEMENTING AND EVALUATION**	**9**

Controlling the Well Path of a Deviated Well, Horizontal Wells and Multi Lateral Well. Importance of Casing in a Well, Designing the Casing String, Role of the Cement Outside the Casing, Mud Removal, Cement Design, Running and Cement Casing and other Cement Jobs. Evaluation Techniques, Physical Sampling at Surface and Downhole, Electrical Logging and Production testing.

UNIT V	**MANAGING DRILLING OPERATIONS, SAFETY AND ENVIRONMENTAL ISSUES**	**9**

Personnel involved in Drilling Operation, Decision Making at the Well site and in the Office, Estimating the Well Cost. Safety Meetings, New Comers on the Rig, Training and Certification, Permit to Work Systems, Safety Alerts, Safety Equipments, Minimizing Spills and Environmental Impact Studies.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the drilling geology and well migration	2
CO2.	Analyze the design and classification of drilling rigs	4
CO3.	Explicate the various drill bits and drilling fluids	4
CO4.	Discuss the directional drilling, casing and cementing procedures	4
CO5	Evaluate the environmental safety aspects in drilling operations	4

TEXT BOOKS:

1. Devereux, S., "Drilling Technology", PennWell Publishing Company, 1999.
2. Rao V.K., Sahoo P. K, "A beginner's guide to Drilling Technology – Oil and gas wells drilling and completion", Shashwat publication, 2020
3. Guan Z., " Theory and Technology of Drilling Engineering", Springer, 2021.

REFERENCES:

1. Oilfield Processing: Crude Oil (Oilfield Processing of Petroleum R. Solvay, Pennwell Books 1995.
2. Devereux, S., "Practical Well Planning and Drilling", PennWell Corporation, 1998.
3. Paulo Davim J., "Drilling Technology:Fundamentals and recent advances, De Gryter, 2018.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	2	2				1	2	1	2	3	3
CO2	3	3	3	2	2				1	2	1	1	3	3
CO3	3	2	2	2	2	3			1	2	1	1	3	3
CO4	3	2	2	2	2				1	2	1	1	3	3
CO5	2	3	2	2	2	3	3	3	1	2	1	1	3	3

CH22022	NATURAL GAS ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To learn the basic concepts and applications of Natural gas engineering

UNIT I	NATURAL GAS TECHNOLOGY AND EARTH SCIENCE	9

Natural gas technology and earth science: Branches of petroleum Industry. Sources of Information for natural gas engineering and its applications. Geology and earth sciences: Earth sciences-Historical geology, Sedimentation process, Petroleum reservoirs, Origin of petroleum. Earth temperatures & pressure, Earth temperatures, Earth pressure. Petroleum: Natural gas, LP gas, Condensate, & Crude oil.

UNIT II	PROPERTIES OF NATURAL GAS	9

Properties of Natural Gases: typical compositions. Equations of state: general cubic equations, specific high accuracy equations. Use of equation of state to find residual energy properties, gas measurement gas hydrates, condensate stabilization, acid gas treating, gas dehydrations, compressors, process control deliverability test, gathering and transmission, and natural gas liquefaction.

UNIT III	GAS COMPRESSION	9

Gas Compression: Positive displacement and centrifugal compressors; fans. Calculation of poser requirements. Compressible Flow in Pipes: Fundamental equations of flow: continuity, momentum, elegy equations.

UNIT IV	GOVERNING EQUATIONS FOR FLOW OF NATURAL GAS	9

Isothermal flow in pipes: the Weymouth equation. Static and flowing bottom-hole pressures in wells. Fundamentals of Gas flow in porous media: Steady state flow equations. Definition of pseudo-pressure function. Gas flow in cylindrical reservoirs: general equation for radial flow of gases in symmetrical homogeneous reservoirs.

UNIT V	GAS WELL DELIVERABILITY AND DRAW DOWN	9

Non-dimensional forms of the equation; derivation of coefficients relation dimensionless to real variables. Infinite reservoir solution: Pseudo-steady-state solution. Gas Well Deliverability Tests: Flow-after-flow tests: prediction of IPR curve and AOF for the well. Isochronal tests. Draw down tests: need for data at two flow rates.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the natural gas technology and exploration of natural gas	2
CO2.	Analyze the properties of natural gas	4
CO3.	Explain the gas compression and compressible flow of natural gas	3
CO4.	Apply the governing equations for flow of natural gas.	3
CO5	Analyze the testing strategies for gas well deliverability and draw down	4

TEXT BOOKS:

1. Katz D.L.et al., Natural Gas Engineering (Production & storage), McGraw-Hill, Singapore.
2. Lyons, W.C., "Standard Handbook of Petroleum and Natural Gas Engineering", Vol.2,Gulf Professional Publishing, Elsevier Inc., 2006.
3. Boyun Guo., "Natural gas engineering handbook", second edition, Gulf publishing company, 2005.

REFERENCES:

1. Katz, D. L. and Lee, R.L., "Natural Gas Engineering", McGraw Hill, 1990.
2. Dring, M.M., "The Natural Gas Industry – A Review of World Resources and Industrial Applications", Butterworth, 1974.
3. Saied Mokhatab, William A. Poe, and James G. Speight, "Handbook of Natural Gas Transmission and Processing", Gulf Professional Publishing, Elsevier Inc., 2006.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2	2	2	3	2		1	2	2	3	3	3
CO2	3	2	3	3	2				1	2	2	2	3	3
CO3	3	3	2	2	2				1	2	2	2	3	3
CO4	3	3	2	2	2				1	2	2	2	3	3
CO5	3	3	3	3	3	3	2		1	2	2	2	3	3

CH22023	HYDROCARBON PROCESSING TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To develop the fundamentals of refining of petroleum crude oil and its fractionation in different useful petroleum products and to understand, design and analyze the various petroleum refinery processes including primary, secondary and supporting processes.

UNIT I	**INTRODUCTION TO HYDROCARBON PROCESSING**	**9**

Overall Refinery Flow, Refinery products – Refinery Feedstocks, Pretreatment of crude oils, Atmospheric distillation, Vacuum distillation of residue products

UNIT II	**THERMAL AND CATALYTIC CRACKING PROCESS**	**9**

Thermal Cracking - Visbreaking, Coking, Fluid Catalytic cracking and Hydrocracking - Hydroprocessing and Hydro treating.

UNIT III	**CATALYTIC CONVERSION PROCESS**	**9**

Catalytic Reforming, Isomerization, Alkylation and Polymerization, Product blending – Supporting Processes and Pollution Control in Refineries.

UNIT IV	**LUBE DISTILLATE TREATMENT TECHNIQUES**	**9**

Evaluation of crude oils for lube oil base stocks, Solvent de-asphalting, Solvent extraction of lube oil fractions, dewaxing, hydrofining, clay contact process – Production of lubricating oils.

UNIT V	**ACID GAS TREATING AND DEHYDRATION OF NATURAL GAS**	**9**

Acid gas removal: Metal oxide process – Slurry process – Amine process –Carbonate washing process – Methanol based process and other process – Sulphur recovery process. Dehydration: Glycol dehydration – Solid desiccant dehydration.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Explain the types of crude and their primary refining technology.	3
CO2.	Analyze the various secondary processing technologies to improve the quality of petroleum products.	4
CO3.	Explicate the appropriate technologies to meet the specified needs of the industries with consideration for safety, environment and society.	4
CO4.	Evaluate the manufacturing techniques involved in lubricating oil.	4
CO5	Analyze the treatment technologies for natural gas	4

TEXT BOOKS:

1. James H. Gary and Glenn E. Handwerk., "Petroleum Refining Technology and Economics", Fourth Edition, Marcel Dekker Inc., 2001.
2. Bhaskara Rao, B.K., "Modern Petroleum Refining Processes", Third edition, Oxford and IBH Publishing Company Pvt. Ltd, 2009.
3. Robert A. Meyers, "Handbook of Petroleum Refining Processes", Fourth edition, Mc-Graw Hill, 2016.

REFERENCES:

1.Standard Handbook of Petroleum and Natural Gas Engineering. Second Edition. William C Lyons, Gary, C Plisga. Gulf Professional Publishing.
2.Ram Prasad, "Petroleum Refining Technology", Khanna Publishers, 2020.
3.Nelson, W.L., "Petroleum Refinery Engineering", McGraw Hill Publishing Company Limited, 1985.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3	1				1	2	1	2	3	3
CO2	3	3	2	3	3		2		1	2	1	2	3	3
CO3	3	3	2	3	3	3	3	2	1	2	1	2	3	3
CO4	3	3	2	3	1				1	2	1	2	3	3
CO5	3	3	2	3	3				1	2	1	2	3	3

CH22024	UNIT PROCESSES IN PETROCHEMICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn feed stock and source of petrochemicals, synthesis gas production.
- To impart knowledge on primary, secondary and tertiary unit processes.

UNIT I	**INTRODUCTION AND SOURCE OF PETROCHEMICALS**	**9**

Overview of Petrochemical Industry – The key growth area of India, Economics – Feed stock selections for Petrochemicals – Steam cracking of Gas and Naphtha to produce Olefins, Diolefins and Production of Acetylene.

UNIT II	**SYNTHESIS GAS PRODUCTION**	**9**

Steam reforming of Natural gas- endothermic reactions involved in steam reforming –Coal gasification- Composition, pathway for formation, and thermochemistry- Naphtha and Heavy distillate to produce Hydrogen and Synthesis gas – Production of Methanol –Oxo process (Hydroformylation)

UNIT III	**PRIMARY UNIT PROCESSES**	**9**

Fundamental and Technological principles involved in Alkylation-catalysts used-new technologies used-HFAU process and SAAU Process – Oxidation –total oxidation and selective oxidation– Nitration-advantages and limitations- and Hydrolysis process-mechanism.

UNIT IV	**SECONDARY UNIT PROCESSES**	**9**

Fundamental and Technological principles involved in Sulphonation-basic chemistry- Sulfation-Sulfamic acid sulfation-commercial scale sulfation equipment-Continuous Tandem Type Sulfonation-Sulfation with Oleum and Isomerisation-skeletal isomerisation process.

UNIT V	**TERTIARY UNIT PROCESSES**	**9**

Fundamental and Technological principles involved in Halogenation-mechanism and applications-Halogenation of OiLsands Bitumen, Maltenes, and Asphaltenes- and Esterification-reaction mechanism-different methods of esterification-applications.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyse the growth of petrochemical industry and feed sources.	3
CO2.	Apply steam reforming process for the production of hydrogen and synthesis gas.	3
CO3.	Analyse the primary unit processes involved in petrochemical industries.	4
CO4.	Distinguish the principles involved in Sulphonation, Sulfation and Isomerization.	4
CO5	Inspect the Fundamental and Technological principles involved in tertiary unit processes	4

TEXT BOOKS:

1.Bhaskara Rao, B.K., "A Text on Petrochemicals", Khanna Publishers, 2000.
2.Sukumar Maiti, "Introduction to Petrochemicals", 2nd Edition, Oxford and IBH Publishers, 2002.

REFERENCES:

1.Margaret Wells, "Handbook of Petrochemicals and Processes", 2nd Edition, Ash Gate Publishing Limited, 2002.
2.Sami Matar, and Lewis F. Hatch., "Chemistry of Petrochemical Processes", 2nd Edition, Gulf Publishing Company, 2000.
3.Dryden, C.E., "Outlines of Chemical Technology", 2nd Edition, Affiliated East-West Press, 1993.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	3	3	-	-	3	3	3	3	3	3	3	3	3
CO2	2	3	3	3	-	3	3	3	-	3	3	3	3	3
CO3	2	3	3	-	3	3	3	3	-	3	3	3	3	3
CO4	2	3	3	-	-	3	3	3	-	3	3	3	3	3
CO5	2	3	3	-	-	3	3	3	-	3	3	3	3	3

CH22025	PETROCHEMICAL DERIVATIVES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To understand the concepts of petrochemical derivatives.

UNIT I	**PRECURSORS**	**9**

Indian Petrochemical Industry - Sources of Petrochemicals - Classification of Petrochemicals - Classification of Hydrocarbons - Alternate routes with flow diagram for production of methane, ethylene, propylene, acetylene. Chemicals from methane, ethylene, propylene, acetylene.

UNIT II	**FIRST GENERATION PETROCHEMICALS**	**9**

Alternate routes with flow diagram for production of butadiene, related dienes, aromatics – Benzene, toluene, xylene – Chemicals from butadiene, related dienes, aromatics – Benzene, toluene, xylene.

UNIT III	**SECOND GENERATION PETROCHEMICALS**	**9**

Alternate routes with flow diagram for production of ethylene glycol, ethylene oxide, Ethyl benzene, VCM, acrylonitrile, phenol, adipic acid, hexmethylenediamine, DMT, TPA, maleic anhydride, styrene.

UNIT IV	**THIRD GENERATION PETROCHEMICALS**	**9**

Polymerization – Modes and techniques – Production of polyethylene – LDPE, HDPE, propylene-polypropylene, SBR, SAN, ABS, PU.

UNIT V	**FIBERS,RESINS AND EXPLOSIVES FROM PETROCHEMICALS**	**9**

Polyacrylonitrile, polyvinyl chloride, polycarbonates, nylon 6, nylon 66, polyesters, resins, explosives, organic dyes.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Construct the techniques and their alternate production of precursors of petrochemicals.	3
CO2.	Identify the various chemicals from first generation petrochemicals and their alternate routes for production.	3
CO3.	Develop the manufacturing process of second generation of petrochemicals and their alternate routes for production.	3
CO4.	Explain the production processes of various types of polymers	3
CO5	Describe the production processes of fibres, resins and explosives	3

TEXT BOOKS:

1.Bhaskara Rao, B.K., "A Text on Petrochemicals", Khanna Publishers, 2000.
2.SukumarMaiti, "Introduction to Petrochemicals", 2nd Edition, Oxford and IBH Publishers, 2002.

REFERENCES:

1.Margaret Wells, "Handbook of Petrochemicals and Processes", 2nd Edition, Ash Gate Publishing Limited, 2002.
2.Sami Matar, and Lewis F. Hatch., "Chemistry of Petrochemical Processes", 2nd Edition, Gulf Publishing company, 2000.
3.Dryden, C.E., "Outlines of Chemical Technology", 2nd Edition, Affiliated East-West Press, 1993.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	1	1	2	3	3	2	1	3	2	3	3	2
CO2	2	2	1	1	2	3	3	2	1	3	3	3	3	2
CO3	2	2	1	1	2	3	3	2	2	3	3	3	3	2
CO4	2	2	1	1	2	3	3	2	2	3	2	3	3	2
CO5	2	2	1	1	2	3	3	2	1	3	2	3	3	2

CH22026	MULTI-COMPONENT DISTILLATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To understand the concepts of Multicomponent distillation systems.

UNIT I	THERMODYNAMIC PRINCIPLES	9

Fundamental Thermodynamic principles involved in the calculation of vapor – liquid equilibria and enthalpies of multi component mixtures – Use of multiple equation of state for the calculation of K values – Estimation of the fugacity coefficients for the vapor phase of polar gas mixtures – calculation of liquid – phase activity coefficients.

UNIT II	THERMODYNAMIC PROPERTY EVALUATION	9

Fundamental principles involved in the separation of multi component mixtures – Determination of bubble-point and Dew Point Temperatures for multi component mixtures – equilibrium flash distillation calculations for multi component mixtures – separation of multi component mixtures at total reflux.

UNIT III	MINIMUM REFLUX RATIO FOR MCD SYSTEM	9

General considerations in the design of columns – Column sequencing – Heuristics for column sequencing – Key components – Distributed components – Non-Distributed components – Adjacent keys. Definition of minimum reflux ratio – calculation of R_m for multi component distillation – Underwood method – Colburn method.

UNIT IV	VARIOUS METHODS OF MCD COLUMN DESIGN	9

Theta method of convergence – K_b method and the constant composition method – Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Stage and reflux requirements – Short cut methods and Simplified graphical procedures.

UNIT V	VARIOUS TYPES OF MCD COLUMNS	9

Design of sieve, bubble cap, valve trays and structured packing columns for multi component distillation – computation of plate efficiencies-various types and applications.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply the fundamental thermodynamic principles involved in VLE	3
CO2.	Identify the fundamental concepts of binary and multicomponent distillation.	3
CO3.	Distinguish the key components in distributed and non distributed system.	4
CO4.	Analyze and solve problems related to various methods of multi component distillation.	4
CO5	Inspect the various types of column in multi component distillation.	4

TEXT BOOKS:

1.Holland, C.D., "Fundamentals of Multi Component Distillation", McGraw Hill Book Company, 1981.
2. Van Winkle, "Distillation Operations", McGraw Hill Publications, 1987.

REFERENCES:

1.King, C.J., "Separation Process Principles", Mc Graw Publications, 1986.
2.Treybal, R.E., "Mass Ttransfer Operations", 3rd Edition, Mc Graw Hill publications. 2017.
3.Mc Cabe and Smith, J.C., Harriot, "Unit Operation of Chemical Engineering", 7th Edition, McGraw Hill, 2017.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	3	3	1	-	-	3	3	3	1	3	2	2
CO2	3	3	3	3	1	-	-	3	3	3	1	3	2	2
CO3	3	3	3	3	1	-	-	3	3	3	1	3	2	2
CO4	3	3	3	3	1	-	-	3	3	3	1	3	2	2
CO5	3	2	3	3	1	-	-	3	3	3	1	3	2	2

CH22027	PETROLEUM REFINERY ENGINEERING AND DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To learn the process design of multi-component distillation columns and heat transfer equipment used in refining and process industry.

UNIT I	MULTI-COMPONENT DISTILLATION	9

Dew point and bubble point for multi component mixtures. Design of multi component distillation column, Number of variables, Selection of key components, Selection of column pressure, Feed condition, Plate-to-plate calculations, Empirical short cut methods, Introduction to rigorous solution procedures.

UNIT II	PETROLEUM REFINERY DISTILLATION	9

TBP, EFV, ASTM distillation curves and their relevance, Material balance and flash zone calculations for petroleum refinery distillation columns, Pump around and pump back calculations, Overall energy requirements, Estimation of number of equilibrium stages, Design using Packie charts and Watkins method, Introduction to rigorous solution procedure based on pseudo components.

UNIT III	COLUMN DESIGN	9

Process design of distillation towers. Flooding charts. Trays and packings. Vacuum devices. Pressure drops. Height, diameter, supports. Piping requirements. Aspects of mechanical design. A typical P&ID for a distillation column.

UNIT IV	FIRED HEATERS	9

Heat load calculations for furnace heaters used in crude refining, Basic constructional features, Different furnace types, Review of factors to be considered in the design of fired heaters, Introduction to manual calculations methods.

UNIT V	PUMPS AND COMPRESSORS	9

Types of pumps and compressors. Selection criteria. Power rating calculations based on process duty. Use of operating curves of centrifugal pump. NPSHR and NPSHA. Pump Cavitation. Surge problem in compressors.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Explain the multi-component distillation	3
CO2.	Design the petroleum refinery distillation columns	5
CO3.	Analyze the process and mechanical design of distillation towers	4
CO4.	Perform heat load calculations for furnace heaters	3
CO5	Analyze the design and selection of pumps and compressors	4

TEXT BOOKS:

1. Van Winkle M., “Distillation”, McGraw Hill, 1967.
2. Watkins, “Petroleum Refinery Distillation”, McGraw Hill, 1993.
3. Marc Boremanns, “Pumps and Compressors, John Wiley & Sons., 2019.

REFERENCES:

1. Nelson, W.L., “Petroleum Refinery Engineering”, McGraw Hill Publishing Company Limited, 1985.
2. Kern, D.Q., “Process Heat Transfer “, McGraw-Hill, 1999.
3. Kayode Coker, A., “Petroleum refining Design and applications handbook”, Wiley, 2018.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	2				1	2	1	2	3	3
CO2	3	3	3	3	2				1	2	1	2	3	3
CO3	3	2	1	3	2	3			1	2	1	2	3	3
CO4	3	2	2	3	2				1	2	1	2	3	3
CO5	3	3	2	3	2	3	3	2	1	2	1	2	3	3

CH22028	PETROLEUM PROCESS EQUIPMENT AUXILIARIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To give an overview of various equipment auxiliaries involved in the chemical processes.

UNIT I	**ELECTRICAL MOTORS AND STARTERS**	**9**

Electrical motors-Types of motors and its applications– Induction-squirrel cage induction motor phase wound motor–Synchronous – Electrical Starters- Manual Starters and AC Magnetic Motor starters

UNIT II	**ROTARY EQUIPMENT**	**9**

Pumps-centrifual pump,gear pump –Turbines-wind, gas and steam turbines – Blowers- Centrifugal, axial, and positive displacement blowers – Compressors- Rotary screw, vane and reciprocating air compressors – Fans – Concept – Working and application.

UNIT III	**INDUSTRIAL VALVES**	**9**

Needle valve – Globe, gate and ball valves – Butterfly valve – Check valve – Piping system-plug valves-safety and relief valves- Working and application.

UNIT IV	**INDUSTRIAL DRYERS**	**9**

Rotary dryer-Rotary fluid bed dryer –comparative study of rotary dryer and rotary fluid bed dryer– Spray dryer-types, advantages and applications and freeze dryers – rotary, manifold and tray freeze dryers.- Electro osmotic dryers – Electro-Osmosis Dehydrator

UNIT V	**PROCESS UTILITY EQUIPMENTS**	**9**

Vacuum devices – Cooling towers –Forced draft and induced draft- Refrigeration systems –main components and their functions- Flare system –Equipments for waste water treatment systems.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Apply the working principle, types, operation, selection and applications of Electrical motors and starters.	3
CO2.	Compare the working of rotary equipments namely pumps, blowers, turbines, compressors and fans.	4
CO3.	Distinguish the various types of Industrial Valves and its applications.	4
CO4.	Analyse the different types of dryers used in industries.	4
CO5	Examine the working principle, types, operation, selection and applications of utility systems	3

TEXT BOOKS:

1.Walas, S.M., "Chemical Process Equipment", Butterworth – Heinemann Oxford Publishing Ltd., 1999.
2.Thomas, C.E., "Process Technology – Equipment and systems", Uhai Publishing, Inc., 2002.

REFERENCES:

1.Ludwig, E.E., "Applied Process Design for Chemical and Petrochemical Plants", Vol.I and III, Gulf Professional Publishing, 2002.
2.Perry, R.H. and Green, D.W., "Perry's Chemical Engineer's Hand Book", 7th Edition, McGraw Hill – International, 1997.
3.Sahu, G.K., "Hand Book of Piping Design", New Age International Publishers, 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1	3	3	1	3	3	3	3	3	2	3	3	3
CO2	3	1	3	3	1	3	3	3	3	3	2	3	3	3
CO3	2	1	3	3	1	3	3	3	3	3	2	3	3	3
CO4	2	1	3	3	1	3	3	3	3	3	2	3	3	3
CO5	2	1	3	3	1	3	3	3	3	3	2	3	3	3

VERTICAL III HSE IN PROCESS INDUSTRIES

CH22031	FIRE ENGINEERING AND EXPLOSION CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide an in-depth knowledge about the science of fire.
- To understand the causes and effects of fire.
- To know the various fire prevention systems and protective equipments.
- To understand the science of explosion and its prevention techniques.
- To understand the various fire prevention techniques to be followed in a building.

UNIT I	**PHYSICS AND CHEMISTRY OF FIRE**	**9**

Fire properties of solid, liquid and gases - fire spread - toxicity of products of combustion - theory of combustion and explosion – vapour clouds–flash fire–jet fires –pool fires –unconfined vapour cloud explosion, shock waves-auto-ignition – boiling liquid expanding vapour explosion – case studies – Flixborough, Mexico disaster, Pasedena Texas, Piper Alpha, Bombay Victoria dock ship explosions, Mahul refinery explosion, Nagothane vapour cloud explosion and Vizag refinery disaster.

UNIT II	**FIRE PREVENTION AND PROTECTION**	**9**

Sources of ignition – fire triangle Fire Tetrahedron – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E-Fire extinguishing agents- Water ,Foam, Dry chemical powder, Carbon-dioxide- Halon alternatives Halocarbon compounds-Inert gases , dry powders – types of fire extinguishers – fire stoppers – hydrant pipes – hoses – monitors – fire watchers – lay out of stand pipes – fire station – fire alarms and sirens, Assembly points –maintenance of fire trucks – foam generators–escape from fire rescue operations – fire drills – first aid for burns.

UNIT III	INDUSTRIAL FIRE PROTECTION SYSTEMS	**9**

Sprinkler-hydrants-stand pipes – special fire suppression systems like deluge and emulsifier, selection criteria of the above installations, reliability, maintenance, evaluation and standards – alarm and detection systems. Other suppression systems – CO_2 system, foam system, dry chemical powder (DCP) system, halon system – need for halon replacement – smoke venting. Portable extinguishers – flammable liquids – tank farms – indices of inflammability-firefighting systems.

UNIT IV	BUILDING FIRE SAFETY	**9**

Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection –structural integrity – concept of egress design - exit – width calculations - fire certificates – fire safety requirements for high rise buildings.

UNIT V	EXPLOSION PROTECTING SYSTEMS	9
Principles of explosion-detonation and blast waves-explosion parameters – Explosion Protection, Containment, Flame Arrestors, isolation, suppression, venting, explosion relief of large enclosure-explosion venting-inert gases, plant for generation of inert gas rupture disc in process vessels and lines explosion, suppression system based on Carbondioxide (CO_2) and halons - hazards in LPG, ammonia(NH_3)		
		TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Appraise the basic concepts of fire and explosion science and analyze various case studies.	**4**
CO2.	Categorize different sources of ignition and their prevention techniques.	**3**
CO3.	Explore the operating principles of various types of fire fighting equipments.	**4**
CO4.	Exemplify the causes of building fire and prevention techniques.	**3**
CO5	Employ explosion protection techniques to suit the industrial requirements.	**4**

REFERENCES:

1. "Accident Prevention manual for industrial operations" N.S.C.,Chicago,1982.
2. "Davis Daniel et al, "Hand Book of fire technology"
3. "Fire Prevention and fire fighting", Loss prevention Association, India.
4. Derek, James, "Fire Prevention Hand Book", Butter Worths and Company,London,1986.
5. Dinko Tuhtar, "Fire and explosion protection"
6. Fire fighters hazardous materials reference book
7. Fire Prevention in Factories", Nostrand ReinHold, New York, 1991.
8. Gupta,R.S.,"HandBook of Fire Technology" Orient Longman, Bombay 1977.
9. Relevant Indian Acts and rules, Government of India.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3

CH22032	INDUSTRIAL SAFETY ASSESSMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To give an overview of the assessment methodologies applicable for industrial safety

To elaborate the hazard identification techniques and implement safety procedures

To apply various risk assessment techniques and evaluate risks

To plan various mitigation techniques based on cost benefits

To document and communicate hazards to relevant authorities

UNIT I	**INTRODUCTION TO INDUSTRIAL SAFETY**	**9**

Historical perspective and evolution of safety standards. Introduction to Hazard Identification; Importance of hazard identification in risk management; Historical perspective on hazard identification and accident prevention; Role of hazard identification in safety culture development. Types of Hazards; Physical hazards, Chemical hazards, Biological hazards, Ergonomic hazards Psychosocial hazards.

UNIT II	**HAZARD IDENTIFICATION TECHNIQUES**	**9**

Workplace walkthroughs and inspections; Job hazard analysis (JHA) or job safety analysis (JSA); Hazard and operability studies (HAZOP); Failure mode and effects analysis (FMEA); Safety data sheets (SDS) and chemical inventory reviews, Safety Management Systems: Overview of safety management systems ; Implementing safety policies and procedures; Incident reporting and investigation

UNIT III	**RISK ASSESSMENT**	**9**

Understanding risk assessment concepts; Qualitative vs. quantitative risk assessment methods; Risk matrix analysis and risk scoring systems; Probability and consequence assessment; Hazard Severity and Likelihood Evaluation; Factors influencing hazard severity and likelihood; Using historical data and incident analysis for severity evaluation; Assessing the probability of hazard occurrence; Risk ranking and prioritization techniques

UNIT IV	MITIGATION STRATEGIES	**9**

Hierarchy of controls for hazard mitigation; Engineering controls, administrative controls, and personal protective equipment (PPE); Developing control measures and corrective actions; Cost-benefit analysis of mitigation strategies, Emergency Preparedness and Response; Developing emergency response plans; Emergency evacuation procedures; Training for emergency situations

UNIT V	HAZARD COMMUNICATION AND DOCUMENTATION	**9**

Communicating identified hazards to stakeholders; Safety data sheets (SDS) and labeling requirements; Hazard identification and risk assessment documentation; Regulatory requirements for hazard communication; Case Studies and Practical Applications - Application of hazard identification techniques in different industries and settings

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Elaborate the importance of hazard identification in ensuring safety and preventing accidents.	**4**
CO2.	Analyze various systematic approaches and techniques for hazard identification.	**4**
CO3.	Explore different risk assessment methodologies and severity evaluation.	**4**
CO4.	Develop various hazard mitigation procedures and cost benefit analysis.	**4**
CO5	Communicate and Document the identified hazards and mitigation methods effectively.	**3**

REFERENCES:

1. "Hazard Identification and Risk Assessment", By Geoff Wells, IchemE, 1997
2. Guidelines for Process Hazards Analysis (PHA, HAZOP), Hazards Identification, and Risk Analysis", Nigel Hyatt, CRC Press Inc; 1st edition , 2003.
3. Hazard Identification Methods, Frank Crawley, Brian Tyler, IchemE, 2003.
4. Industrial Safety Management: Hazard Identification and Risk Control, 1st Edition, L. M. Deshmukh, McGraw Hill Education (India) Private Limited, 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3		3	3		3	3	2	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	2	2	3	2	2	3	2	0	3	3	3	3	3	3

CH22033	ACTS AND REGULATIONS FOR HEALTH, SAFETY ANDENVIRONMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To provide exposure to the students about safety and health provisions related to hazardous processes as laid out in Factories act 1948.

To familiarize students with powers of inspectorate of factories.

To help students to learn about Environment act 1986 and rules framed under the act.

To provide wide exposure to the students about various legislations applicable to an industrial unit.

UNIT I	**FACTORIES ACT–1948**	**9**

Statutory authorities–inspecting staff, health, safety, provisions relating to hazardous processes, welfare, working hours, employment of young persons – special provisions – penalties and procedures - Tamilnadu Factories Rules1950 under Safety and health chapters of Factories Act 1948. Forms, Registers and notices – Tamilnadu Safety Officer Rules 2005 - with updated Amendments

UNIT II	**ENVIRONMENT ACT–1986**	**9**

General powers of the central government, prevention, control and abatement of environmental pollution - Biomedical waste (Management and handling Rules, 1989 - The noise pollution (Regulation and control) Rules, 2000 - The Batteries (Management and Handling Rules) 2001- No Objection certificate from statutory authorities like pollution control board. Air Act 1981 and Water Act 1974: Central and state boards for the prevention and control of air pollution – powers and functions of boards – prevention and control of air pollution and water pollution – fund – accounts and audit, penalties and procedures.

UNIT III	H AZARDOUS CHEMICAL RULES 1989 AND MAJOR ACCIDENT HAZARD CONTROL RULES	**9**

Definitions – duties of authorities – responsibilities of occupier – notification of major accidents – information to be furnished – preparation of offsite and onsite plans – list of hazardous and toxic chemicals – safety reports – safety data sheets. Major Accident Hazard Control Rules. Hazardous Wastes (management, handling and Trans-boundary Movement) Rules 2016.

UNIT IV	**OTHER ACTS AND RULES**	**9**

Indian Boiler (Amendments) Act 2007, static and mobile pressure vessel rules (SMPV), motor vehicle rules, The Mines and Minerals (Development & Regulation) Amendment Act, 2015, workman compensation act, rules –electricity act and rules – hazardous wastes (management, handling and transboundary) rules, 2008 - the building and other construction workers act 1996., Petroleum rules, Gas cylinder rules 2016, Explosives Act 1884-Pesticides Act – E waste (management) rules 2016.

UNIT V	INTERNATIONAL ACTS AND STANDARDS	**9**

Occupational Safety and Health act of USA (The Williames - Steiger Act of 1970) – Health and safety work act(HASAWA 1974, UK) – ISO 14001 – ISO 45001 , European Safety and Health Legislations, American Petroleum Institute (API) Standards, Oil Industry Safety Directorate (OISD) Standards, National Fire Protection Association(NFPA) Standards, Atomic Energy Regulatory Board(AERB), American National Standards Institute(ANSI).

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Appreciate the important clauses explained in Factories Act.	**3**
CO2.	Elaborate the mitigation methodologies required as per environment Act for pollution prevention.	**3**
CO3.	Intricate the rules and regulations to be followed for Hazardous materials act..	**3**
CO4.	Elucidate various acts and rules related to Industrial safety.	**3**
CO5	Explain various international acts and rules related to Environmental and Industrial safety..	**3**

REFERENCES:

1. The Factories Act 1948, Madras Book Agency, Chennai, 2000
2. The Environment Act (Protection) 1986, Commercial Law Publishers (India) Pvt. Ltd., New Delhi.
3. Water (Prevention and control of pollution) act 1974, Commercial Law publishers (India) Pvt. Ltd., New Delhi.
4. Air (Prevention and control of pollution) act 1981, Commercial Law Publishers (India) Pvt. Ltd., New Delhi.
5. The Indian boilers act 1923, Commercial Law Publishers (India) Pvt. Ltd., Allahabad.
6. The Mines Act 1952, Commercial Law Publishers (India) Pvt. Ltd., Allahabad.
7. The manufacture, storage and import of hazardous chemical rules 1989, Madras Book Agency, Chennai.
8. Srinivasan S, "The Tamil Nadu Safety Officers Rules 2005" Madras Book Agency, Chennai, 28th Edition, 2017

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2	1	1	3	3	3	3	3	3	3	3	3
CO2	2	2	2	3	2	3	3	3	3	3	3	3	3	3
CO3	2	2	2	1	3	3	3	3	3	3	3	3	3	3
CO4	2	2	2	1	2	3	3	3	3	3	3	3	3	3
CO5	2	2	2	1	2	3	3	3	3	3	3	3	3	3

CH22034	DISASTER MANAGEMENT IN PROCESS INDUSTRIES	L	T	P	C

COURSE OBJECTIVES:

To educate students about various Industrial Disasters
To train students in various risk reduction methods
To develop students in preparing offsite and onsite plans
To improvise various disaster relief and management strategies
To plan and execute disaster recovery and Rebuilding.

UNIT I	**INTRODUCTION**	**9**

Concept, Need and Importance of Industrial Disaster Management. Chemical hazards, Biological hazards, Radiological hazards, nuclear hazards, Physical hazards, Electrical hazards, Fire hazard, Gas hazards etc.

UNIT II	**DISASTER RISK REDUCTION STRATEGIES**	**9**

Hazard and Risk Reduction Strategies -: Mainstreaming DRR, Objectives of Disaster Risk Reduction, Understanding Resilience, Hyogo and Sendai framework for action and its History (Yokohama Strategy), Resilience linking vulnerability, Disaster Risk Reduction and Disaster Recovery at Community and National Level.

UNIT III	**ONSITE AND OFFSITE DISASTER MANAGEMENT PLANS**	**9**

Onsite: Standard operating procedures, control room, safety officer, Different committees for Disaster management, rescue team, training, exercises and mock drills.
Offsite: Identification of vulnerable locations, Dissemination of information, need and damage assessment, rescue and Relief plans, compensation

UNIT IV	**DISASTER RELIEF AND MANAGEMENT**	**9**

Concept of Relief- policy, Relief delivery and management. Standards and Best Practices in Relief operations –SPHERE standards. Early Warning systems and public evacuation, search and rescue, Sanitation, Dead body disposal, Debris Management, Restoration of key infrastructure. Public heath-Impact on public health and mental health, Planning and managing public health care during a disaster preparedness and response plan. Ethics and standards in public health care delivery.

UNIT V	**DISASTER RECOVERY AND REBUILDING**	**9**

Disaster Recovery, Rebuilding & Rehabilitation, Recovery Time- frames and differential recovery rates, long-term Recovery, Post disaster Recovery Planning & Reconstruction, Post Disaster Housing & Habitat Planning, and Rights- based approach to disaster rehabilitation.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Comprehend the importance of disaster management	**3**
CO2.	Develop risk reduction strategies through various methodologies in process plants.	**4**
CO3.	Analyze situations and prepare onsite and offsite emergency plans	**3**
CO4.	Evaluate the standards and Best Practices in disaster relief management	**4**
CO5	Appraise the steps involved in Disaster recovery.	**4**

REFERENCES:

1. Disaster Administration and Management, Text & Case studies- SL Goel-Deep and Deep Publications
2. Hazardous Materials Disaster Management - Arunkumar Talwar, Common wealth Publisher
3. Heinrich H.W. "Industrial Accident Prevention" McGraw-Hill Company, NewYork, 1980
4. "Safety in Industry" N.V.Krishnan Jaico Publishery House, 1996

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	0	3	0	0	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	2	3	3	3	0	3	3	3	3	3	3	3	3	3
CO4	2	2	3	3	0	3	3	3	3	3	3	3	3	3
CO5	2	2	3	0	0	3	3	3	3	3	3	3	3	3

CH22035	ACCIDENT INVESTIGATION AND REPORTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To learn and analyze various causes of accidents and preventive methods

UNIT I	INDUSTRIAL ACCIDENTS	9

Definition of accidents and incidents, Importance of accident investigation, reportable and non-reportable accidents, and contribution factor for accident – principles of accident prevention, Supervisory role- Role of safety committee – Accident causation models - Cost of accident.

UNIT II	ACCIDENT INVESTIGATION	9

Types of injury, Near misses, Dangerous occurrences, Moral, legal and financial arguments for investigations, Management system requirements (ISO 45001), Benefits of incident investigation , Investigating near misses

UNIT III	ACCIDENT REPORTING	9

Overall accident investigation process - Response to accidents, India reporting requirement, Planning document, Planning matrix, Investigators Kit, functions of investigator, four types of evidences,

UNIT IV	ACCIDENT ROOT CAUSE ANALYSIS	9

Root cause analysis: advanced incident investigation techniques Fault tree analysis, Event tree analysis, Cause and effect analysis/fishbone diagram

UNIT V	ACCIDENT PREVENTION	9

Importance of accurate reporting , Elements of an effective accident report, Legal considerations and confidentiality, Records of accidents, Developing corrective action plans, Implementing preventive measures, Monitoring and evaluating effectiveness. Accident reports - Class exercise with case study

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Assess accident, accident causation models and its impacts	4
CO2.	Analyze the fundamental requirements and importance of accident investigation.	4
CO3.	Investigate accidents and incidents.	3
CO4.	Analyse root cause and effects of accidents.	4
CO5	Identify accident preventive measures and prevent Accidents.	3

TEXT BOOKS:

1. Heinrich H.W. “Industrial Accident Prevention” McGraw-Hill Company, New York, Fifth Edition 2007
2. Lees, F.P. “Loss Prevention in Process Industries” Butterworths and Company, Fourth Edition, 2012.

REFERENCES:

1. Accident Prevention Manual for Industrial Operations”, N.S.C.Chicago, Third edition 2008.
2. Introduction To Incident Investigation, A course book for the NEBOSH HSE Introduction to Incident Investigation
3. Lee N. Vanden Heuvel, "Root Cause Analysis Handbook: A Guide to Efficient and Effective Incident Investigation" 3rd Edittion, ABS Consulting.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	1	0	0	3	3	3	1	1	0	1	3	3
CO2	3	2	1	0	0	3	3	3	1	1	0	1	3	3
CO3	2	2	3	2	3	3	3	2	2	1	3	3	3	3
CO4	3	3	3	3	3	3	3	2	2	2	3	3	3	3
CO5	3	3	3	3	3	3	2	1	3	3	3	3	3	3

CH22036	FIRST AID AND SAFETY PRECAUTIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To educate the students on basic first aid techniques and regulatory compliances

UNIT I	**INTRODUCTION**	**9**

Definition of first aid, importance of first aid in process Industries, overview of safety precautions in process industries. Identification of common hazards in process industries and understand the risk associated with each hazard. Material Safety Data Sheet.

UNIT II	**BASIC FIRST AID TECHNIQUES**	**9**

Assessing the scene and ensuring the safety, assessing the victim and identifying the emergency, Principles of CPR (Cardiopulmonary Resuscitation), Basic wound care: cuts, burns, fractures, etc. Management of shock.

UNIT III	**SPECIFIC FIRST AID SITUATIONS IN PROCESS INDUSTRIES**	**9**

Chemical exposure: identification and treatment, Thermal injuries: burns and scalds, Electrical injuries: shock, burns, and electrocution, Inhalation injuries: exposure to harmful gases or fumes, Machinery accidents: crush injuries, amputations, etc.,

UNIT IV	**EMERGENCY RESPONSE PROCEDURE AND PERSONAL PROTECTIVE EQUIPMENTS**	**9**

Activation of emergency response systems, Evacuation procedures, Communication protocols during emergencies, Role of first aiders in emergency situation, Selection and proper use of PPE in process industries, Importance of PPE in preventing injuries and exposure to hazardous materials.

UNIT V	**SAFETY TRAINING, EDUCATION AND REGULATORY COMPLIANCE**	**9**

Importance of safety training for all employees, Regular drills and exercises for emergency preparedness, Role of management in promoting a safety culture, Overview of relevant regulations and standards, Responsibilities of employers and employees in ensuring workplace safety, Consequences of non-compliance with safety regulations.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Demonstrate proficiency in basic first aid techniques.	3
CO2.	Identify and mitigate workplace hazards.	3
CO3.	Assess the importance of personal protective equipment(PPE).	4
CO4.	Develop Emergency response Skills.	3
CO5	Comply with regulatory requirements.	3

REFERENCES:

1. James S. Angle "Occupational Safety and Health in the Emergency Services" 4th edition Jones & Bartlett Learning , 2015
2. Daniel A. Crowl and Joseph F. Louvar , "Chemical Process Safety: Fundamentals with Applications", 4th edition, Pearson Prentice Hall, 2020
3. "Emergency Care and Transportation of the Sick and Injured" by American Academy of Orthopaedic Surgeons (AAOS)
4. Jeremy W. Stranks , "Health and Safety at Work: An Essential Guide for Managers" Kogan Page, 10th Eddition, 2016
5. Roger L. Brauer, "Safety and Health for Engineers", Wiley, 3rd Edition, 2016.
6. Tao Le, Vikas Bhushan, and Matthew Sochat, "First Aid for the USMLE Step 1", dnamart, 2022.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1	1	1	0	3	0	3	1	2	0	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	1	2	2	0	1	3	3	1	0	0	1	3	3
CO4	2	2	2	2	3	1	3	1	3	3	3	2	3	3
CO5	2	2	1	0	0	3	3	1	2	1	2	0	3	3

CH22037	SAFETY IN PROCESS INDUSTRIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To give an overview of safety in process design, commissioning and maintenance stages.

UNIT I	**SAFETY IN PROCESS DESIGN AND PRESSURE SYSTEM DESIGN**	**9**

Design process, conceptual design and detail design, assessment, inherently safer design- chemical reactor types, batch reactors, reaction hazard evaluation, assessment, reactor safety, operating conditions, unit operations and equipment, utilities. Pressure system, pressure vessel design, standards and codes- pipe works and valves- heat exchangers- process machinery- over pressure protection, pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems- failures in pressure system.

UNIT II	PLANT COMMISSIONING AND INSPECTION	**9**

Commissioning phases and organization, pre-commissioning documents, process commissioning, commissioning problems, post commissioning documentation Plant inspection, pressure vessel, pressure piping system, non destructive testing, pressure testing, leak testing and monitoring- plant monitoring, performance monitoring, condition, vibration, corrosion, acoustic emission-pipe line inspection.

UNIT III	**PLANT OPERATIONS**	**9**

Operating discipline, operating procedure and inspection, format, emergency procedures- hand over and permit system- startup and shut down operation, refinery units- operation of fired heaters, driers, storage- operating activities and hazards- trip systems- exposure of personnel

UNIT IV	**PLANT MAINTENANCE, MODIFICATION AND EMERGENCY PLANNING**	**9**

Management of maintenance, hazards- preparation for maintenance, isolation, purging, cleaning, confined spaces, permit system- maintenance equipment- hot works- tank cleaning, repair and demolition- online repairs- maintenance of protective devices- modification of plant, problemscontrols of modifications. Emergency planning, disaster planning, onsite emergency- offsite emergency, APELL

UNIT V	**STORAGES**	**9**

General consideration, petroleum product storages, storage tanks and vessel- storages lay out segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief- fire prevention and protection- LPG storages, pressure storages, layout, instrumentation, vapourizer, refrigerated storages- LNG storages, hydrogen storages, toxic storages, chlorine storages, ammonia storages, other chemical storages- underground storages- loading and unloading facilities- drum and cylinder storage- ware house, storage hazard assessment of LPG and LNG

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Asses safe design of equipment which are essential to the chemical industry and leads to design of entire process industries.	4
CO2.	Commissioning and Inspection of Plant	5
CO3.	Find innovative solutions while industries facing Problems in commissioning and maintenance stages.	3
CO4.	Prepare the emergency planning for chemical industry problems	3
CO5	Create safe storage systems	6

TEXT BOOKS:

1. "Quantitative Risk Assessment in Chemical Process Industries" American Institute of Chemical Industries, Centre for Chemical Process safety. Second Eddition, 2010
2. Fawcett, H.h. and Wood, "Safety and Accident Prevention in Chemical Operations" Wiley inters, Second Edition.1965.
3. GREEN, A.E., "High Risk Safety Technology", John Wiley and Sons,. 1984.
4. Lees, F.P. "Loss Prevention in Process Industries" Butterworths and Company, Fourth Eddition, 2012.

REFERENCES:

1. "Accident Prevention Manual for Industrial Operations" NSC, Chicago, 1982.
2. Carbide of Calcium Rules, Government of India.
3. Petroleum Act and Rules, Government of India

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	2	2	3	3	3	3	3	3	3	3	3
CO2	3	3	3	2	2	3	3	3	3	3	3	3	3	3
CO3	3	3	2	0	0	3	2	1	3	3	3	2	3	3
CO4	3	3	2	0	0	3	1	1	1	3	2	2	3	3
CO5	3	3	3	2	2	3	3	3	3	3	3	3	3	3

CH22038	PROCESS SAFETY MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To educate students on Process safety and management

UNIT I	**PROCESS SAFETY LEADERSHIP**	**9**

Over view of Process Safety, Importance of Process safety in industrial operations. Process safety leadership, Organizational learning, Management of change, Worker engagement, Competence.

UNIT II	**MANAGEMENT OF PROCESS RISK**	**9**

Establishing a process safety management system, Risk management techniques used within the process industries, Asset management and maintenance strategies, Role and purpose and features of a permit-to-work system, Safe shift handover and Contractor management.

UNIT III	**PROCESS SAFETY HAZARD CONTROL**	**9**

Operating procedures, Safe start-up and shut-down, Safety critical performance standards, Utilities, Electricity/static electricity, Dangerous substances, Reaction hazards, Bulk storage operations. Hazard Identification and Risk assessment, Process safety information, Process Hazard Analysis

UNIT IV	**FIRE AND EXPLOSION PROTECTION**	**9**

Fire hazards, Fire and explosion control, Dust explosions, Primary and secondary explosions, Prevention of dust explosions, Mitigation of dust explosions.

UNIT V	**EMERGENCY RESPONSE**	**9**

Purpose of an emergency plan, Development of an emergency plan, Content of an emergency plan, Information management during emergencies including liaison with the media, Competency of emergency responders / command team.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyze the fundamental principles of process safety and its importance in industrial operations.	4
CO2.	Assess the Process safety and comprehend risk management in chemical process plants	4
CO3.	Analyze the Process Hazard in chemical process industries	4
CO4.	Identify and control fire and explosion hazards.	3
CO5	Develop emergency response plans and participate	5

TEXT BOOKS:

1. Daniel A. Crowl and Joseph F. Louvar , "Chemical Process Safety: Fundamentals with Applications", 4th edition, Pearson Prentice Hall, 2020
2. "Quantitative Risk Assessment in Chemical Process Industries" American Institute of Chemical Industries, Centre for Chemical Process safety.

REFERENCES:

1. Lees, F.P. "Loss Prevention in Process Industries" Butterworths and Company, 1996
2. Dangerous substances and explosive atmosphere, Approved Code of Practice and guidance, L138, HSE Books, ISBN: 978-0-7176-6616-4.
3. Designing and operating safe chemical reaction processes, HSG143, HSE Books, ISBN: 978-0-7176-1051-8.
4. Developing process safety indicators, A step-by-step guide for chemical and major hazard industries, HSG254, HSE Books, ISBN: 978-0-7176-6180-0.
5. Guidance on permit-to-work systems. A guide for the petroleum, chemical and allied industries, HSG250, HSE Books, ISBN: 978-0-7176-2943-5.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1	2	0	0	3	3	3	0	0	0	0	3	3
CO2	3	3	3	2	3	3	3	3	2	0	0	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	0	2	3	3	0	3	3	3	3	0	3	3	3	3
CO5	0	3	3	2	0	3	3	3	3	3	3	0	3	3

VERTICAL IV: ENERGY ENGINEERING

CH22041	RENEWABLE ENERGY RESOURCES (COMMON TO CH, ME AND MR)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Understand energy scenario, energy sources and their utilization.
Explore society's present needs and future energy demands.
Study the principles of renewable energy conversion systems.
Exposed to energy conservation methods

UNIT I	**INTRODUCTION**	**9**

Introduction: Principles of renewable energy; energy and sustainable development, fundamentals and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale. Introduction to Internet of energy (IOE)

UNIT II	**SOLAR ENERGY**	**9**

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Sunshine Recorder.Solar Thermal systems: Flat plate collector; Solar distillation; Solar pond electric power plant. Solar electric power generation- Principle of Solar cell, Photovoltaic system for electric power generation, advantages, Disadvantages and applications of solar photovoltaic system.

UNIT III	**WIND AND BIOMASS ENERGY**	**9**

Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and multiblade system. Vertical axis- Savonius and darrieus types. Biomass Energy: Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies-fixed dome; Urban waste to energy conversion; Biomass gasification (Downdraft)

UNIT IV	**TIDAL AND OCEAN THERMAL ENERGY**	**9**

Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages and limitations. Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems associated with OTEC.

UNIT V	**GREEN ENERGY**	**9**

Green Energy: Introduction, Fuel cells: Classification of fuel cells – H_2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy

TOTAL: PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Describe the environmental aspects of renewable energy resources. In Comparison with various conventional energy systems, their prospects and limitations.	**3**
CO2.	Describe the use of solar energy and the various components used in the energy production with respect to applications like-heating, cooling, desalination, power generation	**3**
CO3.	Apply the conversion principles of wind and tidal energy	**3**
CO4.	Apply the concept of biomass energy resources and green energy.	**3**
CO5	Acquire the basic knowledge of ocean thermal energy conversion and hydrogen energy	**3**

TEXT BOOKS:

1. Principles of Energy conversion, A. W. Culp Jr.,, McGraw Hill, 1996
2. Non-Convention Energy Resources, Shobh Nath Singh, Pearson, 2018

REFERENCES:

1. D. Yogi Goswami & Frank Kreith, Energy Efficiency and Renewable Energy Handbook, Second Edition, 2016
2. Imene Yahyaoui, Advances in Renewable Energies and Power Technologies: Volume 1: Solar and Wind Energies, 2018.
3. John Twiddel & Tony Weir, Renewable Energy Resources, 2006.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	1	1	1	2	1	3	1	1	1	3	2	2
CO2	2	2	2	1	1	2	3	3	2	3	1	3	2	2
CO3	2	2	2	1	1	3	3	3	2	3	1	3	2	2
CO4	3	2	2	1	1	3	3	3	2	3	1	3	3	2
CO5	3	2	2	1	1	3	3	3	2	3	1	3	3	2

CH22042	ENERGY AND ENVIRONMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Understand the various sources of energy and their environmental implications.

Impart energy conversion processes and technologies.

Evaluate the environmental impact of energy production and consumption.

Explore sustainable energy solutions and their implementation.

Develop critical thinking and problem-solving skills to address energy and environmental challenges.

UNIT I	**INTRODUCTION TO ENERGY AND ENVIRONMENT**	**9**

Definition of energy and its forms - Environmental challenges related to energy production and consumption, Role of chemical engineers in energy and environmental sustainability

UNIT II	**ENERGY RESOURCES**	**9**

Fossil fuels - Coal, Oil and natural gas, Renewable energy sources - Solar, Wind, Hydroelectric, Biomass and Nuclear energy

UNIT III	**ENERGY CONVERSION TECHNOLOGIES**	**9**

Thermal power plants, Renewable energy systems, Energy storage technologies, Energy efficiency and conservation

UNIT IV	**ENVIRONMENTAL POLLUTION AND CLIMATE CHANGE**	**9**

Air pollution: sources, effects, and control measures, Water pollution: sources, effects, and treatment methods, Soil contamination and remediation. Greenhouse effect and global warming, Impacts of climate change on ecosystems and human health, Mitigation and adaptation strategies

UNIT V	**SUSTAINABLE ENERGY SOLUTIONS AND ROLE OF CHEMICAL ENGINEERS**	**9**

Sustainable development principles, Energy policy and regulations, Case studies of sustainable energy projects, Application of chemical engineering principles to energy and environmental problems, Technological innovations for sustainable energy production and environmental protection

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the various forms of energy and environmental sustainability	**3**
CO2.	Impart the knowledge on various energy resources	**3**
CO3.	Understand different energy conservation technologies for an efficient usage	**3**
CO4.	Develop the information on environmental pollution and climate change	**3**
CO5	Acquire the information on sustainable energy solutions and role of Chemical Engineers	**3**

TEXT BOOKS:

1. Jeffrey Peirce, P.Aarne Vesilind, and Ruth F. Weiner "Introduction to Energy and Environment" 1998.
2. David J.C. MacKay "Sustainable Energy - Without the Hot Air" 2010
3. Richard Wolfson "Energy, Environment, and Climate" 2018
4. Gilbert M. Masters "Renewable and Efficient Electric Power Systems"2005
5. Mackenzie L. Davis and Susan J. Masten "Principles of Environmental Engineering and Science" 2008

REFERENCES:

1. Bharucha, E., Textbook of Environmental Studies, Universities Press (2005).
2. Chapman, J.L. and Reiss, M.J., Ecology-Principles and Application, Cambridge University Press (LPE) (1999).
3. Wright, R.T., Environmental Science-Towards a sustainable Future, Prentice Hall (2008) 9 th Edition.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	1	2	2	2	1	3	2	2	1	3	3	2
CO2	2	2	2	2	2	2	3	3	2	3	1	3	3	2
CO3	2	2	2	2	2	3	3	3	2	3	1	3	3	2
CO4	3	2	2	2	2	3	3	3	2	3	1	3	3	2
CO5	3	2	2	2	2	3	3	3	2	3	1	3	3	2

CH22043	ENERGY CONSERVATION IN UTILITIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Understand the importance of energy conservation in industrial utilities.
Impart energy consumption patterns and identify opportunities for energy savings.
Apply principles of heat integration and process optimization to maximize energy efficiency.
Evaluate technologies and strategies for waste heat recovery and cogeneration.
Develop skills to design, implement, and assess energy conservation measures in utilities

UNIT I	INTRODUCTION TO ENERGY CONSERVATION IN UTILITIES	9

Importance of energy conservation in industrial operations, Overview of energy consumption in utilities: Steam, Electricity & Refrigeration, Economic and environmental benefits of energy efficiency measures

UNIT II	ENERGY AUDITS AND ENERGY MANAGEMENT SYSTEMS	9

Types of energy audits - Walk-through audit, Preliminary audit, Detailed audit, Energy management standards and frameworks (ISO 50001), Energy performance indicators and benchmarking

UNIT III	HEAT INTEGRATION AND PROCESS OPTIMIZATION AND ENERGY EFFICIENCY MEASURES	9

Pinch analysis and heat exchanger network design, Process integration techniques: Heat cascading and Heat recovery, Optimization of utility systems: Steam generation, Cooling water and refrigeration, Boiler efficiency improvement techniques, Steam system optimization : Steam traps and condensate recovery, Pumping systems efficiency improvement, Lighting and HVAC system optimization

UNIT IV	COGENERATION AND COMBINED HEAT AND POWER (CHP)	9

Principles of cogeneration and CHP systems, Types of prime movers: Steam turbines, Gas turbines, Reciprocating engines, Cogeneration system design and performance evaluation

UNIT V	WASTE HEAT RECOVERY AND EMERGING TECHNOLOGIES AND BEST PRACTICES	9

Sources of waste heat in industrial processes, Technologies for waste heat recovery: Heat exchangers, Organic Rankine cycle, Case studies of waste heat recovery projects.

Advanced process control for energy efficiency, Integration of renewable energy sources, Energy storage technologies and demand-side management.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Familiarity with energy conservation in utilities	**2**
CO2.	Ability to understand about energy audits and energy management systems	**3**
CO3.	Acquire the concept of heat integration and process optimization and energy efficiency measures	**3**
CO4.	Apply the concepts of cogeneration and combined heat and power	**3**
CO5	Acquire the knowledge on waste heat recovery and emerging technologies and best practices	**3**

TEXT BOOKS:

Wayne C. Turner and Steve Doty, " Energy Management Handbook" 2013
D. Yogi Goswami and Frank Kreith, "Industrial Energy Management: Principles and Applications" 2012

REFERENCES:

Francis S. Lee and George E. Kelly , "Energy Conservation in the Process Industries" 2018
Henning H. Meier and Hans-Peter Kau, "Cogeneration: Combined Heat and Power (CHP): Thermodynamics and Economics" 2003
Kuppan Thulukkanam, "Heat Exchanger Design Handbook"2013

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	1	2	2	2	1	3	1	1	1	3	3	2
CO2	2	2	2	2	2	2	3	3	2	3	1	3	3	2
CO3	2	2	2	2	2	3	3	3	2	3	1	3	3	2
CO4	3	2	2	2	2	3	3	3	2	3	1	3	3	2
CO5	3	2	2	2	2	3	3	3	2	3	1	3	3	2

CH22044	ENERGY CONVERSION AND STORAGE TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Understand energy storage systems and their utilization.
Explore batteries magnetic and electric storage systems and its usage in present scenario
Study the principles of renewable energy conversionsystems.
Exposed to fuel cells and its

uses

UNIT I	ENERGY CONVERSION AND STORAGE	9

Need of energy storage - flywheel storage- electrical and magnetic energy storage- capacitors - electromagnets- chemical energy storage- thermo chemical- photochemical- biochemical - electrochemical- fossil fuels and synthetic fuels- hydrogen for energy storage -Ragone plot of energy storage devices.

UNIT II	MECHANICAL, THERMAL AND ELECTROCHEMICAL ENERGY CONVERSION	9

Mechanical power generation technologies: Turbines and Generators, Energy conversion in rotating machinery: Pumps and Compressors

Thermal power generation technologies: Steam turbines, Gas turbines and Combined heat and power (CHP) systems

Fuel cells: types, working principles, and applications, Electrochemical capacitors and supercapacitors

UNIT III	ENERGY STORAGE SYSTEMS	9

Battery energy storage: types, construction, and operation, Thermal energy storage: Phase change materials, Sensible heat storage, Flywheel energy storage and Compressed air energy storage

UNIT IV	INTEGRATION OF ENERGY CONVERSION AND STORAGE IN RENEWABLE ENERGY SYSTEMS	9

Grid integration of renewable energy sources, Energy management and control strategies, Case studies of integrated energy systems

UNIT V	EMERGING TRENDS AND INNOVATIONS	9

Advances in energy conversion technologies: Nanotechnology and materials science, Innovations in energy storage materials and systems, Future directions in energy conversion and storage research

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Familiarity with various energy storage systems, different types of batteries, supercapacitors, direct energy conversion devices and fuel cells	**3**
CO2.	Ability to understand about different energy conversion techniques	**3**
CO3.	Apply the mechanism and principle of various energy storage systems	**3**
CO4.	Apply the concepts of integration of energy conversion and storage in renewable energy systems	**3**
CO5	Acquire the knowledge on emerging trends and innovations in energy conversion and storage technologies	**3**

TEXT BOOKS:

1. Non -Conventional Energy Sources and Utilization, Er.R.K.Rajput, S.Chand Publishers
2. Non -Conventional Energy Resources, third edition B. H. Khan, Mc Graw Hil Education Pvt. Ltd.
3. S. Kalaiselvam and R. Parameshwaran."Thermal Energy Storage Technologies for Sustainability: Systems Design, Assessment, and Applications" 2018

REFERENCES:

1. Fundamentals of Energy Storage, J. Jensen , B. Squrensen, John Wiley, NY
2. Electrochemical Power Sources: Primary and Secondary Batteries , P. Peregrines, IEE
3. Supercapacitors: Materials, Systems, and Applications ,Kindle Edition, Francois Beguin , Elzbieta Frackowiak ,Wiley-VCH
4. Serguei N. Lvov, "Introduction to Electrochemical Science and Engineering"2021

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	1	1	2	2	1	3	1	1	1	3	2	2
CO2	2	2	2	1	2	2	3	3	2	3	1	3	2	2
CO3	2	2	2	1	2	3	3	3	2	3	1	3	2	2
CO4	3	2	2	1	2	3	3	3	2	3	1	3	3	2
CO5	3	2	2	1	2	3	3	3	2	3	1	3	3	2

CH22045	WASTE MANAGEMENT AND ENERGY RECOVERY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: Provides with a comprehensive overview of waste management methodologies, covering a spectrum of practices from collection to disposal. Through detailed study, insights into the latest advancements in waste-to-energy technologies, including anaerobic digestion, landfill gas recovery, and thermal conversion methods. Additionally, recent innovations in waste disposal techniques such as landfill mining and bioreactor landfills will be explored, highlighting their potential for minimizing environmental impact and promoting resource recovery.

UNIT I	**CHARACTERISTICS AND PERSPECTIVES**	**9**

Sources – Types – Composition – Generation – Estimation Techniques – Characterization – Types of Collection System – Transfer Stations – Transfer Operations – Material Recycle / Recovery Facilities.

UNIT II	**UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES**	**9**

Separation & Processing: Size Reduction – Separation through Density Variation, Magnetic / Electric Field : Densification - Physical, Chemical and Biological Properties and Transformation Technologies – Selection of Proper Mix of Technologies.

UNIT III	**WASTE DISPOSAL**	**9**

Landfill Classification – Types – Siting Considerations – Landfill Gas (Generation, Extraction, Gas Usage Techniques) – Leachates Formation, Movement, Control Techniques – Environmental Quality Monitoring – Layout, Closure & Post Closure Operation – Reclamation.

UNIT IV	**TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION**	**9**

Physical Transformation: Component Separation & Volume Reduction: Chemical Transformation – Combustion/Gasification/ Pyrolysis: Energy Recovery - Biological Transformation – Aerobic Composting – Anaerobic Digestion.

UNIT V	HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING	**9**

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – RDF / Mass Firing – Material Recycling: Paper / Glass / Plastics etc., - Disposal of White Goods & E-Wastes.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Identify concepts necessary to contribute effectively to the planning, design, operation, and management of solid waste management systems.	U

CO2.	Acquire the expertise needed to design, implement, and enhance solid waste separation, processing, and transformation processes, promoting sustainable waste management practices and maximizing resource utilization.	U
CO3.	Demonstrate proficiency in designing, operating, and managing landfills with environmental responsibility, ensuring regulatory compliance, and minimizing adverse effects on public health and the environment.	AP
CO4.	Evaluate, select, and implement physical, chemical, and biological transformation technologies for sustainable waste management and resource recovery initiatives.	AP
CO5	Apply recycling technologies for sustainable waste management and resource recovery initiatives.	AP

TEXT BOOKS:

Energy Cogeneration Hand book, George Polimveros, Industrial Press Inc, New York 1982
Howard S. Peavy etal, "Environmental Engineering", McGraw Hill International Edition, 1985.
LaGrega, M., et al., "Hazardous Waste Management", McGraw-Hill, c. 1200 pp., 2nd ed.,2001

REFERENCES:

Manoj Datta, "Waste Disposal in Engineered Landfills", Narosa Publishing House, 1997.
Parker Colin and Roberts, "Energy from Waste – An Evaluation of Conversion Technologies", Elsevier Applied Science, London, 1985.
Tchobanoglous, Theisen and Vigil, "Integrated Solid Waste Management", 2d Ed. McGrawHill, New York, 1993

COURSE ARTICULATION MATRIX

CO	**PO**												**PSO**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2			3	3	2	1	2	2	3	3	2
CO2	3	3	2			3	3	2	1	2	2	3	3	2
CO3	3	3	2			3	3	2	1	2	2	3	3	2
CO4	3	3	2			3	3	2	1	2	2	3	3	2
CO5	3	3	2			3	3	2	1	2	2	3	3	2

CH22046	ALTERNATIVE ENERGY RESOURCES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To understand the concept of various forms of energy and the utilization of renewable energy sources for both domestic and industrial applications, and to study the environmental and cost economics of using renewable energy sources compared to fossil fuels.

UNIT I	**COMMERCIAL ENERGY**	**9**

Coal, Oil, Natural gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

UNIT II	**SOLAR ENERGY**	**9**

Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

UNIT III	**WIND ENERGY**	**9**

Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics, applications – offshore wind energy - Hybrid systems - safety and environmental aspects – wind energy potential and installation in India - Repowering concept

UNIT IV	**BIO-ENERGY**	**9**

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - types of biogas Plant - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT V	**OTHER TYPES OF ENERGY**	**9**

Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plant - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plant – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Achieve expertise in analyzing historical, current, and projected energy consumption trends, evaluating the environmental impact of fossil fuel utilization, and assessing challenges and opportunities within India's energy sector.	U
CO2.	Apply solar energy technologies and their role in addressing global energy challenges and advancing sustainable development goals.	AP
CO3.	Develop knowledge and skills necessary to contribute effectively to the development, deployment, and management of wind energy projects, fostering sustainable energy transition and environmental stewardship.	AP
CO4.	Apply knowledge and skills necessary to development, implementation, and management of biomass energy projects, fostering sustainable bioenergy production and utilization.	AP
CO5	Apply concepts of management of ocean energy, geothermal energy, and hydrogen-based technologies, fostering sustainable energy solutions and environmental stewardship.	AP

TEXT BOOKS:

1. Bent Sorensen , "Renewable Energy", Elsevier, Academic Press, 2011
2. Bridgurater A.V., "Thermochemical processing of Biomass", Academic Press, 1981

REFERENCES:

1. Anthony San Pietro, "Biochemical and Photosynthetic aspects of Energy Production", Academic Press, 1980.
2. Godfrey Boyle, "Renewable Energy Power for a Sustainable Future", Oxford University Press, U.K, 1996

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2			3	3	2	2	3	2	3	3	2
CO2	3	2	2			3	3	2	2	3	2	3	3	2
CO3	3	2	2			3	3	2	2	3	2	3	3	2
CO4	3	2	2			3	3	2	2	3	2	3	3	2
CO5	3	2	2			3	3	2	2	3	2	3	3	2

CH22047	MEASUREMENT AND CONTROL FOR ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To understand the principle and use of sensors for measurement of different thermal and electrical parameters and concept of control systems, modes, design and their applications.

UNIT I	**MEASUREMENT CHARACTERISTICS**	**9**

Introduction to measurements, Errors in measurements, Statistical analysis of data, Regression analysis, Correlation, Estimation of uncertainty and Presentation of data, Design of experiments – Experimental design factors and protocols

UNIT II	**MEASUREMENTS IN ENERGY SYSTEMS**	**9**

Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow rate, thermo-physical and transport properties of solids liquids and gases, Radiation properties of surfaces, Vibration and noise - Computer assisted data acquisition, Data manipulation and data presentation.

UNIT III	**CONTROL SYSTEMS**	**9**

Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Effect of disturbances – Dynamic characteristics.

UNIT IV	**CONTROL COMPONENTS AND CONTROLLER**	**9**

Process characteristics, Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - continuous, discontinuous and composite control modes – Analog and Digital controllers.

UNIT V	**DESIGNING OF MEASUREMENT AND CONTROL SYSTEMS**	**9**

Designing of temperature, pressure, flow and liquid level measurement and control system – Performance – Steady state accuracy – Transient response – Frequency response – Fault finding – Computer based controls.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Develop a solid foundation in measurement principles, error analysis, statistical data analysis including regression and correlation techniques,	U
CO2.	Equip with the knowledge and skills in basic electrical measurements, Additionally, proficient in computer-assisted data acquisition, manipulation, and presentation techniques.	AP
CO3.	Build clarity on control aspects, particularly in relation to Energy Conservation Schemes.	U
CO4.	Develop proficiency in understanding process characteristics and control system parameters.	U
CO5	Acquire the skills to design measurement and control systems for temperature, pressure, flow, and liquid level.	AP

TEXT BOOKS:

Alan S Morris and Reza Langari, "Measurements and Instrumentation – Theory and Application", Elsevier Inc, 2012.
Bolten. W, "Industrial Control and Instrumentation", University Press, 2004.

REFERENCES:

Curtis D Johnson, 'Process Control Instrumentation Technology", PHI Learning Private Limited, 2011.
Doblin E.O, 'Measurement System Application and Design", Second Edition, McGraw Hill, 1978.
Venkateshan.S.P, "Mechanical Measurements", Ane Books Pvt Ltd, 2010

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3			2	2	2	1	3		3	3	2
CO2	3	3	3			2	2	2	1	3		3	3	2
CO3	3	3	3			2	2	2	1	3		3	3	2
CO4	3	3	3			2	2	2	1	3		3	3	2
CO5	3	3	3			2	2	2	1	3		3	3	2

CH22048	ENERGY AUDIT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To provide advanced knowledge and skills in energy management and auditing, enabling them to analyze, optimize, and implement effective energy conservation strategies across diverse sectors, thereby fostering sustainable energy practices and resource utilization.

UNIT I	**ENERGY SCENARIO**	**9**

Energy needs of growing economy, long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment: Air pollution, Climate change, Energy security, Energy conservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features

UNIT II	**ENERGY MANAGEMENT:**	**9**

Concept of energy management, energy demand and supply, economic analysis; Duties and responsibilities of energy managers. Energy Conservation: Basic concept, energy conservation in Household, Transportation, Agricultural, service and Industrial sectors, Lighting, HAVC.

UNIT III	**MATERIAL ENERGY BALANCE**	**9**

Method for preparing process flow; material and energy balance diagrams. Energy Action Planning: Key elements, force field analysis; Energy policy purpose, perspective, content, formulation, rectification.

UNIT IV	**MONITORING AND TARGETING**	**9**

Definition monitoring & targeting; Data and information analysis. Electrical Energy Management: energy conservation in motors, pumps and fan systems; energy efficient motors.

UNIT V	**THERMAL ENERGY MANAGEMENT:**	**9**

Energy conservation in boilers, steam turbine and industrial heating system; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pump; Building Energy Management.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Analyse about energy scenario nationwide and worldwide.	AN
CO2.	Apply energy management in more effective way.	AP
CO3.	Analyse, plan, and manage energy resources within various organizational contexts, contributing to sustainable practices and efficiency improvements.	AN
CO4.	Efficiently manage and optimize electrical energy systems to achieve cost savings, enhance environmental sustainability, and improve organizational efficiency.	AP
CO5	Acquire knowledge and skills necessary to implement effective energy conservation measures across a wide range of industrial and commercial settings, contributing to sustainability goals and operational efficiency.	AP

TEXT BOOKS:

1. Ashok Kumar L and Gokul Ganesan, Energy Audit and Management, CRC press, 2022
2. Murphy & Mckay, Energy Management, BSP Books Pvt. Ltd.

REFERENCES:

1. Rajan GG, Optimising Energy Efficiency in Industry, TMH.
2. Callaghan P O, Energy Management, McGraw-Hill Book Company.
3. Hamies; Energy Auditing and Conservation: Method, Measurement

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2			2	3	2	2	3	2	3	3	2
CO2	3	2	2			2	3	2	2	3	2	3	3	2
CO3	3	2	2			2	3	2	2	3	2	3	3	2
CO4	3	2	2			2	3	2	2	3	2	3	3	2
CO5	3	2	2			2	3	2	2	3	2	3	3	2

VERTICAL V: ENVIRONMENTAL ENGINEERING (Common to CH & CE)

CH22051	INDUSTRIAL WASTE MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To provide an understanding of solid waste classification, characteristics and its management, by following regulations and including environment risk assessment.

UNIT I	**FUNDAMENTALS**	**9**

Types of industries and industrial pollution – Characteristics of industrial wastes – Population equivalent – Bioassay studies – effects of industrial effluents on streams, sewer, land, sewage treatment plants and human health – ISI tolerance limits for discharging industrial effluents into surface water, into public sewers and on to land for irrigation- Environmental legislations related to prevention and control of industrial effluents and hazardous wastes.

UNIT II	**CLEANER PRODUCTION**	**9**

Waste management Approach – Waste Audit – Volume and strength reduction – Material and process modifications – Removal of Nitrogen and Phosphorus –Boiler water treatment methods and cooling water treatment methods Recycle, reuse and byproduct recovery – Applications

UNIT III	**POLLUTION FROM MAJOR INDUSTRIES**	**9**

Sources, Characteristics, waste treatment flow sheets for selected industries such as Textiles, Tanneries, Pharmaceuticals, Electroplating industries, Dairy, Sugar, Paper, distilleries, Cement,Steel plants, Refineries, fertilizer, thermal power plants – Wastewater reclamation concepts.

UNIT IV	**TREATMENT TECHNOLOGIES**	**9**

Equalisation – Neutralisation – Flotation – Precipitation – Heavy metal Removal– Aerobic and anaerobic biological treatment – Sequencing batch reactors – High Rate reactors - Chemical oxidation – Ozonation – carbon adsorption - Photocatalysis – Wet Air Oxidation – Evaporation – Ion Exchange – Membrane Technologies – Nutrient removal.- Treatability studies

UNIT V	**HAZARDOUS WASTE MANAGEMENT**	**9**

Hazardous wastes - Physico chemical treatment – solidification – incineration – Secured landfills, Zero effluent discharge system.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Develop the knowledge on the sources and characteristics of pollutants.	3
CO2.	Analyze the sources, types and composition of solid waste with methods of handling, sampling and storage of solid waste.	4
CO3.	Inspect the appropriate method for solid waste collection, transportation, redistribution and disposal.	4
CO4.	Identify the methods of disposal of hazardous & radioactive solid waste.	3
CO5	Infer about the risk assessment and regulations of solid waste management.	3

TEXT BOOKS:

1. M.N.Rao & A.K.Dutta, "Wastewater Treatment", Oxford - IBH Publication, 1995.
2. W .W. Eckenfelder Jr., "Industrial Water Pollution Control", McGraw-Hill Book Company, New Delhi, 2000.

REFERENCES:

1. T.T.Shen, "Industrial Pollution Prevention", Springer, 1999.
2. R.L.Stephenson and J.B.Blackburn, Jr., "Industrial Wastewater Systems Hand book", Lewis Publisher, New Yark, 1998.
3. H.M.Freeman, "Industrial Pollution Prevention Hand Book", McGraw-Hill Inc., New Delhi, 1995.
4. Bishop, P.L., "Pollution Prevention: Fundamental & Practice", McGraw-Hill, 2000.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	3	2	2	3	2	3	3	2	2	2	2	2	2
CO2	2	3	2	2	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	3	3	2	2	2	2	2	3
CO4	2	2	2	2	2	2	3	3	2	2	2	2	2	2
CO5	2	2	1	2	2	2	2	3	3	2	2	2	1	1

CH22052	AIR POLLUTION MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This subject covers the sources, characteristics and effects of air and noise pollution and the methods of controlling the same. The student is expected to know about source inventory and control mechanism.

UNIT I	**SOURCES AND EFFECTS OF AIR POLLUTANTS**	**9**

Classification of air pollutants – Particulates and gaseous pollutants – Sources of air pollution – Source inventory – Effects of air pollution on human beings, materials, vegetation, animals – global warming-ozone layer depletion, Sampling and Analysis – Basic Principles of Sampling – Source and ambient sampling – Analysis of pollutants – Principles-Impacts of Air pollution on building materials and structures.

UNIT II	**DISPERSION OF POLLUTANTS**	**9**

Elements of atmosphere – Meteorological factors – Wind roses – Lapse rate - Atmospheric stability and turbulence – Plume rise – Air Quality Index-Dispersion of pollutants – Dispersion models – Applications

UNIT III	**AIR POLLUTION CONTROL**	**9**

Concepts of control – Principles and design of control measures – Particulates control by gravitational, centrifugal, filtration, scrubbing, electrostatic precipitation – Selection criteria for equipment - gaseous pollutant control by adsorption, absorption, condensation, combustion – Pollution control for specific major industries- Air Pollution control devices.

UNIT IV	**AIR QUALITY MANAGEMENT**	**9**

Air quality standards – Air quality monitoring – Sampling and Analysis of SO_2 and NO_2 in ambient air-Preventive measures - Air pollution control efforts – Zoning – Town planning regulation of new industries – Legislation and enforcement – Environmental Impact Assessment and Air quality-Various models for checking Air Quality.

UNIT V	**AIR QUALITY SAMPLING AND MONITORING**	**9**

Stack sampling - instrumentation and methods of analysis of SO_2, CO etc - legislation for control of air pollution and automobile pollution.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Interpret the sources and effects of air pollutants.	2
CO2.	Inspect the various dispersion of pollutants.	4
CO3.	Identifying the concepts involved in air pollution control.	3
CO4.	Analyze the air quality standards and management policies.	4
CO5	Judge the monitoring levels of SO2,CO etc	5

TEXT BOOKS:

1. Anjaneyulu, D., "Air Pollution and Control Technologies", Allied Publishers, Mumbai, 2002
2. Rao, C.S. Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.
3. Rao M.N., and Rao H. V. N., Air Pollution Control, Tata-McGraw-Hill, New Delhi, 1996.

REFERENCES:

1. W.L.Heumann, Industrial Air Pollution Control Systems, McGraw-Hill, New Yark, 1997.
2. Mahajan S.P., Pollution Control in Process Industries, Tata McGraw-Hill Publishing Company, New Delhi, 1991.
3. Peavy S.W., Rowe D.R. and Tchobanoglous G. Environmental Engineering, McGraw Hill, New Delhi, 1985.
4. Garg, S.K., "Environmental Engineering Vol. II", Khanna Publishers, New Delhi.
5. Mahajan, S.P., "Pollution Control in Process Industries", Tata McGraw-Hill, New Delhi, 1991

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2	2		3	3	3	2	3	3	2	2	2
CO2	2	3	2		2	3	3	2	2	2	2	2	2	2
CO3	1	2	2	2	3	3	3	3	2	2	2	2		
CO4	2	2	2	2	3	2	3	3	2	2	2	1	2	2
CO5	2	2	2	2	2	3	3	2	2	2	2	2	2	2

CH22053	DISASTER MITIGATION AND MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To impart knowledge of causes of various disaster and its impact.

To understand the concept of Disaster Management Cycle and Framework.

To build skills to respond to disaster.

To explain the Applications of Science and Technology for Disaster Management & Mitigation

UNIT I	**INTRODUCTION**	**9**

Understanding the Concepts and definitions of Disaster and its types, Hazard, Vulnerability, Risk, Capacity, Disaster and Development, and disaster management.

UNIT II	**DISASTER RISK REDUCTION (DRR)**	**9**

10 Disaster Risk Reduction Strategies, Disaster Cycle, Phases of Disaster, Preparedness Plans, Action Plans and Procedures, Early warning Systems, Models in disaster preparedness, Components of Disaster Relief-(Water, food, sanitation, shelter, Health and Waste Management), Community based DRR, Structural nonstructural measures in DRR, Factors affecting Vulnerabilities, Mainstreaming disaster risk reduction in development, Undertaking risk and vulnerability assessments, Policies for Disaster Preparedness Programs, Preparedness Planning, Roles and Responsibilities, Public Awareness and Warnings, Rehabilitation measures and long term reconstruction.

UNIT III	**DISASTER MANAGEMENT CYCLE AND FRAMEWORK**	**9**

Disaster Management Cycle, Paradigm Shift in Disaster Management Pre-Disaster Risk Assessment and Analysis, Risk Mapping, zonation and Micro zonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development, Awareness During Disaster Evacuation, Disaster Communication, Search and Rescue, Emergency Operation Centre, Incident Command System, Relief and Rehabilitation, Damage and Needs Assessment, Restoration of Critical Infrastructure, Early Recovery, Reconstruction and Redevelopment, IDNDR, Yokohama Strategy, Hyogo Framework of Action.

UNIT IV	**MITIGATION AND DISASTER MANAGEMENT**	**9**

Disaster Profile of India, Mega Disasters of India and Lessons Learnt, Disaster Management Act 2005, Institutional and Financial Mechanism, National Policy on Disaster Management, National Guidelines and Plans on Disaster Management, Role of Government, Non-Government and Intergovernmental Agencies.Early Warning Systems, Building design and construction in highly seismic zones, retrofitting of buildings.

UNIT V	APPLICATIONS OF SCIENCE AND TECHNOLOGY FOR DISASTER MANAGEMENT & MITIGATION	9

Geo-informatics in Disaster Management, Disaster Communication System, Land Use Planning and Development Regulations, Structural and Non Structural Mitigation of Disasters, S&T Institutions for Disaster Management in India.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Classifying the various types of disasters, causes and their impact on environment and society.	2
CO2.	Analyze and evaluate the measures adopted to mitigate the impacts.	4
CO3.	Relate the skills in various stages of disaster preparedness, mitigation and management.	3
CO4.	Explain about organizational and administrative strategies for managing disasters.	2
CO5	Summarise the methodologies for disaster risk assessment with the help of latest tools like GPS, GIS, Remote sensing, information technologies, etc.	2

TEXT BOOKS:

1. Singhal J.P. "Disaster Management", Laxmi Publications, 2010. ISBN-10: 9380386427 ISBN-13: 978-9380386423
2. Disaster Management by Dr. Mrinalini Pandey, Published by Wiley India, 2014 ISBN 10:8126549246/ISBN 13:9788126549245
3. Tushar Bhattacharya, "Disaster Science and Management", McGraw Hill India Education Pvt. Ltd., 2012. ISBN-10: 1259007367, ISBN-13: 978-1259007361]

REFERENCES:

1. Disaster Management Act, Publisher by Govt. of India.
2. Publications of National Disaster Management Authority (NDMA) on Various Templates and Guidelines for Disaster Management 6. NIDM Publications, GoI.
3. National Disaster Management Policy, GoI.
4. Roy, P.S. (2000): Space Technology for Disaster management: A Remote Sensing & GIS Perspective, Indian Institute of Remote Sensing (NRSA) Dehradun

COURSE ARTICULATION MATRIX														
CO	**PO**												**PSO**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2	2	3	2	3	3	2	2	2	1	2	2
CO2	2	3	2	2	2	2	3	3	2	3	2	2	1	1
CO3		3	2	2	3	2	3	2	2	2	3	2	2	2
CO4	2	2	2	2	2	2	3	2	2	2	3	1	1	1
CO5	2	2	2	2	2	2	3	3	2	2	2	1		1

CH22054	GLOBAL CLIMATE CHANGE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To educate about Climate system and its changes and causes
- To impart knowledge about impacts, adaptation and mitigation of climate change
- To provide knowledge about clean technology and clean energy.

UNIT I	INTRODUCTION TO CLIMATE CHANGE SCIENCE	9

Introduction- The basics of climate change science -Climate in the spotlight - The Earth's Climate Machine – Climate Classification - Global Wind Systems – Trade Winds and the Hadley Cell – The Westerlies - Cloud Formation and Monsoon Rains – Storms and Hurricanes - The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect - Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle.

UNIT II	OBSERVED CHANGES AND ITS CAUSES	9

Observation of Climate Change – Changes in patterns of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks – The Montreal Protocol – history of international climate change negotiations and introduces the United Nations Framework Convention on Climate Change (UNFCCC) – IPCC – Evidences of Changes in Climate and Environment – on a Global Scale and in India – climate change modeling.

UNIT III	IMPACTS OF CLIMATE CHANGE	9

Concept of climate change adaptation- Framework for assessing climate vulnerability -Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water Resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for Different Regions – Uncertainties in the Projected Impacts of Climate Change – Risk of Irreversible Changes. Introduction to linkages between climate change adaptation and development. Important international adaptation initiatives and programmes.

UNIT IV	CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES	9

Adaptation Strategy/Options in various sectors – Water – Agriculture –- Infrastructure and Settlement including coastal zones – Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and Practices – Energy Supply – Transport – Buildings – Industry – Agriculture – Forestry - Carbon sequestration – Carbon capture and storage (CCS) - Waste (MSW & Bio waste, Biomedical, Industrial waste – International and Regional cooperation.

UNIT V	CLEAN TECHNOLOGY & CLIMATE CHANGE FINANCE	9

Clean Development Mechanism – Carbon Trading - examples of future Clean Technology – Biodiesel – Natural Compost – Eco- Friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding. National financing and the centrality of the national budget in leveraging other sources of finance, including private sector finance. The major streams of international climate finance.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Outline about the basics of earth's climate system.	2
CO2.	Identifying the changes in climate change and its causes.	3
CO3.	Summarise the impacts of climate change	2
CO4.	Discover the adaption and mitigation measures for climate change.	4
CO5	Analyzing clean technology and energy	4

TEXT BOOKS:

1. Jan C. van Dam, Impacts of Climate Change and Climate Variability on Hydrological Regimes, Cambridge University Press, 2003.
2. Dash Sushil Kumar, "Climate Change – An Indian Perspective", Cambridge University Press India Pvt. Ltd.

REFERENCES:

1. Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 'Climate Change and Water'. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 2008.
2. IPCC fourth assessment report - The AR4 synthesis report, 2007.
3. IPCC fourth assessment report –Working Group I Report, " The physical Science Basis", 2007.
4. IPCC fourth assessment report - Working Group II Report, " Impacts, Adaptation and Vulnerability", 2007.
5. IPCC fourth assessment report – Working Group III Report" Mitigation of Climate change", 2007.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1	2	2	2	2	2	3	2	2	2	2	2		2
CO2	2	2	2	2	2	2	3	3	2	2	2	2	2	2
CO3		2	2	2	1	2	3	2	2	2	1	2	2	2
CO4	2	2	2	2	2	3	3	3	2	2	2	2	1	1
CO5	2	2	1	2	1	2	3	3	2	2	2	2	2	2

CE22051	MUNICIPAL SOLID WASTE MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To make the students conversant with the types, sources, generation, storage, collection, transport, processing and disposal of municipal solid waste

UNIT I	**SOURCES AND TYPES**	**9**

Sources and types of municipal solid wastes-waste generation rates-factors affecting generation, characteristics-methods of sampling and characterization; Effects of improper disposal of solid wastes-Public health and environmental effects. Elements of solid waste management –Social and Financial aspects – Municipal solid waste handling and management rules – integrated management-Public awareness; Role of NGO‟s.

UNIT II	**ON-SITE STORAGE AND PROCESSING**	**9**

On-site storage methods – Effect of storage, materials used for containers – segregation of solid wastes – Public health and economic aspects of open storage – waste segregation and storage – case studies under Indian conditions – source reduction of waste – Reduction, Reuse and Recycling.

UNIT III	**COLLECTION AND TRANSFER**	**9**

Methods of Residential and commercial waste collection – Collection vehicles – Manpower– Collection routes – Analysis of collection systems; Transfer stations – Selection of location, operation & maintenance; options under Indian conditions – Field problems- solving.

UNIT IV	**OFF-SITE PROCESSING**	**9**

Objectives of waste processing – Physical Processing techniques and Equipment; Resource recovery from solid waste composting and bio-methanation; Thermal processing options – case studies under Indian conditions.

UNIT V	**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

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Explain the sources, types, generation rates, characteristics, sampling, effects of improper disposal of municipal solid wastes and the elements, regulatory requirements regarding municipal solid waste management.	3
CO2.	Explain the onsite storage methods, processing and source reduction of municipal solid waste.	3
CO3.	Analyse the collection systems and explain the various collection methods, collection vehicles, transfer stations and manpower requirements.	3
CO4.	Describe the physical and thermal processing of municipal solid waste and resource recovery from the municipal solid waste.	3
CO5	Determine the size of sanitary landfill and explain the operation and maintenance of sanitary landfill and dumpsite rehabilitation.	3

TEXT BOOKS:

1. Tchobanoglous, G., Theisen, H. M., and Samuel A Vigil. "Integrated Solid Waste Management Engineering Principles and Management Issues". McGraw Hill, New York, 2015.
2. George Tchobanoglous and Frank Kreith"Handbook of Solidwaste Management", McGraw Hill, New York, 2002.

REFERENCES:

1. Government of India, "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, New Delhi, 2016.
2. Tchobanoglous, G., Theisen, H. M., and Eliassen, R. "Solid. Wastes: Engineering Principles and Management Issues". McGraw Hill, New York, 1993.
3. Vesilind, P.A. and Rimer, A.E., "Unit Operations in Resource Recovery Engineering", Prentice Hall, Inc., 1981.
4. Paul T Willams, "Waste Treatment and Disposal", John Wiley and Sons, 2005.
5. Bhide A.D. and Sundaresan, B.B. "Solid Waste Management Collection", Processing and Disposal, 2001.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1	1	-	-	3	3	-	-	-	-	-	3	3
CO2	3	1	1	-	-	3	3	-	-	-	-	-	3	3
CO3	3	1	1	-	-	3	3	-	-	-	-	-	3	3
CO4	3	1	1	-	-	3	3	-	-	-	-	-	3	3
CO5	3	1	1	-	-	3	3	-	-	-	-	-	3	3

CE22052	ENVIRONMENTAL POLICY AND LEGISLATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The course will analyze the legislative and judicial responses to environmental problems and the administrative system of environment related laws such as air, water, land, and hazardous substances etc. Environment advocacy and approaches for using litigation in environment protection will receive special attention.

UNIT I	INTRODUCTION TO ENVIRONMENTAL LEGISLATIONS AND INTERNATIONAL SCENARIO	9

Significance of Environmental Law -International Environmental Law -Development of International Environmental Law -Source and General principals of International Environmental Law –General rights and obligations of States -General Issues of the international law related to environmental protection - Stockholm Declaration-Rio Declaration on Environment and Development-Basel Convention on the Control of Trans boundary Movement of Hazardous Wastes and their disposal - Convention of Biological Diversity - U.N Frame Work Convention on Climate Change-Montreal Protocol on Substances that deplete Ozone Layer-Kyoto Protocol.

UNIT II	INDIAN CONSTITUTIONS AND ENVIRONMENTAL PROTECTION	9

Indian Constitution and Environmental Protection -Constitutional provisions concerning Environment Articles 14,15,(2) (b) 19 (e),21,31,32,38,39,42,47, 48-A,49,51,51-A: Indian Environmental Policy 2006 Administrative machinery for pollution control Common Law & Criminal Law Nuisance, Negligence, Strict liability and Absolute liability, Provisions of IPC relating to environmental problems (public nuisance u/s 268 and others (Sections 269,270,277,284,285,286,425 to 440) Section 133 of Cr.P.C.

UNIT III	REMEDIES FOR ENVIRONMENTAL POLLUTION	9

Common Law Remedies/Remedies under Law of Tort – Penal Remedies – Indian Penal Code and Code of Criminal Procedure – Remedies under Constitutional Law – Writs – Public Interest Litigation - Public Liability Insurance Act, 1991 – The National Green Tribunal Act 2010.

UNIT IV	MAJOR INDIAN LEGISLATIONS	9

Water Act (1974) Air Act (1981) Environmental Protection Act (1986) Major Notifications, The Municipal solid Wastes (Management and Handling) Rules 2000-Bio Medical Wastes (Management and Handling) Rules 1998- Hazardous Wastes (Management and Handling Rules 1989 - Environment Impact Assessment Notifications- Coastal Regulation Zone Notification- Public Hearing Notifications.

UNIT V	ENVIRONMENT AND DEVELOPMENT CASE LAWS	9

Meaning and concept of development - Its impact on environment; conflict between environment and development, Concept of Sustainable Development., Polluter Pay Principle, Precautionary Principle, Public Trust Doctrine. Landmark Judgments - Olium gas leakage case, Rural Litigation and Entitlement Kendra, Dehradun, (1985) Supp SCC 487) Vellore Citizen Welfare Forum v. Union of India, (1996) 5SCC 647) Ganga Pollution case (1988) I SCC) S. Jagannath v. UOI (1997) SCC867) Vellore Citizens welfare forum case M.C. Mehta V. Kamalnath (1997) I SCC 388).

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Describe origins and sources of environmental laws, and understand how and by whom environmental laws are made and interpreted.	2
CO2.	Describe Indian constitutions and environmental protection.	2
CO3.	Explain the remedies for environmental pollution.	2
CO4.	Explain the major Indian environmental management legislations.	2
CO5	Describe the environment and development case laws.	2

TEXT BOOKS:

1. Leelakrishnan P., Environmental Law in India, Butterworths,1998
2. Leelakrishnan P., Environmental Case Book, Lexis Nexis, 2000

REFERENCES:

1. Shanthakumar S. , Environmental Law – An Introduction, Butterworths,2004
2. Shyam Diwan and Armin Rosencranz, Environmental Law and Policy in India, Oxford, 2001

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1	2	-	-	3	3	3	-	2	-	-	3	3
CO2	3	1	2	-	-	3	3	3	-	2	-	-	3	3
CO3	3	1	2	-	-	3	3	3	-	2	-	-	3	3
CO4	3	1	2	-	-	3	3	3	-	2	-	-	3	3
CO5	3	1	2	-	-	3	3	3	-	2	-	-	3	3

CE22053	ENVIRONMENT, HEALTH AND SAFETY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To educate overview of EHS in industries and related Indian regulations, types of Health hazards, effect, assessment and control methods and EHS Management System

UNIT I	INTRODUCTION	9

Need for developing Environment, Health and Safety systems in work places- Internationalinitiatives, National Policy and Legislations on EHS in India - Regulations and Codes of Practice - Role of trade union safety representatives - Ergonomics.

UNIT II	OCCUPATIONAL HEALTH AND HYGIENE	9

Definition of occupational health and hygiene - Categories of health hazards – Exposure pathways and human responses–Exposure Assessment-occupational exposure limits - Hierarchy of control measures - Role of personal protective equipment and the selection criteria.

UNIT III	WORKPLACE SAFETY AND SAFETY SYSTEM	9

Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and color, Ventilation and Heat Control, Noise, Chemical and Radiation Safety – Electrical Safety – Fire Safety – Safety at Construction sites, ETP – Machine guarding – Process Safety, Working at different levels.

UNIT IV	HAZARDS AND RISK MANAGEMENT	9

Safety appraisal – Job Safety Analysis-Control techniques – plant safety inspection – Accident investigation - Analysis and Reporting – Hazard and Risk Management Techniques –Onsite and Offsite emergency Plans. Employee Participation- Education and Training- Case Studies.

UNIT V	ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT	9

Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Summarise the need for EHS in industries and related Indian regulations	2
CO2.	Describe various types of Health hazards, effect, assessment and control methods	2
CO3.	Enumerate various safety systems in working environments	2
CO4.	Explain the methodology for preparation of Emergency Plans and Accident investigation	2
CO5	SummariseEHS Management System and its elements	2

TEXT BOOKS:

1. Fundamentals of Industrial Safety and Health by Dr.K.U.Mistry, Siddharth Prakashan, 2012
2. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007

REFERENCES:

1. Industrial Health and Safety Acts and Amendments, by Ministry of Labour and Employment, Government of India.
2. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services, 2005.
3. Environmental and Health and Safety Management by Nicholas P.Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	-	3	-	3	-	3	-	3	2	-	1	2	3	3
CO2	2	2	2	3	-	-	-	-	2	-	-	3	3	3
CO3	-	-	2	-	3	3	1	1	2	-	2	3	3	3
CO4	-	-	3	2	-	1	2	-	-	-	-	-	3	3
CO5	1	-	-	-	2	-	-	-	1	-	1	-	3	3

CE22054	SUSTAINABILITY AND SOCIAL DEVELOPMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To impart knowledge on environmental, social and economic dimensions of sustainability and the principles evolved through landmark events so as to develop an action mind-set for Sustainable development.

UNIT I	**SUSTAINABILITY AND DEVELOPMENT CHALLEGES**	**9**

Definition of sustainability – environmental, economic and social dimensions of sustainability - sustainable development models – strong and weak sustainability – defining development millennium development goals – mindsets for sustainability: earthly, analytical, precautionary, action and collaborative– syndromes of global change: utilisation syndromes, development syndromes, and sink syndromes – core problems and cross cutting Issues of the 21 century - global, regional and local environmental issues – social insecurity - resource degradation – climate change – desertification.

UNIT II	**PRINCIPLES AND FRAME WORK**	**9**

History and emergence of the concept of sustainable development - our common future - Stockholm to Rio plus 20 – Rio Principles of sustainable development – Agenda 21 natural step peoples earth charter – business charter for sustainable development – UN Global Compact – Role of civil society, business and government – United Nations' 2030 Agenda for sustainable development – 17 sustainable development goals and targets, indicators and intervention areas.

UNIT III	**SUSTAINABLE DEVELOPMENT AND WELLBEING**	**9**

The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution – Combating Poverty - - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities and Industry for Prevention, Precaution , Preservation and Public participation.

UNIT IV	**SUSTAINABLE SOCIO-ECONOMIC SYSTEMS**	**9**

Sustainable Development Goals and Linkage to Sustainable Consumption and Production Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation - Biodiversity conservation and Ecosystem integrity – Ecotourism - Sustainable Cities – Sustainable Habitats- Green Buildings – Sustainable Transportation — Sustainable Mining - Sustainable Energy– Climate Change – Mitigation and Adaptation - Safeguarding Marine Resources - Financial Resources and Mechanisms.

UNIT V	**SUSTAINABILITY AT GLOBAL AND NATIONAL LEVEL**	**9**

Nature of sustainable development strategies and current practice- Sustainability in global, regional and national context –Approaches to measuring and analysing sustainability– limitations of GDP- Ecological Footprint- Human Development Index- Human Development Report – National initiatives for Sustainable Development - Hurdles to Sustainability - Science and Technology for sustainable development –Performance indicators of sustainability and Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning and National Status of Sustainable Development Goal

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Explain and evaluate current challenges to sustainability, including modern world social, environmental, and economic structures and crises.	2
CO2.	Identify and critically analyze the social environmental and economic dimensions of sustainability in terms of UN Sustainable development goals.	3
CO3.	Develop a fair understanding of the social, economic and ecological linkage o Human wellbeing, production and consumption.	3
CO4.	Evaluate sustainability issues and solutions using a holistic approach that focuses on connections between complex human and natural systems.	3
CO5	Integrate knowledge from multiple sources and perspectives to understand environmental limits governing human societies and economies and social justice dimensions of sustainability.	3

TEXT BOOKS:

1. Tom Theis and Jonathan Tomkin, Sustainability: A Comprehensive Foundation, Rice University, Houston, Texas, 2018.
2. A guide to SDG interactions:from science to implementation, International Council for Science, Paris, 2017.

REFERENCES:

1. Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide, Rouledge Taylor and Francis, 2017.
2. The New Global Frontier - Urbanization, Poverty and Environmentin the 21st Century George Martine,Gordon McGranahan,Mark Montgomery and Rogelio Fernández-Castilla, IIED and UNFPA, Earthscan, UK, 2008.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	-	3	-	-	-	-	-	3	-	3	-	-	3	3
CO2	-	3	-	2	-	2	-	-	-	3	-	-	3	3
CO3	-	-	3	2	-	2	-	-	-	3	-	-	3	3
CO4	-	-	3	2	-	-	-	3	2	3	-	-	3	3
CO5	-	-	3	2	-	-	1	-	2	3	-	1	3	3

VERTICAL VI MATERIAL TECHNOLOGY

CH22061	MATERIALS ENGINEERING FUNDAMENTALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To give an overview of the material engineering fundamentals

UNIT I	**INTRODUCTION TO MATERIALS SCIENCE AND ENGINEERING**	**8**

Overview of material science and engineering; Atomic structure and bonding in materials; Classification of materials: metals, ceramics, polymers, and composites; Properties of materials: mechanical, thermal, electrical, and optical.

UNIT II	**STRUCTURE AND PROPERTIES OF ENGINEERING MATERIALS**	**9**

Crystal structure and crystalline defects; Phase diagrams and phase transformations; Mechanical properties of materials: strength, hardness, toughness, and elasticity; Thermal properties of materials: conductivity, expansion, and heat capacity.

UNIT III	**PROCESSING OF ENGINEERING MATERIALS**	**9**

Manufacturing processes for metals: casting, forming, machining, and welding; Processing of ceramics: sintering, firing, and glazing; Polymer processing techniques: extrusion, moulding, and compounding; Composite fabrication methods: lay-up, compression moulding, and filament winding.

UNIT IV	**CHARACTERIZATION TECHNIQUES FOR ENGINEERING MATERIALS**	**10**

Microscopic techniques: optical microscopy, electron microscopy; Spectroscopic techniques: X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR); Thermal analysis techniques: differential scanning calorimetry (DSC), thermogravimetric analysis (TGA); Mechanical testing techniques: tensile testing, hardness testing, impact testing.

UNIT V	**Applications of Engineering Materials**	**9**

Material selection criteria for engineering applications; Case studies on the use of materials in aerospace, automotive, construction, and biomedical engineering; Emerging trends in materials science and engineering; Sustainability and environmental considerations in material selection and design

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Demonstrate a fundamental understanding of the principles of materials science and engineering.	2
CO2.	Analyze the relationship between material structure and properties, including mechanical and thermal behaviour.	3
CO3.	Identify and describe common manufacturing processes used for metals, ceramics, polymers, and composites.	3
CO4.	Demonstrate proficiency in using various characterization techniques to analyze the structure, composition, and properties of engineering materials.	3
CO5	Evaluate material selection criteria for specific engineering applications, analyze case studies of material usage in different industries.	5

TEXT BOOKS:

1. Callister, W. D., & Rethwisch, D. G. (1964). *Materials Science and Engineering: An Introduction*. New York: Wiley.
2. Budinski, K. G., & Budinski, M. K. (1998). *Engineering Materials: Properties and Selection*. Pearson Education Inc.
3. Gilmore, C. (2014). *Materials Science and Engineering Properties*. Cengage Learning.

REFERENCES:

1. Raghavan, V. (2015). *Materials Science and Engineering: A first course*. PHI Learning Pvt. Ltd.
2. Shackelford, J. F. & Muralidhara, M. K. (2016). *Introduction to materials science for engineers*. Pearson Education Inc.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	2	1	3	3	2	1	2	1	3	3	3
CO2	3	3	2	2	2	3	3	2	1	2	1	3	3	3
CO3	3	3	3	3	2	3	3	2	1	2	1	3	3	3
CO4	3	3	3	3	3	3	3	2	1	2	1	3	3	3
CO5	3	3	3	3	3	3	3	2	1	2	1	3	3	3

CH22062	SURFACE ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To familiarize the students with basic principles of various surface modification techniques in engineering materials.

UNIT I		**9**

Topography of Surfaces– Surface features – Properties and measurement– Surface interaction - Adhesive Theory of Sliding Friction–Rolling Friction- Friction properties of metallic and nonmetallic materials– Friction in extreme conditions –Thermal considerations in sliding contact.

UNIT II		**9**

Introduction – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear Laws of wear – Theoretical wear models – Wear of metals and nonmetals – International standards in friction and wear measurement.

UNIT III		**9**

Introduction – principle – parameters of electrodeposition –Faraday's laws of electrodeposition electrodeposition of copper, nickel, chromium and gold for industrial practices – organic coatings paints - requirements of good paints-constituents of paints-function-formulation of durable paint enamel coatings-special paints-heat resistant and fire retardant paints-electroless coatings conversion coatings.

UNIT IV		**9**

Introduction–Surface properties, Superficial layer–Changing surface metallurgy–Wear resistant coatings and Surface treatments – Techniques – PVD – CVD – Physical CVD – Ion implantation – Surface welding – Thermal spraying – Laser surface hardening and alloying, laser re-melting, and laser cladding. New trends in coating technology –DLC – CNC. Nano-engineered coatings.

UNIT V		**9**

Introduction–Advanced alloys–Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys–Ceramics–Polymers–Biomaterials–Applications–Bio Tribology NanoTribology.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Examine the various surface features and different types of friction in metals and nonmetals.	3
CO2.	Analyze the different types of wear mechanism and international standard used in friction and wear measurement	3
CO3.	Appraise the different types surface modification techniques.	3
CO4.	Persuade the different types of surface treatments.	4
CO5	Interpret the different types of Engineering materials and its applications.	3

TEXT BOOKS:

K. G. Budinski (Ed.): Surface Engineering for Wear Resistance, Prentice Hall, New Jersey 1988
J. R. Davis (Ed.): Surface Engineering for Corrosion and Wear Resistance, ASM International, Materials Park, Ohio, 2001.

REFERENCES:

Budinski, K.G., Surface Engineering for Wear Resistance, Prentice Hall (1988).
Mathews, A., Advanced Surface Coatings: A Hand book of Surface Engineering, Spinger (1991).

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	1	1	2	3	3	2	1	1	1	1	3	3
CO2	1	3	2	3	1	3		2	1	1	1	1	3	3
CO3	1	2	1	1	1	3	2	2	1	1	1	1	3	3
CO4	1	1	2	1	1	3	2	2	1	1	1	2	3	3
CO5	1	1	2	2	1	3	2	2	2	2	1	2	3	3

CH22063	FRONTIER MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To select and design components based on their properties and requirements.
- Knowledge about bio materials like, titanium and stainless steel based.

UNIT I		**9**

Structural Steels: Introduction, Classification: HSLA steels, Dual phase steels, TRIP steels, Maraging steels, HSS steels.

UNIT II		**9**

Superalloys: Introduction, Classification, Applications and properties of Ni, Fe, Co based superalloys and their thermo-mechanical treatments.

UNIT III		**9**

Electrical and Electronic Materials: Introduction, Classification, Applications and properties of Pyro, Piezo, Ferro-electrics, Extrinsic and Intrinsic semiconductors; super conducting materials.

UNIT IV		**9**

Classification of composite materials – the concept of load transfer - matrix materials - polymers, metals and ceramics - fibers - glass, boron, carbon, organic and metallic fibers-fiber packing arrangements - particle reinforced composites - fibre reinforced composites – interface region bonding mechanisms – mechanical behavior of composites.

UNIT V		**9**

Biomaterials: Introduction, Property requirements for biomaterials, concept of biocompatibility, important bio metallic alloys.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Elucidate the Classification of HSS steels.	4
CO2.	Compile the various properties and applications of Alloys.	3
CO3.	Appraise the principles and properties of Electrical and Electronic Materials	4
CO4.	Device the classification and applications of composite materials	4
CO5	Investigate the Biomaterials and its alloys in various Industries.	4

TEXT BOOKS:

1. An Introduction to Materials Science and Engineering, W. D. Callister, John Wiley & Sons (2007).
2. Superalloys-II edited by C.T. SIMS, N.S. Stoloff and W.C.Hagel A Wiley-Interscience publication John wiley and sons, Newyork, 1972.

REFERENCES:

1. Materials Science and Engineering, V. Raghavan, PHI, 2004.
2. V.R. Gowarikar, N.V.Viswanathan & J.Sreedhar. Polymer Science. New Age International, 2019.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1	2	1	1	1	3	3	3	1	2	1	1	1	2
CO2		2	2	3	2		3	2	1	2	2	1		2
CO3	1	2	1	3	2	3		2	1	1	1	1	1	2
CO4	1	1	2				1		1	2	2	1	1	1
CO5	2	1	1	1	1	3	3	1	2	1	2	2	2	1

CH22064	BIOMATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Learn characteristics and classification of Biomaterials.
- Understand different metals, ceramics and its nanomaterial's characteristics as biomaterials.

UNIT I	**9**

Overview, structural characteristics of solid material: mechanical properties, visco elasticity, atomic structure and bonding, crystalline structures and defects.

UNIT II	**9**

Metallic implants - Stainless steels, co-based alloys, Ti-based alloys, shape memory alloy, nanostructured metallic implants, degradation and corrosion, ceramic implant – bio inert, biodegradable or bioresorbable, bioactive ceramics, nanostructured bio ceramics.

UNIT III	**9**

Biopolymers: Natural versus synthetic, Inert versus bioactive polymers, Biodegradable polymers, Hydrogel; Biocomposites: Engineering material properties, Different combinations and logistic applications.

UNIT IV	**9**

Characterization of biomaterials: Physical and physicochemical surface characterization: Mechanical, Optical and Electrochemical characterization.

UNIT V	**9**

Application of Biomaterials Cardiovascular Applications; Dental implants; Adhesives and Sealants; Opthalmologic Applications; Orthopedic Applications; Drug Delivery System; Sutures; Bioelectrodes; Biomedical Sensors and Biosensors.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Analyze different types of Biomaterials and its classification and apply the concept of nanotechnology towards biomaterials use.	4
CO2.	Create combinations of materials that could be used as a replacement implant.	3
CO3.	Compose the various Polymeric materials and its applications.	3
CO4.	Appraise the various characterisation techniques for biomaterials.	4
CO5	Identify significant gap required to overcome challenges and further development Biomaterials	4

TEXT BOOKS:

1. Sujata V. Bhatt, “Biomaterials”, Second Edition, Narosa Publishing House, 2005.
2. Sreeram Ramakrishna, MuruganRamalingam, T. S. Sampath Kumar, and Winston O. Soboyejo, “Biomaterials: A Nano Approach”, CRC Press, 2010.

REFERENCES:

1. Myer Kutz, “Standard Handbook of Biomedical Engineering & Design”, McGraw Hill, 2003
2. John Enderle, Joseph D. Bronzino, Susan M.Blanchard, “Introduction to Biomedical Engineering”, Elsevier, 2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1											3	2
CO2	2	2		3				1		1			2	3
CO3	1	1	2	1	1	3						1	1	2
CO4	1	1	2				2				1	1	2	1
CO5	2	1	1	1	1				1	1		1	2	2

CH22065	HIGH TEMPERATURE MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To examine the various deformation mechanisms that take place under given stress and temperature-required for proper design.

UNIT I		**9**

Creep: Creep phenomena, various stages of creep, Andrade's analysis, metallurgical factors influencing creep, stress rupture test, structural changes during creep, activation energy for creep, Factors influencing functional life of components at elevated temperatures.

UNIT II		**9**

Fatigue, thermal fatigue, ageing, structural changes, material damage, crack propagation, damage mechanics, life time analysis.

UNIT III		**9**

Mechanisms of oxidation: Oxidation of pure metals, Oxidation of alloys, High Temperature Oxidation theory, Reactions of metals in mixed environments.

UNIT IV		**9**

Ceramics, composites, Refractory metals and alloys. High temperature Polymers.Materials for high temperature applications: Heat resistance steels, Stainless steels, Super alloys, Titanium alloys, Intermetallics.

UNIT V		**9**

Case studies: Power plant materials, boiler materials, turbine materials, steam engine, jet engines and gas turbine materials.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Elucidate the mechanisms of creep and Factors influencing functional life of components.	4
CO2.	Compile the various changes associated with thermal fatigue.	3
CO3.	Appraise the principles of oxidation of metals and oxidation of high temperature corrosion and alloys.	4
CO4.	Device the ceramics, metals and alloys for high temperature applications	4
CO5	Investigate the high temperature materials in various Industries.	4

TEXT BOOKS:

1. Materials for High Temperature Engineering Applications, G.W. Meetham, M.H. Van de Voorde, Springer, 2000.
2. Fundamentals of Creep in Metals and Alloys, Michael E. Kassner Maria-Teresa Perez-Prado, Elsevier, 2004.

REFERENCES:

1. Introduction to creep, Institute of Materials, R.W. Evans, B Wilshire, 1993.
2. High Temperature Oxidation and Corrosion of Metals, David young, Elsevier Publications, 2016, 2nd Edition.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1	1	1	1	3	3	2	1		1	1	2	3
CO2	2	2	2	2	1		2	2	1	3	1	1	2	2
CO3	1	1	1	1	1	3	2	2	1	2	1	1	3	2
CO4	1	1	2	1	1		2	2	1	2	1	1	2	2
CO5	1	1	1	2	1	3	2	2	1	2	1	1	3	3

CH22066	PARTICULATE PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To educate the students on particle characterization techniques and processing methods

UNIT I	**INTRODUCTION TO PARTICULATE MATERIALS**	**9**

Classification of particulate materials. Properties of particulate materials: size, shape, surface area, and porosity. Characteristics of particulate systems: flow behaviour, segregation, and packing. Importance of particulate materials in various industries.

UNIT II	**PARTICLE CHARACTERIZATION TECHNIQUES**	**9**

Techniques for particle size analysis: sieving, sedimentation, laser diffraction; Surface area measurement methods: BET analysis, mercury intrusion porosimetry; Particle shape characterization techniques: microscopy, image analysis; Methods for assessing particle morphology, surface properties, and chemical composition.

UNIT III	**PARTICLE HANDLING AND STORAGE**	**9**

Basics of particle handling: conveying, feeding, and storage; Considerations for designing and operating particle handling systems; Techniques for minimizing particle attrition, degradation, and contamination; Safety considerations and regulations in particle handling operations.

UNIT IV	**PARTICLE PROCESSING TECHNIQUES**	**9**

Particle size reduction methods: milling, grinding, crushing; Particle agglomeration and granulation techniques: spray drying, fluidized bed granulation; Particle coating and surface modification methods: fluidized bed coating, spray coating; Techniques for particle separation and classification: sieving, cyclones, centrifuges.

UNIT V	**APPLICATIONS OF PARTICULATE PROCESSING**	**9**

Application of particulate processing techniques in pharmaceutical manufacturing; Utilization of particulate materials in food processing and formulation; Role of particulate processing in chemical engineering processes; Emerging trends and innovations in particulate processing technology

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the fundamental properties and classifications of particulate materials.	2
CO2.	Demonstrate proficiency in using various techniques to analyze the size, shape, surface area, and morphology of particulate materials.	3
CO3.	Design and implement efficient and safe particle handling systems while minimizing attrition, degradation, and contamination risks.	3
CO4.	Apply different particle processing techniques, including size reduction, agglomeration, coating, and separation, to modify particulate properties.	3
CO5	Identify and evaluate the role of particulate processing techniques in various industries demonstrating the diverse applications.	3

TEXT BOOKS:

1. Richardson, J. F., Backhurst, J. R., & Harker, J. H. (2002). *Coulson and Richardson's Chemical Engineering Volume 2 - Particle technology and separation processes*. Elsevier.
2. Rhodes, M. J. (2008). *Introduction to particle technology*. John Wiley & Sons.
3. Hiroaki Masuda, K. H., & Yoshida, H. (2006). *Powder Technology: Handling and Operations, Process Instrumentation and Working Hazards*. CRC Press.

REFERENCES:

1. Seville, J. P., & Wu, C. Y. (2016). *Particle technology and engineering: An engineer's guide to particles and powders: Fundamentals and computational approaches*. Butterworth-Heinemann.
2. Fayed, M., & Otten, L. (2013). *Handbook of powder science & technology*. Springer Science & Business Media.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2	1	1	1	1		1	2	1	3	3	3
CO2	2	2	3	1	3	1	1		1	2	1	3	3	3
CO3	3	2	2	2	3	1	1		1	2	1	3	3	3
CO4	3	2	2	2	3	1	1		1	2	1	3	3	3
CO5	2	2	3	3	3	1	1		1	2	1	3	3	3

CH22067	POLYMER PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To impart knowledge on polymer processing

UNIT I	**INTRODUCTION TO POLYMERS**	**5**

Definition of polymers and their significance in modern industries; Classification of polymers based on structure and properties; Polymerization techniques: addition polymerization, condensation polymerization; Polymer structure and morphology: amorphous vs. crystalline polymers, polymer chains, cross-linking.

UNIT II	**RHEOLOGY AND POLYMER FLOW BEHAVIOUR**	**8**

Basics of rheology and its importance in polymer processing, Newtonian vs. non-Newtonian behaviour of polymer melts; Flow phenomena: shear-thinning, viscoelasticity, relaxation behaviour; Rheological characterization techniques: rheometers, capillary viscometers; Influence of temperature, pressure, and additives on polymer flow behaviour.

UNIT III	**POLYMER PROCESSING TECHNIQUES**	**8**

Extrusion: principles, equipment, and applications; Injection molding: process steps, mold design, material selection; Blow molding: types, advantages, limitations; Compression molding: process overview, tooling requirements; Thermoforming: principles, sheet extrusion, forming processes.

UNIT IV	**ADVANCED POLYMER PROCESSING TECHNIQUES**	**12**

Introduction to advanced polymer processing methods beyond traditional molding and extrusion; Polymer foam processing: principles, types of foaming agents, applications; Polymer composite manufacturing: overview of composite materials, reinforcement techniques, fabrication methods; Reactive processing: in-situ polymerization, reactive extrusion, advantages, and challenges; Electrospinning and electrospinning: principles, equipment, and applications in nanofiber production; Solvent casting and phase separation techniques for polymer film formation; Emerging trends and future directions in advanced polymer processing technologies.

UNIT V	**QUALITY CONTROL AND OPTIMIZATION IN POLYMER PROCESSING**	**12**

Importance of quality control in polymer processing industries; Inspection techniques: visual inspection, dimensional measurement, non-destructive testing; Statistical process control (SPC) methods for monitoring and improving process consistency; Process optimization techniques: Design of Experiments (DOE), process parameter optimization; Case studies and real-world examples demonstrating the impact of quality control and optimization on product quality and cost-effectiveness.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the basics of polymers, including their types and how their structure affects their properties.	2
CO2.	Predict the flow of polymers under different manufacturing process conditions.	3
CO3.	Operate common polymer processing equipment and understand the basic steps involved in making polymer products.	3
CO4.	Assess the suitability and potential applications of various advanced polymer processing techniques	3
CO5	Implement quality control measures to ensure that polymer products meet specified standards.	3

TEXT BOOKS:

1. Baird, D. G., & Collias, D. I. (2014). *Polymer processing: principles and design*. John Wiley & Sons.
2. Young, R. J., & Lovell, P. A. (2011). *Introduction to polymers*. CRC Press.
3. Morrison, F. A. (2001). *Understanding rheology*. Oxford University Press

REFERENCES:

1. Tadmor, Z., & Gogos, C. G. (2013). *Principles of polymer processing*. John Wiley & Sons.
2. Mark H. F. (2014). *Encyclopedia of Polymer Science and Technology*. John Wiley & Sons.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1	2	2	1	1	1		1	1	1	3	3	3
CO2	3	3	2	2	2	1	1		1	1	1	3	3	3
CO3	3	2	3	2	3	1	1		1	1	1	3	3	3
CO4	3	2	3	2	3	1	1		1	1	1	3	3	3
CO5	2	3	3	2	3	1	1		1	1	1	3	3	3

CH22068	NANO MATERIALS AND APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To learn the basic synthesis and characterization of nano materials

UNIT I	FUNDAMENTALS OF NANOSCIENCE	9

Introduction to nanoscience: history, significance, and interdisciplinary nature; Quantum mechanics basics and its relevance to nanomaterials; Size effects and quantum confinement phenomena; Nanomaterials classification: zero-dimensional, one-dimensional, and two-dimensional structures.

UNIT II	SYNTHESIS TECHNIQUES FOR NANO MATERIALS	9

Bottom-up synthesis methods: sol-gel, chemical vapor deposition (CVD), and hydrothermal synthesis; Top-down synthesis methods: lithography, etching, and mechanical exfoliation; Hybrid and templated synthesis approaches; Green synthesis methods and their advantages in nanomaterial fabrication.

UNIT III	CHARACTERIZATION METHODS FOR NANO MATERIALS	9

Microscopy techniques: scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM); Spectroscopic techniques: X-ray diffraction (XRD), Raman spectroscopy, and Fourier-transform infrared spectroscopy (FTIR); Surface analysis techniques: X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES); Thermal and mechanical characterization methods for nanomaterials.

UNIT IV	PROPERTIES AND APPLICATIONS OF NANO MATERIALS	9

Electronic properties of nanomaterials: quantum dots, carbon nanotubes, and nanowires; Optical properties of nanomaterials: plasmonic effects, photonic crystals, and quantum confinement; Mechanical properties of nanomaterials: strength, elasticity, and ductility; Applications of nanomaterials in electronics, photonics, medicine, and catalysis.

UNIT V	ADVANCED NANO MATERIAL APPLICATIONS	9

Nanomaterials for energy applications: solar cells, batteries, and fuel cells; Nanomedicine: drug delivery systems, diagnostics, and therapeutics; Nanocomposites and their role in enhancing material properties; Environmental applications of nanomaterials: pollution remediation and water purification

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Demonstrate a thorough understanding of the principles and significance of nanoscience.	2
CO2.	Identify the techniques for fabricating nanomaterials, including bottom-up and top-down approaches.	3
CO3.	Employ advanced characterization techniques to analyze nanostructures.	3
CO4.	Evaluate the unique properties of nanomaterials, such as electronic, optical, and mechanical properties, and understand their applications in various fields.	3
CO5	Identify and analyze advanced applications of nanomaterials.	3

TEXT BOOKS:

1. Edelstein, A. S., & Cammaratra, R. C. (1998). *Nanomaterials: synthesis, properties and applications*. CRC Press.
2. Parameswaranpillai, J., Hameed, N., Kurian, T., & Yu, Y. (2016). *Nanocomposite materials: synthesis, properties and applications*. CRC Press.
3. Das, A. K., & Das, M. (2005). *An Introduction to Nanomaterial and Nanoscience*. CBS Publishers & Distributors Pvt. Ltd.

REFERENCES:

1. Goyal, R. K. (2017). *Nanomaterials and nanocomposites: synthesis, properties, characterization techniques, and applications*. CRC Press.
2. Willard, H. H., Merritt Jr, L. L., Dean, J. A., & Settle Jr, F. A. (1986). *Instrumental methods of analysis*. CBS Publishers & Distributors Pvt. Ltd.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	1	2	1	2	1	1	1		3	3	3
CO2	3	3	2	1	2	1	2	1	1	1		3	3	3
CO3	3	3	2	1	2	1	2	1	1	1		3	3	3
CO4	3	3	2	1	2	1	2	1	1	1		3	3	3
CO5	3	3	2	1	2	1	2	1	1	1		3	3	3

VERTICAL VII PROCESS ENGINEERING

CH22071	PROCESS OPTIMIZATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To impart knowledge on the formulation and solution of Chemical Process Optimization problems

UNIT I	**INTRODUCTION**	**9**

Introduction; formulation of objective functions; fitting models to data; classification of functions; necessary and sufficient conditions for optimum; unimodal, multimodal functions; analytical methods, Lagrange multiplier methods.

UNIT II	**NON-LINEAR UNCONSTRAINED OPTIMIZATION**	**9**

Continuity of function, convex and concave function, unconstrained NLP, methods for one dimensional search, Newton's method, Quasi Newton's method, Newton's method for Uni-dimensional search, polynomial approximation methods.

UNIT III	**NON-LINEAR CONSTRAINED AND MULTI VARIABLE OPTIMIZATION**	**9**

Direct Substitution, Quadratic programming, Penalty, Barrier and Augmented methods, weighted sum of squares method, Epsilon constraints method and Goal attainment.

UNIT IV	**LINEAR PROGRAMMING AND NON-LINEAR PROGRAMMING**	**9**

SIMPLEX method, Barrier method, Sensitivity analysis, Quadratic programming, Introduction to integer and mixed integer programming

UNIT V	**APPLICATIONS OF OPTIMIZATION IN CHEMICAL ENGINEERING**	**9**

Heat transfer and energy conservation; Optimizing recovery of waste heat, shell and tube heat exchanger design, separation processes, Optimal design of staged distillation column, liquid-liquid extraction column, chemical reactor design and operation, optimal design of an ammonia reactor.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply the concepts of process optimization techniques.	3
CO2.	Solve non-linear unconstrained optimization problems.	3
CO3.	Apply various optimization techniques to solve multi-variable optimization problems.	3
CO4.	Analyze the methods of linear and dynamic programming.	4
CO5	Formulate and solve optimization problems for chemical engineering applications.	4

TEXT BOOKS:

1. Edgar, T.F., Himmelblau, D.M., "Optimisation of Chemical Processes", McGraw-Hill II Edition, 2001
2. Kalyanmoy Deb., "Optimization for Engineering Design: Algorithms and Examples", Prentice Hall of India, New Delhi, 2005.
3. Ioannis K. Kookos., "Practical Chemical Process Optimization: with MATLAB and GAMS:197, Springer International Publishing AG, 2022.

REFERENCES:

1. Venkataraman P., Applied Optimization with MATLAB Programming, John Wiley & Sons, Inc., 2009.
2. Rangaiah G P., Petriciolet A B., Multi-Objective Optimization in Chemical Engineering: Developments and Applications, John Wiley & Sons, Inc., 2013.
3. Rao, S. S., Engineering Optimization: Theory and Practice, IV Edition John Wiley & Sons, Inc.,2009.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	3				1	2	1	2	3	3
CO2	3	3	3	3	3				1	2	1	2	3	3
CO3	3	3	3	3	3				1	2	1	2	3	3
CO4	3	3	3	3	3				1	2	1	2	3	3
CO5	3	3	3	3	3		2		1	2	1	2	3	3

CH22072	CHEMICAL REACTOR ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Chemical Reactor Analysis and Design is a unique, capstone course in the chemical engineering. This course will provide an introduction to the principles and calculation techniques used to analyze and design chemical reactors for the production of petrochemicals, advanced materials, polymers, and biochemical.

UNIT I		**9**

Models for Non-Ideal flow Reactors: Two- parameter models- RealCSTR modeled using bypass and dead space, real CSTR modeled as twoCSTR interchange, testing a model and determining its parameters. Mixing of fluids: Zero parameter models-Segregation model, and qualitative concept of Maximum Mixedness model.

UNIT II		**9**

Fluid-Particle Reactions–Design: Various types of contacting in gas-solid operations; Development of performance equation for frequently met contacting pattern assuming uniform gas composition- Particles of a single size, plug flow of solids, Mixture of particles of different but unchanging sizes, Application to a fluidized bed with entrainment of solidfines.

UNIT III		**9**

Fluid-Fluid Reactions- Design: Factors to consider in selecting a gas liquid contactor, Straight mass Transfer: Plug flow G/Plug flow L – counter current flow in a tower. Mass transfer plus not very slow reaction: Plug flow G/Plug flow L – mass transfer and reaction in a countercurrent tower. Plug flow G/Plug flow L – mass transfer in a cocurrent tower.

UNIT IV		**9**

Catalysis and catalytic reactors: Design of reactors for gas-solid reactions. Heterogeneous data analysis for reactor design; catalyst deactivation–Types of Deactivation, Moving bed Reactors.

External diffusion effects on heterogeneous reactions- External resistance to mass Transfer: Mass transfer coefficient, mass transfer to a single particle, mass transfer limited reactions in packed beds.

UNIT V		**9**

Non- isothermal reactor design- energy balance, non- isothermal adiabatic, CSTR, PFR, Flow, reactors at steady state, equilibrium conversion; multiple steady states- ignition- extinction curve.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Describe the two parameter models for non-ideal flow reactors.	L1
CO2.	Explain and Design the various types of contacting in gas-solid operations.	L3
CO3.	Design the various factors to be considered in selecting a gas liquid contact.	L3
CO4.	Define catalysis, catalyst deactivation, diffusion and reaction in porous catalysts.	L4
CO5	Discuss the non isothermal reactor design and multiple steady states and solve the problems on adiabatic flow reactors at steadystate.	L4

TEXT BOOKS:

Froment G, Bischoff K and De Wilde J, *"Chemical Reactor Analysisand Design",* 3rd Edition, John Wiley and Sons, 2011

REFERENCES:

1. Fogler, H.S., *"Elements of Chemical ReactionEngineering",*4thEdition, Prentice Hall, New Jersey, 1986.
2. Levenspiel, O., *"Chemical Reaction Engineering",* 3rd Edition, JohnWiley and Sons, 2007

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2					3						3	2
CO2	3	2	2	1			3	1			1		3	2
CO3	3	1	2				3						3	2
CO4	3	2	2		2		3					2	3	3
CO5	3	2	2	1			3					2	3	2

CH22073	SCALE-UP IN CHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To learn the basic knowledge and design requirements for the scale-up models by considering with and without chemical reactions

UNIT I	**DIMENSIONAL ANALYSIS AND CONCEPT OF SCALE-UP**	**9**

Dimensional Analysis: Pi Theorem and Rayleigh's method; Similitude: Principles of Similarity, Similarity criterion, Regime concept; Scale-up criterion, methods, procedures; Mock-up & Pilot plant models and studies.

UNIT II	**TRANSPORT PROCESSES**	**9**

Mixing and Heat Transfer equipment: Mixing of solids and Mixing vessels, Pipes. Exchanger

UNIT III	**SEPARATIONS**	**9**

Separation Equipment: packed bed absorbers and bubble columns.

UNIT IV	**REACTOR ENGINEERING**	**9**

Noncatalyzed Chemical Reactors: Kinetics, reactor development, Tubular reactor, Fluidized reactor.

UNIT V	**REACTION KINETICS**	**9**

Solid Catalyzed Chemical Reactors: Pseudo-homogeneous and heterogeneous models, Two-dimensional models, Scale-up considerations.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply the theoretical principles /concepts of scaling up the Laboratory process and designing equipment for the pilot plant	3
CO2.	Solve the problems raised during converting a process from a Lab scale to a large production unit.	3
CO3.	Analyze the relevant theoretical knowledge on scale-up models for designing Process equipment for separation.	3
CO4.	Explore the scale-up of common process equipment used as reactors.	3
CO5	Examine the scaled-up equipment to carry out a unit process	3

TEXT BOOKS:

1. Marko Zlokarnik, Scale-up in chemical engineering, Wiley-VCH, 2006
2. R.E. Johnstone and M.W. Thring, Pilot Plants, Models and Scale-up Methods in Chemical Engineering, McGraw-Hill 1957

REFERENCES:

1. Colin Divall, Sean Johnston, Scaling up: The Institution of Chemical Engineers and the rise of a new profession, Springer 2000.
2. Bisio, A. and Kabel, R.L., Scale-up of Chemical Processes, John Wiley 1985.
3. Jean-Paul Euzon, Pierre Trambouze, Jean Pierre Wauquier, Scale-up Methodology for Chemical Processes, Editions Technip, 1993.
4. Donald G. Jordan, Chemical Process Development (Part 1 and 2), Interscience Publishers 1998.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2	1	1	3	2	2	2	2	2	2	3	3
CO2	3	2	2	1	1	3	2	2	2	2	2	2	3	3
CO3	3	2	2	1	1	3	2	2	2	2	2	2	3	3
CO4	3	2	2	1	1	3	2	2	2	2	2	2	3	3
CO5	3	2	2	1	1	3	2	2	2	2	2	2	3	3

CH22074	PIPING DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To impart knowledge on the basic fundamentals and design aspects of process plant piping.

UNIT I	**FUNDAMENTALS OF PROCESS PLANT PIPING**	**9**

Definitions, Piping Components their introduction, applications. Piping MOC, Budget Codes and Standards, Fabrication and Installations of piping, piping materials, Pipeline Economics and Costs,

UNIT II	**PIPE HYDRAULICS AND SIZING**	**9**

Fluid property, Pipe sizing based on velocity and pressure drop consideration, least annual cost approach, pipe drawing basics, dimensions and drawing of piping, different types of joints and bends. Pipe fittings, ANSI / ASME Calculation Procedure

UNIT III	**PLOT PLAN**	**9**

Development of plot plan for different types of fluid storage, equipment layout, process piping layout, utility piping layout. Stress analysis -Different types of stresses and its impact on piping, methods of calculation, dynamic analysis, and flexibility analysis

UNIT IV	**PIPING SUPPORTS**	**9**

Classification of Pipe Supports, Selection Criteria for process plant piping supports, Pipe support design calculations, types of loads

UNIT V	**PIPING INSTRUMENTATION**	**9**

Final Control Elements; measuring devices, instrumentation symbols introduction to process flow diagram (PFD) and piping & instrumentation diagram (P&ID), data processing, Computer-Aided Piping Design – case studies.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Identify the various piping components	2
CO2.	Apply the principles of pipe hydraulics and sizing	3
CO3.	Perform stress analysis and pipe support design calculations	5
CO4.	Develop plot plan for Chemical Process Industries	3
CO5	Ability to read PFD and P&ID diagrams	2

TEXT BOOKS:

1. M.L. Nayyar, “Piping Handbook, Seventh edition”, Mc Graw-Hill, Inc., 2000
2. John J McKetta ,“Piping Design Handbook”, CRC Press, 1992

REFERENCES:

1. Moe Toghraei, “Piping and Instrumentation Diagram Development”, John Wiley & Sons Inc., 2019
2. Ed Bausbacher, Roger Hunt, “Process Plant Layout and Piping Design”, PTR Prentice hall, 1993
3. Peter Smith, “Process Piping Design Handbook vol 1. The Fundamentals of Piping Design”, Gulf Publishing Company, 2007

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2	3	1	3					3		3	3	3
CO2	3	2	3	3	3					3		3	3	3
CO3	3	3	3	3	3				3	3		3	3	3
CO4	3	3	3	3	3				3	3	3	3	3	3
CO5	3	2	2	2	2				3	3	1	2	3	3

CH22075	CHEMICAL PROCESS INTENSIFICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: Understand the techniques and applications of process intensification

UNIT I	**INTRODUCTION**	**9**

Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process- Intensifying Equipment, Process intensification toolbox, Techniques for PI application, AI & ML in Process intensification

UNIT II	**COMBINED CHEMICAL REACTOR HEAT EXCHANGERS AND REACTOR SEPARATORS**	**9**

Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modelling, Reactive Extraction Case Studies: Absorption of NOx Coke Gas Purification. Compact heat exchangers: Classification of compact heat exchangers, Plate heat exchangers, Spiral heat exchangers, Flow pattern, Heat transfer and pressure drop, Flat tube-and-fin heat exchangers,

UNIT III	**REACTIVE AND HYBRID SEPARATIONS**	**9**

The concept of reactive separations, reactive distillation, membrane-based reactive separation reactive adsorption, reactive extraction, reactive crystallization, hybrid separations, extractive distillation, adsorptive distillation, membrane distillation, membrane chromatographic separation, design, application

UNIT IV	**ENHANCED FIELDS**	**9**

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sono-crystallization, Reactive separations, Supercritical fluids.

UNIT V	**PROCESS INTENSIFICATION THROUGH MICRO REACTION TECHNOLOGY**	**9**

Effect of miniaturization on unit operations and reactions, Implementation of Microreaction Technology, From basic Properties To Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand principles of process intensification.	**3**
CO2.	Develop compact heat exchangers for enhanced heat suty	**4**
CO3.	Develop compact reactors for process industries	**4**
CO4.	Design intensified processes with enhanced performance	**4**
CO5	Apply intensification techniques in process industries	**3**

TEXT BOOKS:

1. Reengineering the Chemical Process Plants, Process Intensification, Stankiewicz, A. and Moulijn, (Eds.), Marcel Dekker, 2018.
2. Process Intensification, David Reay, Colin Ramshaw, Adam Harvey, Butterworth Heinemann, Second Edition, 2013
3. Modelling of Process Intensification, Frerich Johannes Keil, Wiley VCH, 2008.

REFERENCES:

1. Integrated Reaction and Separation Operations: Modelling and experimental validation, Schmidt-Traub Henner, Gorak, Andrzej, Springer, 2007..
2. Micro Process Engineering'A Comprehensive Handbook, Hessel, V., A. Renken, J.C. Schouten and J.-I. Yoshida (eds.). Wiley-VCH, 2009.
3. Process Intensification for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Boodhoo, K. and A. Harvey, John Wiley & Sons Inc., 2013.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2	3	2	3	3	2	1	1	1	2	3	3
CO2	3	3	3	3	3	3	2	2	3	3	3	2	3	3
CO3	3	3	3	3	3	3	3	2	3	3	3	2	3	3
CO4	3	3	3	1	3	3	2	2	3	3	3	2	3	3
CO5	3	3	2	1	2	3	3	3	1	2	3	3	3	3

CH22076	PROCESS PLANT UTILITIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To enable the students to understand the process plant utilities and optimization techniques to optimize various parameters in chemical industries.

UNIT I	**IMPORTANCE OF UTILITIES**	**9**

Requisites of Industrial Water and its uses. Methods of water Treatment such as Chemical Softening and Demineralization, Resins used for Water Softening and Reverse Osmosis. Effects of impure Boiler Feed Water.

UNIT II	**STEAM AND STEAM GENERATION**	**9**

Types of Steam Generator such as Solid Fuel Fired Boiler, Waste Gas Fired Boiler and Fluidized Bed Boiler. Scaling and Troubleshooting. Steam Traps and Accessories.

UNIT III	**REFRIGERATION**	**9**

Refrigeration Cycles, Methods of Refrigeration used in Industry and Different Types of Refrigerants such as Monochloro difluro Methane, Chlorofluro Carbons and Brins. Refrigerating Effects

UNIT IV	**COMPRESSED AIR**	**9**

Classification of Compressor, Reciprocating Compressor, Single Stage and Two Stage Compressor, Velocity Diagram for Centrifugal Compressor, Slip Factor, Impeller Blade Shape. Properties of Air – Water Vapors and use of Humidity Chart. Equipments used for Humidification, Dehumidification and Cooling Towers

UNIT V	**FUEL AND WASTE DISPOSAL**	**9**

Types of Fuel used in Chemical Process Industries for Power Generation such as Natural Gas, Liquid Petroleum Fuels, Coal and Coke. Waste Disposal.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Exemplify the knowledge on the various process plant utilities.	**3**
CO2.	Examine an efficient steam operation is imperative for economic and safe operation for the process industries.	**4**
CO3.	Contrast the concept of refrigeration and its cycles	**4**
CO4.	Categorize the types of compressor and cooling towers and Industrial applications	**4**
CO5	Assess the effective ways of waste disposal & types of fuel used for power generation.	**4**

TEXT BOOKS:

1. Eckenfelder, W. W, Jr. "Industrial Water Pollution Control" McGraw-Hill: New York, 1966.
2. P. L. Ballaney, "Thermal Engineering", Khanna Publisher New Delhi, 1986.

REFERENCES:

1. P. N. Ananthanarayan, "Basic Refrigeration & Air conditioning", Tata McGraw Hill, New Delhi, 2007.
2. S.C.Arora & S.Domkumdwar; A course in refrigeration and air conditioning

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3	3	3	3	3	1	3	2	1	3	3
CO2	2	2	3	1	3	3	3	3	2	1	1	3	3	3
CO3	1	2	2	2	3	2			1	1		1	3	3
CO4	1	1	3	1		2	2		2	2		2	3	3
CO5		2	3	2		3	2	2	3	2	3	3	3	3

CH22077	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To demonstrate competence in setting up computational fluid dynamics models for industrially important applications
2. To appraise the numerical analysis of transport processes at process industries.
3. To understand the life cycle of CFD simulation for solving industrial problems.

UNIT I	**CONSERVATION LAWS AND TURBULENCE MODELS**	**9**

Governing equation for fluid flow and heat transfer –mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form. Boundary layer treatment, RANS turbulence models: k-epsilon and k – omega.

UNIT II	**FINITE DIFFERENCE APPROXIMATION**	**9**

Mathematical behaviour of Partial Differential Equation, basic aspects of discretization by FDM: Taylor series. Finite difference operators, explicit and implicit methods, error and stability analysis.

UNIT III	**FINITE ELEMENT METHOD**	**9**

One-dimensional elements: Rayleigh-Ritz, Galerkin, and Least square methods

UNIT IV	**FINITE VOLUME METHOD**	**9**

Diffusion problems – explicit and implicit time integration; Convection-diffusion problems – properties of discretization schemes, central, upwind, hybrid, QUICK schemes; Solution of discretized equations.

UNIT V	**FLOW FIELD COMPUTATION & CONVERGENCE**	**9**

Spatial discretization, Temporal discretization. Pressure velocity coupling, staggered grid, SIMPLE algorithm, and PISO algorithm for steady and unsteady flows. Convergence – asymptotic grid convergence.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Interpret the governing equation for solving transport processes involving fluid flow and/or heat transfer.	3
CO2.	Explore the algorithms to solve the difference and discretized equation based on Taylor series	3
CO3.	Acquire the skill to computationally solve the governing equation of the transport process using elements	2
CO4.	Apply the fundamental knowledge on solving the transport processes using control volume	3
CO5	Infer the techniques for computationally solving the physical model by providing the verification of results.	2

TEXT BOOKS:

1. Anderson, J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw- Hill, 2012.
2. Versteeg, H.K. and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education Ltd., 2007

REFERENCES:

1. Fletcher, C. A. J., "Computational Techniques for Fluid Dynamics", Springer Verlag, 2011
2. Chung T.J Computational Fluid Dynamics Cambridge University Press, 2003.
3. Subas, V. Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	1	2	3	3	2	2	3	2	1	3	3	3
CO2	3	3	1	2	3	3	2	2	3	2	1	3	3	3
CO3	3	3	1	2	3	3	2	2	3	2	1	3	3	3
CO4	3	3	1	2	3	3	2	2	3	2	1	3	3	3
CO5	3	3	1	2	3	3	2	2	3	2	1	3	3	3

CH22078	QUALITY CONTROL, ASSURANCE AND RELIABILITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To develop the awareness and understanding about Quality control at process industries.
2. To introduce the students in Quality management and their assessment in chemical manufacture.
3. To enable the students to access the process industries, about the Quality of product and ways to give assurance to stake holders.
4. To introduce the role of reliability and acceptance in process industries.

UNIT I	**INTRODUCTION TO QUALITY CONTROL AND TOTAL QUALITY SYSTEM**	**9**

Evolution of Quality Control – Components of Quality Control, Quality Assurance and Reliability. - Kano Model. Total Quality System - Benefits of Quality control and Total Quality system. - Deming's philosophy, Crosby's philosophy and Juran's philosophy – Impact of Philosophies over Quality.

UNIT II	**PRODUCT QUALITY CONTROL AND PROCESS QUALITY CONTROL**	**11**

Concepts in sampling, Frequency distributions and Histograms, Run charts, Stem- and-leaf plots, Pareto diagram, Cause-and-effect diagram, Normal probability plot, Scatter diagrams, Multivariable charts. Causes of variation, Statistical Basis for Control Charts, Selection of Rational Samples. Various Control charts – Mean and Range, Standard deviation, X and R Charts – CUSUM charts.

UNIT III	**QUALITY ASSURANCE**	**9**

Process Capability Analysis – Tolerance – Process Capability Indices: Taguchi Capability Index. Gage Repeatability and Reproducibility. Sampling Plans – Types, Evaluating Sample plan: - Bayes Rule – Deming's Rule. Acceptance Sampling Plans for Attributes and Variables: Operating Characteristic Curve.

UNIT IV	**RELIABILITY AND ACCEPTANCE**	**8**

Failure Rate:- Probability Distribution, Life cycle Curve, System Reliability and Life Testing plans, Quality Function Deployment (QFD):- Experimental Design – Taguchi method.

UNIT V	**TQM AND QUALITY SYSTEMS**	**8**

Total Quality Management (TQM) Principles. Continuous process improvement – PDSA cycle, 5S, KAIZEN. Six Sigma Principles: - FMEA stages. Quality Systems: ISO 9000 and 14001: - Concepts and Benefits.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply the principles by acquiring knowledge about Quality control and Quality system at process industries	2
CO2.	Contrast the visualization techniques used to describe Product quality and quality in a production process.	2
CO3.	Develop the practice of sampling to analyse the process quality and its assurance at process industries	3
CO4.	Make use of Testing, Failure rate, life cycle charts to access the Reliability and Acceptance at manufacturing industries	2
CO5	Relate the quality management and standards at process industries	2

TEXT BOOKS:

1. Mitra A., Fundamentals of Quality Control and Improvement, Pearson Education, 2nd Edition, 2001.
2. Dale H.Besterfiled, et al., "Total Quality Management", Pearson Education Asia, 3rd Edition, Indian Reprint (2006).

REFERENCES:

1. Gryna, F. M., Chua, R. C. H. and Defeo, J. A., Juran's Quality Planning and Analysis for Enterprise Quality, Tata McGraw Hill, 5th Edition, 2007.
2. Montgomery, D. C., Introduction to Statistical Quality Control, John Wiley & Sons, 4th Edition, 2003.
3. Kapur, K. and Lamberson, L., Introduction to Reliability Engineering, John Wiley & Sons, 2nd Edition, 1989.
4. Montgomery, D.C., Design and Analysis of Experiments, John Wiley & Sons, 3rd Edition, 2000.
5. James R. Evans and William M. Lindsay, "The Management and Control of Quality", (6thEdition), South-Western (Thomson Learning), 2005.
6. Janakiraman,B and Gopal, R.K, "Total Quality Management – Text and Cases", Prentice Hall (India) Pvt. Ltd.(2006)

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1	2	1	1	3	3	3	3	2	2	2	3	2
CO2	3	1	2	1	1	3	3	3	3	2	2	2	3	3
CO3	3	1	2	1	1	3	3	3	3	2	2	2	2	3
CO4	3	1	2	1	1	3	3	3	3	2	2	2	2	3
CO5	3	1	2	1	1	3	3	3	3	2	2	2	3	3

DIVERSIFIED VERTICAL GROUP I:

CH22081	BIOCHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To learn about the role of microbial kinetics, enzyme kinetics and downstream processing of bioproducts

UNIT I	**INTRODUCTION TO BIOSCIENCE**	**9**

Role of biochemical engineers in various industries. Comparing chemical and biochemical processes. Types of Microorganisms: Structure and function of microbial cells. Fundamentals of microbial growth, batch and continuous culture. Cell growth measurement.

UNIT II	**ENZYME KINETICS**	**9**

Enzyme kinetics, Enzyme reactor with simple kinetics, Inhibition of enzyme reactions, Other influences on enzyme activity. Immobilization of enzymes, immobilized enzyme kinetics,. Effect of mass transfer in immobilised enzyme particle systems. Industrial applications of enzymes. Enzyme Bioreactors. Case studies.

UNIT III	**MICROBIAL CELL KINETICS AND FERMENTER**	**9**

Growth cycle for batch cultivation, Elemental balances, degree of reduction of substrate and biomass, electron balances, yield co-efficient, maintenance co-efficient, Kinetics and design considerations for batch and continuous cultivation, Stirred-tank fermenter, fermenters connected in series. Cell recycling, Structured Model, Medium design and optimization, Thermal death kinetics of cells and spores, sterilization, sizing of continuous sterilizer

UNIT IV	**BIOREACTOR DESIGN**	**9**

Transport phenomena in bioprocess systems; Continuously stirred aerated tank bioreactors, Mixing power correlation, Determination of volumetric mass transfer rate of oxygen from air bubbles, effect of mechanical mixing and aeration on oxygen transfer rate, power requirements for sparged and agitated vessels, scaling of bioreactors, heat transfer and power consumption, Multiphase bioreactors.

UNIT V	**DOWNSTREAM PROCESSING AND PRODUCT RECOVERY**	**9**

Strategies to recover and purify products, Separation of insoluble products, filtration and centrifugation, Cell disruption: mechanical and non-mechanical methods; Separation of soluble products: liquid-liquid extractions, membrane separation (dialysis, ultra-filtration and reverse osmosis). Chromatographic separation: gel permeation chromatography, electrophoresis Final steps in purification: crystallization and drying. Case studies.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify microbes and cultivation for bioprocess.	3
CO2.	Develop enzyme kinetics and apply in bio reactions.	3
CO3.	Inspect cell kinetics data and study fermenter	4
CO4.	Analyse the dynamics and design of bioreactors.	4
CO5	Apply downstream processing and product recovery in bioprocess.	3

TEXT BOOKS:

1) Biochemical engineering fundamentals by J. E. bailey and D. F. Ollis, Second edition, 1986, McGraw Hill.
2) Bioprocess Engineering by Michael Shuler and Fikret Kargi, Second edition, person education, 2001

REFERENCES:

1) Biochemical Engineering by James M. Lee- Prentice – Hall, 1992
2) Bioprocess Engineering principles, Pauline M. Doran, 2nd edition, Academics press, 2013.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	2			3	3	2	3	3		3	3	2
CO2	3	3	3			3	3	2	3	3		3	3	3
CO3	3	3	3			3	3	2	3	3		3	3	3
CO4	3	3	3			3	3	2	3	3	3	3	3	3
CO5	3	2	3			3	3	2	3	3		3	3	2

CH22082	FOOD PROCESSING TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: The course provides knowledge on basic unit operations such as post harvest processing, size reduction, mechanical separation and To impart knowledge of drying, heating and cooling as preservation techniques in food processing.

UNIT I	**PRE-PROCESSING OPERATIONS**	**9**

Post-harvest losses in field crops – Cleaning - Peeling - Grading and Sorting - Principles, types and equipment's. Moisture content – free moisture, bound and unbound moisture. Equilibrium moisture content - determination methods, models - Hysteresis effect. Water activity

UNIT II	**PROCESSING TECHNOLOGY OF FRUITS AND FRUIT BEVERAGES**	**9**

Unit operations involved in Juice preparation-equipments-screw type juice extractor, pulper, pressing, Rack and cloth press,Hydraulic Press, Filters, clarification and concentration by membranes. Classification of fruit juices- Squash, cordial, nectar, RTS.IMF products -Jam, Jelly, marmalade, candied preserves.

UNIT III	**SAMPLING AND STATISTICAL QUALITY CONTROL**	**9**

Sampling- concept, methods and importance. Statistical Process and Quality Control – concept, importance and tools. Control charts: importance, types, design process, Control limits and errors, Process Capability.

UNIT IV	**FOOD PRESERVATION**	**9**

Methods of applying heat to food - Blanching, Pasteurization, Sterilization. Thermal death time relationships (D, Z and F values), Chilling - Equipments, Cold storage. Freezing - Thermodynamics of food freezing, Phase diagrams, Ice crystals formation, Properties of frozen foods.

UNIT V	**FOOD PACKAGING TECHNOLOGY**	**9**

Definitions and basic functions of a food package. Food package design and development Active and intelligent packaging, modified atmosphere packaging - vacuum and inert gas packaging, biodegradable and edible packaging, aseptic packaging, self-heating and cooling cans. Recycling of non-biodegradable packaging materials.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	identify appropriate pre-processing operations and determine the moisture characteristics of food products	L2
CO2.	select suitable storage and preservation techniques for fruits and vegetables	L2
CO3.	analyze and Categorize sampling and statistical quality control techniques.	L2
CO4.	identify appropriate thermal preservation techniques for food materials and make use of low temperature processing as a preservation techniques	L2
CO5	select and adapt recent trends in food packaging	L3

TEXT BOOKS:

1.Fellows P.J., "Food Processing Technology: Principles and Practice", 3rd Edition, Woodhead Publishing Ltd, New Delhi, 2009.
2. Earle R.L., "Unit Operations in Food Processing", 2nd Edition, Pergamon Press, U.K., 2004.

REFERENCES:

1.Paul Singh R. and Dennis R. Heldman, "Introduction to Food Process Engineering", 5th Edition, Academic Press, USA, 2014.
Han Jung H, "Innovations in Food Packaging", 2nd Edition, Academic Press, USA, 2014.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2					3						3	2
CO2	3	2	2				3				2		3	2
CO3	3	1	2				3						3	2
CO4	3	2	2		2		3					2	3	3
CO5	3	2	2				3					2	3	2

CH22083	PULP AND PAPER TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To provide a fundamental knowledge on paper products and their chemical, physical and mechanical behavior, the processing techniques, along with the production of different types of paper.

UNIT I	**INTRODUCTION**	**9**

Importance of paper industry, historical background of paper making, development of paper industry in India, Importance of paper, definitions of pulp, paper, and paperboard, Selection of pulp and paper making raw materials - Wood based raw materials, Non woody raw materials, Recycled fibers and Synthetics fibers.

UNIT II	**RAW MATERIALS PREPARATION AND STORAGE**	**9**

Classification of fibres, characteristics and composition of some important vegetable fibers (hard woods, softwoods, bagasse, straws, rags and paper stock), Wood preparation – pulp wood measurement, barking, chipping, screening and conveying of chips), Bagasse depithing – dry and wet depithing, effect of depithing on pulping and paper making properties, disposal of pith.

UNIT III	**PULPING PROCESSES**	**9**

Mechanical pulping, alkaline pulping (Soda and Kraft), sulfite pulping, semi-chemical pulping, recovery of cooking chemicals from spent cooking liquors, Bleaching agents, bleaching methods – single stage and multistage bleaching

UNIT IV	**MANUFACTURE OF PAPER**	**9**

Beating and refining, sizing and loading (filling), Paper machines (Fourdrinier and Cylinder), making of paper – forming section, press section, dryer section, calendaring section

UNIT V	**TESTING OF PAPER**	**9**

Testing and evaluation of pulp, various properties of pulp and paper and their testing, Different types and uses of papers and paper boards, composition, method of making different types of papers and boards.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Identify the importance of paper industry with their applications	U
CO2.	Interpret complete understanding of papermaking terms, equipment, process technology, science, and engineering fundamentals, operations, and variables. Use of various energy sources.	U
CO3.	Apply the knowledge about various unit operations in pulping processes	AP
CO4.	Interpret the processes involved in the manufacture of paper	U
CO5	Develop the various testing and evaluation procedures for different types of paper.	AP

TEXT BOOKS:

Britt K W, Handbook of Pulp and Paper Technology, Reinhold Publishing Corporation, New York
G.A. Smook, Handbook of Pulp and Paper technologists, 4 th Edition, Tappi Press, 2016

REFERENCES:

MacDonald R G, Pulp and Paper Manufacture Vol I to III, Second Edition., McGraw Hill, New York
Pulp and Paper: Chemistry and Chemical Technology Vol I to IV, Casey JP, Ed., Wiley Inter science, New York
Pulp and Paper Manufacture, Kocurek, Tappi Publication. Mark, Handbook of Physical and Mechanical Testing of Paper and Board, Vol.I & II, Dekker Publication

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3			2	3	2	2	3		3	3	2
CO2	3	3	3			2	3	2	2	3		3	3	2
CO3	3	3	3			2	3	2	2	3		3	3	2
CO4	3	3	3			2	3	2	2	3		3	3	2
CO5	3	3	3			2	3	2	2	3		3	3	2

CH22084	FLUIDIZATION ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To enable the students to learn the design aspects of fluidized beds.

UNIT I	**BASICS OF FLUIDIZATION**	**9**

Packed bed – Velocity – Pressure drop relations – Correlations of Ergun, Kozney karman – Onset of fluidization – Properties of fluidized beds – Development of fluidization from fixed bed- Advantages and disadvantages of fluidized beds.

UNIT II	**FLUIDIZED BED TYPES AND APPLICATIONS**	**9**

Minimum fluidization conditions – Expanded bed – Elutriation – Moving solids and dilute phase – spouted bed - Industrial applications of fluidized beds: Coal gasification

UNIT III	**DESIGN ASPECTS**	**9**

Channeling – Bed expansion in liquid – Solid and gas – Solid fluidizations. Design aspects of fluidized bed systems. Concept of RTD

UNIT IV	**HEAT AND MASS TRANSFER IN FLUIDIZED BEDS**	**9**

Heat and mass transfer in fluidized beds: Heat transfer mechanism, principles of gas-solid and bed surface transfer, heat transfer to liquid fluidized systems, generalized correlation for fluidized bed mass transfer and its limitations.

UNIT V	**OTHER TYPES OF FLUIDIZATION**	**9**

Single stage and multistage fluidization – Collection of fines – Use of cyclones.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	**STATEMENT**	**RBT LEVEL**
CO1.	Calculate pressure drop for packed bed and fluidized bed.	3
CO2.	Understand different types of fluidization and its applications	3
CO3.	Model the performance and design gas-fluidized bed reactors.	5
CO4.	Estimate heat and mass transfer effects on fluidized beds.	4
CO5	Compare the various types of fluidization.	3

TEXT BOOKS:

1. Kunni, D., Levenspiel O., “Fluidization Engineering”, Second Edition, Butterworth – Heinmann, 2012
2. Robert H. Perry and Don W. Green, “Perry‟s Chemical Engineer‟s Handbook”, Seventh Edition, Mc Graw Hill – International, 1997.

REFERENCES:

1. Davidson J. F., Harrison D, “Fluidization”, Academic Press, 1971.
2. Wen-Ching Yang, “Handbook of Fluidization and Fluid-Particle Systems”, Marcel Dekker Inc, 2003.
3. Liang – Shih FAN, Howard Brenner, “Gas-Liquid-Solid Fluidization Engineering” Butterworth Publishers, 1989

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	1			2	2	1	3	3		3	3	3
CO2	3	3	1			2	2	1	3	3		3	3	3
CO3	3	3	3			2	2	1	3	3		3	3	3
CO4	3	3	1			2	2	1	3	3		3	3	3
CO5	3	3	1			2	2	1	3	3		3	3	3

CH22085	DESIGN OF EXPERIMENTS AND PARAMETER ESTIMATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To enable the students to learn the design methodologies

UNIT I	**FUNDAMENTALS OF EXPERIMENTATION**	**9**

Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation.

UNIT II	**COMPARATIVE EXPERIMENTS**	**9**

Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA.

UNIT III	**FACTORIAL DESIGN**	**9**

Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

UNIT IV	**RESPONSE SURFACE METHODOLOGY**	**9**

Concept, linear model, steepest ascent, second order model, regression, optimization.

UNIT V	**TAGUCHI TECHNIQUE**	**9**

Design of experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments- Response Graph Method, ANOVA- attribute data analysis- Robust design- noise factors, Signal to noise ratios, Inner/outer OA design.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply the fundamental principles of Classical Design of Experiments.	3
CO2.	Analyze data to identify its significance in the model	4
CO3.	Apply Factorial Design principles for analyzing process parameters	3
CO4.	Evaluate and optimize process parameter by Response Surface method	5
CO5	Apply Taguchi‟s approach to experimental design for attaining robustness	3

TEXT BOOKS:

1. Montgomery DC, Design and Analysis of Experiments, Seventh Edition, John Wiley & Sons, NY, 2008.
2. Krishnaiah K, Shahabudeen P, Applied design of experiments and Taguchi method, Second edition, PHI, 2012.

REFERENCES:

1. Daniel Coleman, Belt Gunter, A DOE, Handbook, Create space publisher, 2013
2. Ross PJ, Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3		3	2	2	2	3	3	2	3	3	3
CO2	3	3	3		3	2	2	2	3	3	2	3	3	3
CO3	3	3	3		3	2	2	2	3	3	2	3	3	3
CO4	3	3	3		3	2	2	2	3	3	2	3	3	3
CO5	3	3	3		3	2	2	2	3	3	2	3	3	3

CH22086	DRUG AND PHARMACEUTICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To gain knowledge in formulation and manufacturing of drugs and its quality analysis.

UNIT I	**PRINCIPLES AND KINETICS**	**9**

Introduction to drugs and pharmaceutical, application of organic therapeutic agents, pharmaco kinetics- Absorption, Distribution, metabolism and Excretion-mechanism and physico chemical principles

UNIT II	**PROCESS SYNTHESIS**	**9**

Chemical Conversion process- alkylation, carboxylation, condensation and cyclisation, dehydration, esterification, halogenation, oxidation and sulfonation reactions.

UNIT III	**DRUG DELIVERY SYSTEMS**	**9**

Tablets and capsules -Types of Tablets and capsules -Formulation and Manufacturing; parential solutions, oral liquids, injections and ointments- methods of preparation.

UNIT IV	**PHARMACEUTICAL PRODUCTS:**	**9**

Vitamins-Functions, laxatives-classification and uses, analgesics-Types and Mechanisms, antacids and antiseptics-classification, mechanism and applications.

UNIT V	**QUALITY CONTROL:**	**9**

Concept of quality control-IPQC tests for tablets, Quality analysis – raw materials, process and finished products. Good Manufacturing Practices- cGMP, FDA regulations.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	explain the drug metabolism and pharmaco–kinetic principles	L2
CO2.	illustrate the different chemical conversion processes in pharmaceutical industries	L2
CO3.	outline the formulation and manufacturing of drug delivery systems	L3
CO4.	describe the manufacturing processes of different types of pharmaceutical products	L3
CO5	elaborate the importance of good manufacturing practices and quality control procedures	L3

TEXT BOOKS:

1. Brahmankar D.M. and Sunil B. Jaiswal, “Bio pharmaceutics and Pharmacokinetics: A Treatise”, 1st Edition, Vallabah Prakashan India, 2017 forunits I, II & III.
2. .Arthur Owen Bentley, "Text book of Pharmaceutics", 8th Edition, All India Traveller Book Seller, India, 2002 for units IV & V.

REFERENCES:

1.Banker G.S. and Rhodes C.T., "Modern Pharmaceutics", 4th Edition, Marcel Dekker Inc, United State of America, 2002.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3				2						3	2	2
CO2	3	3				2						3	2	2
CO3	3	3				2						3	2	2
CO4	3	3				2						3	2	2
CO5	3	3				2						3	2	2

CH22087	CHEMICAL PROCESS AUTOMATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To gain knowledge about automation and control systems in industries

UNIT I	**INTRODUCTION**	**9**

Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems : Modbus & Profibus

UNIT II	**AUTOMATION COMPONENTS**	**9**

Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT. Introduction of DC and AC servo drives for motion control.

UNIT III	**COMPUTER AIDED MEASUREMENT AND CONTROL SYSTEMS**	**9**

Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer aided process control software, Computer based data acquisition system, Internet of things (IoT) for plant automation.

UNIT IV	**PROGRAMMABLE LOGIC CONTROLLERS**	**9**

Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC selection, PLC Installation, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.

UNIT V	**DISTRIBUTED CONTROL SYSTEM**	**9**

Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Design a signal conditioning circuits for various application	5
CO2.	Acquire a detail knowledge on different sensors	2
CO3.	Understand the basics and Importance of communication buses in applied automation Engineering	2
CO4.	Ability to design PLC Programmes by Applying Timer/Counter and Arithmetic and Logic Instructions Studied for Ladder Logic and Function BIock	3
CO5	Acquire a detail knowledge on DCS and able to develop a PLC logic for a specific application on real world problem	3

TEXT BOOKS:

1. S.K.Singh, "Industrial Instrumentation", Tata Mcgraw Hill, 2nd edition companies,2003.
2. C D Johnson, "Process Control Instrumentation Technology", Prentice Hall India,8th Edition, 2006.
3. E.A.Parr, Newnes ,NewDelhi,"Industrial Control Handbook",3rd Edition, 2000

REFERENCES:

1. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003
2. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw- Hill, New York, 2016
3. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
4. Gary Dunning, Thomson Delmar,"Programmable Logic Controller", CeneageLearning, 3rd Edition,2005.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3		2		2		3	3	2	3	3	3
CO2	2	3	3		2				3	3	2	3	3	3
CO3	2	3	3		2		3		3	3	2	3	3	3
CO4	3	3	3		2				3	3	2	3	3	3
CO5	2	2	3		2		3		3	3	2	3	3	3

CH22088	DATA ANALYTICS & MACHINELEARNING FOR CHEMICAL ENGINEERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To introduce Data Analytics & MachineLearning For Chemical Engineers

UNIT I	INTRODUCTION TO DATA ANALYTICS IN CHEMICAL ENGINEERING	9

Overview of data analytics and its importance in chemical engineering; Basic concepts of data exploration, visualization, and descriptive statistics; Introduction to data mining techniques for extracting patterns and trends from chemical engineering data; Case studies demonstrating the use of data analytics in process optimization and quality improvement.

UNIT II	STATISTICAL METHODS FOR DATA ANALYSIS	9

Fundamentals of probability theory and statistical inference; Parametric and non-parametric statistical tests for hypothesis testing and confidence intervals; Regression analysis techniques for modelling relationships between process variables; Design of experiments (DOE) principles and methodologies for process optimization.

UNIT III	MACHINE LEARNING FUNDAMENTALS	9

Introduction to machine learning concepts and algorithms; Supervised learning techniques: linear regression, logistic regression, decision trees; Unsupervised learning techniques: clustering algorithms, principal component analysis (PCA); Model evaluation and validation techniques for assessing predictive performance.

UNIT IV	ADVANCED TOPICS IN DATA ANALYTICS FOR CHEMICAL ENGINEERING	9

Time series analysis and forecasting methods for predicting process behaviour; Anomaly detection techniques for identifying abnormal process conditions; Feature engineering and selection strategies for improving model performance; Case studies on applying advanced data analytics techniques to real-world chemical engineering problems.

UNIT V	APPLICATIONS OF DATA ANALYTICS IN CHEMICAL ENGINEERING	9

Predictive modelling for process optimization and control; Quality control and anomaly detection in chemical manufacturing processes; Integration of data analytics with process monitoring and control systems; Future trends and emerging applications of data analytics in chemical engineering.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Demonstrate competency in comprehending the essential principles of data analytics within the domain of chemical engineering.	2
CO2.	Apply statistical methods to analyze chemical engineering data sets, including hypothesis testing, regression analysis, and design of experiments.	3
CO3.	Comprehend the principles of machine learning and implement supervised and unsupervised learning algorithms to solve chemical engineering problems.	3
CO4.	Utilize advanced data analytics techniques such as time series analysis, anomaly detection, and feature engineering to address complex challenges in chemical engineering processes	3
CO5	Identify and evaluate applications of data analytics in various areas of chemical engineering	3

TEXT BOOKS:

1. Constales, D. and Yablonsky, G.S. and D'hooge, D.R. and Thybaut, J.W. and Marin, G.B. (2016). *Advanced Data Analysis and Modelling in Chemical Engineering*. Elsevier.
2. Vining, G.G. and Kowalski, S. (2010). *Statistical Methods for Engineers*. Cengage Learning
3. Montgomery D.C. (2019). *Introduction to Statistical Quality Control*. John Wiley and Sons.

REFERENCES:

1. Stephanopoulos G. (2015). *Chemical Process Control: An Introduction to Theory and Practice*. Pearson Learning.
2. Towler G and Sinnott R. (2012). *Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design*. Butterworth-Heinemann.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2	3		3	2	1	1	1	2	1	3	3	3
CO2	3	3	3		3	2	1	1	1	2	1	3	3	3
CO3	2	2	2		3	2	1	1	1	2	1	3	3	3
CO4	2	2	2		3	2	1	1	1	2	1	3	3	3
CO5	2	2	2		3	2	1	1	1	2	1	3	3	3

LIST OF OPEN ELECTIVES

OE22301	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To impart the knowledge on the waste management and energy recovery through various process.

UNIT I	**INTRODUCTION TO WASTE & WASTE PROCESSING**	**9**

Definitions, sources, types, composition and characterization of various types of solid wastes including biomedical waste; waste collection and transportation; waste processing-size reduction, separation; waste management hierarchy, waste minimization and recycling of MSW; Life Cycle Analysis (LCA)

UNIT II	**WASTE TREATMENT AND DISPOSAL**	**9**

Aerobic composting, incineration, different type of incineration; medical and pharmaceutical waste incinerations- land fill classification, types, methods and sitting consideration, layout and preliminary design of landfills: composition, characteristics, generation, movement and control of landfill leachate and gases

UNIT III	**ENERGY FROM WASTE-THERMO CHEMICAL CONVERSION**	**9**

Sources of energy generation, incineration, pyrolysis, gasification of waste using gasifiers, briquetting, utilization and advantages of briquetting, - environmental and health impacts of incineration; strategies for reducing environmental impacts.

UNIT IV	**ENERGY FROM WASTE- BIO-CHEMICAL CONVERSION**	**9**

Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, anaerobic digestion biogas production, land fill gas generation and utilization, design of waste to energy plants for cities, small townships and villages

UNIT V	**ENVIRONMENTAL AND HEALTH IMPACTS-CASE STUDIES**	**9**

Environmental and health impacts of waste to energy conversion, case studies of commercial waste to energy plants, waste to energy- potentials and constraints in India, eco-technological alternatives for waste to energy conversions - Rules related to the handling, treatment and disposal of MSW and BMW in India.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Apply fundamentals of waste management, material recovery and recycling process.	3
CO2.	Identify the importance of waste treatment and disposal	3
CO3.	Apply the process of incineration, pyrolysis, gasification of waste and strategies for reducing environmental impacts.	3
CO4.	Apply the process of anaerobic digestion for sewage and municipal waste and present status of technologies for conversion of waste into energy.	3
CO5	Analyze the environmental and health impacts during waste to energy conversion	4

TEXT BOOKS:

1. Dieter D. And Angelika S, Biogas from waste and renewable resources, Wiley-Vch Publication, 2010.
2. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000.

REFERENCES:

1. Gary C. Young, Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, John Wiley & Sons, 2010.
2. Robert Green, From Waste to Energy, Cherry Lake, 2009.
3. G. Evans, Biowaste and Biological Waste Treatment, 2014.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3				3	3	3	3	3		3	3	3
CO2	3	3				3	3	3	3	3		3	3	3
CO3	3	3				3	3	3	3	3		3	3	3
CO4	3	3				3	3	3	3	3		3	3	3
CO5	3	3				3	3	3	3	3		3	3	3

OE22302	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To gain knowledge on the safety measures to be practiced in process industries

UNIT I	**INTRODUCTION**	**9**

Safety in industries; need for development; importance safety consciousness in Indian chemical industry; social environmental setup; tolerance limit of the society; psychological attitude towards safety programme, Elements of safety programme, Role of chemical engineer in process industries.

UNIT II	**INDUSTRIAL SAFETY**	**9**

Chemical process industries; potential hazards, industrial health hazards – health standards, and rules; high pressure; high temperature operation; dangerous and toxic chemicals; highly radioactive materials; Industrial lighting and ventilation; Occupational diseases and prevention methods.

UNIT III	**SAFETY PERFORMANCE**	**9**

Appraisal, effective steps to implement safety procedures; periodic inspection and constant maintenance; periodic advice and checking to follow safety procedures; proper selection and replacement of handling equipments; personal protective equipments.

UNIT IV	**ACCIDENTS**	**9**

Industrial accidents – accident costs – identification of accident spots; remedial measures; Case studies pertaining to chemical industries: Bhopal gas tragedy, causes, affects & lessons learnt, Risk Management and Hazard Analysis – Steps in risk management, Risk analysis using HAZOP, FTA Fire prevention and fire protection

UNIT V	**LEGAL ASPECTS**	**9**

Legal framework for safety and environment: The Factories Act, The Environmental (Protection) Act, ESI Act – Workmen Compensation Act. Role of Government, safety organizations, management and trade unions in promoting industrial safety.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Impart knowledge on need for safety program and tolerance limit of the society.	3
CO2.	Perceive the different types of potential hazards associated with different chemical processes.	4
CO3.	Identify effective personal protective equipment with the knowledge of respiratory and non-respiratory techniques.	4
CO4.	Exemplify the concepts of HAZOP, FTA and ETA analysis in chemical industries risk analysis.	4
CO5	Acquire knowledge about various Indian laws and roles in promoting safety in chemical process industries.	3

TEXT BOOKS:

1. H.H. Fawcett and W. S. Wood, "Safety and Accident Prevention in Chemical Operation", 2nd Ed, Wiley Interscience, 1982.
2. Sam Mannan, Frank P. Lees, "Lees' Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control", 4th Edition, Butterworth-Heinemann, 2005.

REFERENCES:

1. Guide for Safety in the Chemical laboratory, 2nd 1977, Manufacturing Chemists Association. Van Nostrand Reinhold Company, New York.
2. Industrial Safety and Laws, 1993, by Indian School of Labour Education, Madras.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	3	2	2	2	3	3	3	1	2	3	3	3	3
CO2	3	3	3	3	1	3	3	3	1	2	2	2	3	3
CO3	1	2	2	1	1	3			1	1	1	1	3	3
CO4	1	1	1	1	3	3	2	2	1	1	1	2	3	3
CO5		2	2	1	1	3	2	2	1	2	1	2	3	3

OE22303	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To understand the various types of composites and its applications.

UNIT I	INTRODUCTION TO COMPOSITE MATERIALS	9

Definition, history, constituent materials in composites, characteristics, classifications (lightweight, high strength, corrosion resistance), composite material fabrication techniques, advantages and limitations, industrial scenario and applications of composite materials.

UNIT II	PROPERTIES AND STRUCTURAL PARAMETERS OF COMPOSITES	9

Static mechanical properties, fatigue, impact and creep properties, viscoelastic and dynamic properties, fracture behaviour and damage tolerance, fire resistance and flammability. Material and micro structural parameters of composites. Unidirectional-fibre composites: fibre properties, longitudinal and transverse strength and modulus, critical and optimal fibre volume fractions and factors influencing composite strength. Moisture and environmental effects. Non-destructive testing and evaluation.

UNIT III	FAILURE MODES OF COMPOSITES	9

Single and multiple fractures. Failure mechanism in composites. Short-fibre composites: Stress transfer, critical fiber length. Modulus and strength. Composite Failure in Extreme Conditions. Whiskers and whisker reinforced composites.

UNIT IV	PARTICULATE COMPOSITES	9

Particulate composites: Large-particle composites and dispersion-strengthened composites. Advantages and disadvantages of cermet composites. Zirconia toughened ceramics. Interface: Interface characteristics and their effects on adhesive, frictional and mechanical bonding mechanisms. Coupling agents and their role on the properties of composites. Advanced Interface Modification Techniques.

UNIT V	ADVANCED COMPOSITES	9

Nano composites, hybrid composites, sandwich composites, in-situ composites, smart composites, self-healing composites, and carbon-carbon composites, future trends in composite materials, bioinspired composites, metal matrix composites, functionally graded composites

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Classify composite materials based on industrials applications.	2
CO2.	Analyze and evaluate mechanical, dynamic, environmental, and fire properties of composites.	3
CO3.	Analyze fracture mechanisms and composite behaviour in extreme conditions.	3
CO4.	Discern the different types of composites and their interface characteristics.	3
CO5	Gain knowledge on advanced composites and its future trends.	2

TEXT BOOKS:

1. K.K. Chawla, Composite materials, Third edition, Springer-Verlag, 2013.
2. P. M.Ajayan, L. S.Schadler, P.V.Braun, Nanocomposite Science and Technology, Wiley-VCH Verlag GmbH Co. KGaA, 2006.

REFERENCES:

1. V.V. Vasiliev and E.V. Morozov, Mechanics and Analysis of Composite Materials, Second edition, Elsevier Science Ltd, 2001.
2. Agarwal,B.D. and Broutman, L. J., Analysis and Performance of Fiber Composites, Third edition, John Wiley & Sons, 2012.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1		3	3	3		3				2		3		
CO2	2	3	3	2	3	3				3		3		
CO3	3	3	3	3	3	3				3		3		
CO4	2	2	3	1	1					2		3		
CO5			3			3				2		3		

OE22304	INDUSTRIAL WASTEWATER TREATMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To promote understanding of basic and advanced concepts in Industrial wastewater treatment technologies

UNIT I	**SOURCES AND TYPES OF INDUSTRIAL WASTEWATER**	9

Sources and types of industrial wastewater – Characterization: Physical, Inorganic non metallic constituents, metallic constituents, Organic constituents, Biological Characteristic, Toxicity tests

UNIT II	**INTRODUCTION TO PROCESS SELECTION**	9

Physical unit operation: Screening, Coarse solid reduction, Mixing and flocculation, Equalization, Gravity separation, Grit removal, Sedimentation, Neutralization, Clarification, Flotation. Role of Chemical unit operations in wastewater treatment, Chemical unit Process: Chemical Coagulation, Chemical Precipitation- Heavy metal Removal, Phosphorus removal, Chemical oxidation, Chemical Neutralization and stabilization

UNIT III	**BIOLOGICAL TREATMENT**	9

Composition and Classification, Bacterial growth, Microbial growth, Aerobic biological oxidation, biological Nitrification, Anaerobic fermentation and oxidation, Biological removal of heavy metals, Activated sludge process, Trickling Filters, Rotating Biological Contactors, Combined aerobic treatment processes, Anaerobic treatment process, Anaerobic sludge blanket process, Attached growth process

UNIT IV	**ADVANCED WASTEWATER TREATMENT**	9

Depth filtration, surface filtration Membrane filtration, Adsorption, Ion exchange, advanced oxidation process, Photo catalysis, Wet Air Oxidation, Evaporation. Disinfection Processes: Disinfection with chlorine, Disinfection with chlorine dioxide, Dechlorination, Disinfection with ozone, Ultraviolet radiation Disinfection. Other chemical Disinfection methods

UNIT V	**INDUSTRIAL EFFLUENT TREATMENT PLANTS**	9

Individual and Common Effluent Treatment Plants – Zero effluent discharge systems -Wastewater reuse – Disposal of effluent on land – Quantification, characteristics and disposal of Sludge. Industrial process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing - Pharmaceuticals – Sugar and Distilleries – Food Processing –Fertilizers – Industrial Estates, Indian regulations.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Describe the sources and types of Industrial Wastewater	**3**
CO2.	Apply the principles of physical and chemical unit operations in wastewater treatment	**3**
CO3.	Explain the industrial biological wastewater treatment techniques	**2**
CO4.	Describe the advanced wastewater treatment techniques used in industries	**2**
CO5.	Demonstrate the operations of various industrial effluent treatment plant	3

TEXT BOOKS:

1. Metcalf Eddy by George Tchobanoglous, Franklin L. Burton, "Wastewater Engineering: Treatment and Reuse", 1st Edition, McGraw Hill Book Co, USA, 2011.

REFERENCES:

1. Eckenfelder, W.W., "Industrial Water Pollution Control", 1st Edition, McGraw Hill International edition, United State of America, 1999.
2. Frank Woodard, "Industrial waste treatment Handbook", 1st Edition, Butterworth Heinemann, New Delhi, 2001.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2		2	3	2	3	3	3	3	2	2	3	2
CO2	3	2	2	2	3	2	3	3	3	3	2	2	3	2
CO3	3	2	2	2	3	3	3	2	3	3	2	2	3	2
CO4	3	2	2	2	3	2	3	3	3	3	2	2	3	3
CO5	3	2	2	2	3	3	3	2	3	3	2	2	3	2

OE22305	FUEL CELL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To impart knowledge on concepts and application of fuel cell technology

UNIT I	**FUEL CELL SYSTEMS**	**9**

Introduction to fuel cells as energy converter, Classification of fuel cells, Proton exchange membrane (PEM) fuel cell stack, fuel cell power conditioner, automotive applications, portable applications.

UNIT II	**FUEL CELL THERMODYNAMICS**	**9**

Low and high temperature fuel cells; Fuel cell thermo dynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency, thermal and mass balance in fuel cells.

UNIT III	**FUEL CELL REACTION KINETICS**	**9**

Fuel cell reaction kinetics - electrode kinetics, Potential and Rate: Butler–Volmer Equation, Simplified activation kinetics: Tafel equation. Kinetics of different fuel cell reactions, Catalyst– electrode design

UNIT IV	**TRANSPORT PROCESSES AND CHARACTERIZATION IN FUEL CELLS**	**9**

Fuel cell charge transport and mass transport, Flow field, transport in electrode and electrolyte. Fuel cell characterization: In-situ and ex-situ characterization techniques, current-voltage curve.

UNIT V	**FUEL PRODUCTION FOR FUEL CELL OPERATION**	**9**

Balance of plant, Hydrogen production from renewable sources and storage, Safety issues, Cost expectation and life cycle analysis of fuel cells.

TOTAL:45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Explain the fundamentals and classification of fuel cells	3
CO2.	Apply the thermodynamic concepts in fuel cells	3
CO3.	Analyze the reaction kinetics in fuel cells	4
CO4.	Evaluate the transport process and characteristics of fuel cells	4
CO5	Analyze the safety issues and production of fuel for fuel cell operation	4

TEXT BOOKS:

1. Ryan O "Hayre, Suk Won Cha and Whitney Colella, Fuel cell fundamentals, Second edition, John Wiley and Sons, 2016.
2. Viswanathan, B and M Aulice Scibioh, "Fuel Cells – Principles and Applications", Universities Press, 2006

REFERENCES:

1. Gregorhoogers, Fuel cell technology – Handbook, First Edition, CRC Press, 2002.
2. Supramaniam Srinivasan, Fuel cells: From fundamental to application, First Edition, Springer,2010
3. Basu,S.(Ed) Fuel Cell Science and Technology,Springer, N.Y.2007.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	3	2				1	2	1	2	3	3
CO2	3	3	3	3	2				1	2	1	2	3	3
CO3	3	3	2	3	2				1	2	1	2	3	3
CO4	3	3	3	3	2				1	2	1	2	3	3
CO5	3	3	3	3	2	2	2	2	1	2	1	2	3	3

OE22306	INDUSTRIAL POLLUTION PREVENTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To understand the importance of industrial Pollution Prevention with case studies and understand the underlying principles of Industrial Pollution Prevention.

UNIT I	**9**

Introduction to Pollution Abatement.Importance of IPA-Basics of Jurisprudence-Environmental law relation with other disciplines-Criminal law -Common Law-Relevant sections of the code of civil procedure, criminal procedure code, EPA, Environmental regulatory legislations and standards.

UNIT II	**9**

Evaluation of Pollution prevention options-Fundamental Rights-Directive principles of state policy-Article 48(A) and 51-A (g) Judicial enforceability-Constitution and resources management and pollution control-Indian forest policy (1990) –Case Study.Indian Environmental policy (1992) & its case Study

UNIT III	**9**

Regulatory boards related with Administration-constitution of pollution control Boards Powers, functions, Accounts, Audit etc.-Formal Justice Delivery Mechanism Higher and Lower of judiciary- Constitutional remedies writ jurisdiction Article 32,226,136 special reference to mandamus and certiorari for pollution abatement-Equitable remedies for pollution control.

UNIT IV	**9**

Regulation under recent legislations in water pollution control, Water (prevention and control of pollution)Act 1974 as Amended by amendment act 1988 Water(prevention of control and pollution)Rules1975 Water (prevention and pollution) Cess Act.1977 as amended by amendment act 1991. Air(prevention and control of pollution)Act 1981 as amended by Amendment act 1987 and relevant notifications- Environmental Protection act 1986.

UNIT V	**9**

Relevant notifications in connection with Hazardous Wastes (Management and handling),Biomedical Wastes (Management and Handling), Noise pollution, Eco labeling, and EIA and ESA-Strategic Environmental Assessments (SEA).The different steps of the EIA and SEA.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Illustrating the basic environmental laws and relevant sections of the code of civil procedures.	L4
CO2.	Discuss the fundamentals Rights-Directive principles of state policy-Article.	L2
CO3.	Make use of regulations for pollution abatement and waste minimization.	L3
CO4.	Interpret recent legislation for water and air pollution.	L6
CO5	Identifying the skill on the Management and handling of Hazardous and Biomedical wastes.	L3

TEXT BOOKS:

Tiwari, H.N., Environmental Law, Allahabad Law. Agency 1997.

REFERENCES:

1. Shyam Divan and Armin Roseneranz "Environmental law and policy in India "Oxford University Press, New Delhi, 2001.
2. Constitution of India Eastern Book Company Lucknow Twelfth Edition.1997.
3. Kesari, U.P.D, Administrative Law, Universal Book Trade, Delhi, 1998.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1	2	2	1	1	1	2		1	1		1	1	1
CO2	1	1	2	1	1		1			1	1	1	1	1
CO3		2	2	2	2	1	2	2	2	1		1	1	1
CO4		2	1	1	1	1	1		1	1		1		
CO5		1	2	1	1	2	2		2		2	1	1	1

OE22307	SOLID WASTE MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To provides an understanding of solid waste classification, characteristics and its management, by following regulations and including environment risk assessment

UNIT I	**FUNDAMENTALS**	**12**

Solid Waste - Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; Chemical treatment processes for Solid Waste – combustion, stabilization and solidification of hazardous wastes); Physicochemical processes for hazardous wastes – soil vapour extraction, air stripping, chemical oxidation; Biological Treatment of Solid Waste – Composting; bioreactors; anaerobic decomposition of solid waste; Elements of integrated solid waste management.

UNIT II	**SOLID &HAZARDOUS WASTE MANAGEMENT**	**9**

Characterization of waste; compatibility and flammability of chemicals; handling and transport of chemicals; health effects. Landfill for solid and hazardous wastes; working of sanitary landfills – Landfill liners – Management of leachate and landfill gas-incineration

UNIT III	**RADIOACTIVE WASTE MANAGEMENT**	**9**

Sources, measures and health effects; nuclear power plants and fuel production; waste generation from nuclear power plants; disposal options, Atomic energy regulatory board (AERB) rules.

UNIT IV	**REGULATIONS**	**9**

Municipal solid waste (management and handling) rules; hazardous waste (management and handling) rules; biomedical waste handling rules; fly-ash rules; recycled plastics usage rules; batteries (management and handling) rules. Requirements and salient features of Solid waste management rules (2016).

UNIT V	**ENVIRONMENTAL RISK ASSESSMENT**	**6**

Defining risk and environmental risk; methods of risk assessment; steps involved in risk assessment, case studies.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Examine the various sources of solid waste and its treatment processes.	4
CO2.	Apply the knowledge about the solid and hazardous waste management.	3
CO3.	Identify the methods of disposal of hazardous & radioactive solid waste.	3
CO4.	Acquire knowledge about the regulations involved in solid waste management.	4
CO5	Explain about environmental risk assessment methods and the steps involved.	3

TEXT BOOKS:

1. George Tchobanoglous and Hillarytheisen, Samuel Vigil; Integrated solid waste Management; McGraw Hill, 1993.
2. Michael E Henstock Butterworths, Ann Arbor Science; Disposal and recovery of municipal solid waste; Butterworth-Heinemann Ltd, 1983.
3. William A Worrell, P AarneVesilig; Solid waste management, Cengage Learning, 2010
4. Mackenzie L Davis, David A Cornwell; Environmental Engineering; McGraw Hill 2006

REFERENCES:

1.John Pichtel; Waste Management Practices; CRC Press, Taylor and Francis Group 2005.
2. LaGrega, M.D.Buckingham,P.L. and Evans, J.C.; Hazardous Waste Management, McGraw Hill International Editions, New York, 1994.
3. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors; John Wiley and Sons, New York, 1997

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	-	-	3	3	3	3	3	2	3	3	3	2	2
CO2	2	-	-	3	3	3	3	3	2	3	3	3	2	2
CO3	2	-	-	3	3	3	3	3	2	3	3	3	2	2
CO4	2	-	-	3	3	3	3	3	2	3	3	3	2	2
CO5	2	-	-	3	3	3	3	3	2	3	3	3	2	2

OE22308	PLANT UTILITIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: To equip the chemical engineering students with knowledge on the various process utilities so as to ensure smooth and proper operation of utilities in the process plants.

UNIT I	**WATER AS BASIC UTILITY**	**9**

Introduction: Different utilities. Role of utilities in process plant operations and criteria for selection and estimation of suitable utilities. Water as a utility: Sources of water, hard and soft water, Requisites of industrial water and its uses, Methods of water softening processes, Boiler Feed water and demineralized water

UNIT II	**STEAM AND STEAM GENERATION**	**9**

Use of Steam as utilities Properties of Steam, Steam Generator: Classification, comparison, components, Factors affecting selection of Boiler, Boiler Accessories and mountings, scaling and trouble shooting. Economy of steam generation with different fuels, Fuels: Types, Calorific value. Proximate and ultimate analysis and its calculations

UNIT III	**REFRIGERATION SYSTEMS AND INSULATION**	**9**

Refrigeration system and their characteristics, load calculation, refrigerating effects and liquefaction processes, production of liquid N_2 and O_2. Types of insulation, Different types of insulating materials and their Characteristics. Selection criteria for insulating materials

UNIT IV	**COMPRESSORS AND VACUUM PUMPS**	**9**

Classification of Compressors and Vacuum Pumps and their performance characteristics, Power requirement and performance Calculations, equipments used for humidification, dehumidification and cooling towers, basic Concepts of vacuum and pressure and its measurement, Components of a vacuum system like vacuum chamber, pumps, gauges, valves, seals, and many other subsidiary components. Inert gas

UNIT V	**PINCH ANALYSIS**	**9**

Pinch Analysis: Problem representation, temperature enthalpy diagram, simple match matrix. Heat content diagram, Temperature interval diagram. Heat Exchanger Network Synthesis using Pinch technology.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Understand the importance and selection of utilities	2
CO2.	Choose suitable type of equipment for pressure and vacuum Equipment required for steam and co-generation Equipment	3
CO3.	Interpret the concept of refrigeration and their applications in process industries.	4
CO4.	Outline the different types of compressors for handling air and inert gases and the application of correct type of insulation system	2
CO5	Ability to do pinch analysis.	4

TEXT BOOKS:

1. P. L. Ballaney, "Thermal Engineering", Khanna Publisher New Delhi, 1986.
2. Plant Utilities by D.B. Dhone, 2nd Edition, 2012, Nirali Prakashan, Pune

REFERENCES:

1. Robin M. Smith, "Chemical Process: Design and Integration", John Wiley & Sons Ltd., 2005.
2. Mahesh Rathore, "Thermal Engineering," Tata McGraw Hill India, New Delhi, 2010.
3. Plant Utilities by Dr. Mujawar, Nirali Prakashan Publication.
4. Chemical Engineer"s Handbook, Robert H. Perry and DON W. Green.Seventh Edition, 2005, McGraw Hill, New York, ISBN: 10: 0071422943

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	2	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	2	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	2	3	3	3

OE22309	GREEN ENERGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To impart knowledge on available energy sources, rising energy demand for the day-to day life requirements and the need of research on this area to meet the demand.

UNIT I	**INTRODUCTION**	**9**

Current energy requirements, growth in future energy requirements, Review of conventional energy resources, Coal, gas and oil reserves and resources, Tar sands and Oil Shale, Nuclear energy Option.

UNIT II	**SOLAR ENERGY**	**9**

Solar radiation: measurements and prediction. Solar thermal collectors- flat plate collectors, concentrating collectors. Basic theory of flat plate collectors, solar heating of buildings, solar still, solar water heaters, solar driers; conversion of heat energy into mechanical energy, solar thermal power generation systems. Solar Photovoltaic: Principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping, power generation schemes

UNIT III	**WIND ENERGY**	**9**

Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Betz limit, WECS: classification, characteristics, and applications. Nature of wind energy potential and installation in India - Repowering concept.

UNIT IV	**OCEAN ENERGY**	**9**

Ocean energy resources-ocean energy routes - Principles of ocean thermal energy conversion systems-ocean thermal power plants- Principles of ocean wave energy conversion and tidal energy conversion.

UNIT V	**HYDRO AND OTHER SOURCES OF ENERGY**	**9**

Hydropower, Basic principle of hydroelectric power generation, Nuclear fission and fusion-Geothermal energy: Origin, types of geothermal energy sites, site selection, geothermal power plants; Magneto-hydro-dynamic (MHD) energy conversion.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Develop the knowledge about the current scenario of energy requirements.	U
CO2.	Apply the solar energy-based systems to meet the energy demand	AP
CO3.	Identify the wind energy-based set-ups for energy management.	AP
CO4.	Analyze the principles underlying ocean and tidal energy generation to address current and future energy demands	AN
CO5	Interpret the various source of energy like nuclear, geo-thermal and hydropower to withstand the present and future energy requirements	U

TEXT BOOKS:

D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, Second Edition, 2000.
J. Twidell, & T. Weir, Renewable energy resources. Taylor and Francis, Third edition, 2015.

REFERENCES:

D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press, Second Edition, 2009.
S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw Hill, Third Edition, 2008.
L.L. Freris, Wind Energy Conversion Systems, Prentice Hall,1990.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	1	2		2		3	3	2		3		1	3	2
CO2	1	2		2		3	3	2		3		1	3	2
CO3	1	2		2		3	3	2		3		1	3	2
CO4	1	2		2		3	3	2		3		1	3	2
CO5	1	2		2		3	3	2		3		1	3	2

OE22310	ENERGY MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To give an overview on energy management techniques

UNIT I	ENERGY MANAGEMENT	**9**

Definition of energy management, Importance of energy management, Overview of energy sources and consumption patterns, Overview of energy policy frameworks, Government initiatives and incentives for energy management, Regulatory challenges and opportunities. Linkages between energy management and sustainable development goals

UNIT II	ENERGY AND ENVIRONMENT	**9**

Structural properties of environment – Biogeochemical cycles – Society and environment population and technology , Various forms of Energy, Energy storage, Overview of nonrenewable energy resources, Nuclear Energy, Thermal Energy,

UNIT III	ENERGY ALTERNATIVES	**9**

Overview of renewable energy sources – Wind and water – Geothermal – Tidal and solar power – MHD, fuel cells – Hydrogen as fuel. Integration of renewable energy into existing energy systems

UNIT IV	MANAGEMENT OF ENERGY CONSERVATION IN CHEMICAL INDUSTRIES	**9**

Analysis of scope and potential for energy conservation in chemical industries – Classification of chemical industries - Conservation in unit operation such as separation – Cooling tower – Drying, Conservation applied to refineries, chemical, cement, pulp and paper, food industries. Conservation using optimization techniques.

UNIT V	ENERGY AUDIT	**9**

Definition, need and objectives - Types of energy audit - Basic components of energy audit - Preparing for audit - Energy audit instruments - Data collection - Safety considerations. Methodologies of conducting energy audit - Preliminary questionnaire - Review of previous records - Walk through audit - Energy flow diagram (Sankey diagram).

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Interpret the need of Energy Management and Sustainability	3
CO2.	Evaluate renewable energy resources and its Environmental Impacts	4
CO3.	Identify renewable energy resources and its conversion technology.	4
CO4.	Assessing advantages of energy conservation and management techniques.	4
CO5	Determine the components involved in energy auditing.	3

TEXT BOOKS:

1. Rao, S. and Parulekar, B.B., Energy Technology, Khanna Publishers, 2005.
2. Rai, G.D., Non-conventional Energy Sources, Khanna Publishers, New Delhi, 1984.
3. Wayne C. Turner and Steve Doty, "Energy Management Handbook" The Fairmont Press (2016).

REFERENCES:

1. Craig B. Smith, Energy Management Principles: Applications, Benefits, Savings, CRC Press, 1st Edittion, 2016.
2. Godfrey Boyle, "Renewable Energy: Power for a Sustainable Future", Oxford University Press,4th Eddition, 2012.
3. Gramlay, G. M., "Energy", Macmillon Publishing Co., 1975.
4. Kenney, W.F., Energy Conservation in the Process Industries, Academic Press, (1984).

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	3	2	2	0	3	3	3	3	3	3	2	3	3
CO2	2	3	3	3	0	3	2	3	3	3	0	2	3	3
CO3	3	3	3	3	3	3	2	0	3	3	0	2	3	3
CO4	3	3	3	3	3	3	2	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	2	0	3	3	3	3	3	3

VALUE ADDED COURSES

VD22301	CHEMICAL ENGINEERING PLANT DESIGN	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES: To impart knowledge about process plant design, engineering drawings, and importance of cost, safety and environment in plant design

UNIT I	**FUNDAMENTALS OF ENGINEERING DESIGN**	**6**

General overall design considerations, Anatomy of chemical engineering projects, Process Design development, Types of designs, comparison of different processes by technical factors, raw materials, by-products, plant location, equipment, Process design codes, Standard sources of information, Plant location, Plant layout, Plant operation and control, Importance of laboratory development to pilot plant, scale up methods.

UNIT II	**ENGINEERING FLOW DIAGRAMS**	**6**

Introduction to block, process flow, Logic, Information flow diagrams. Preparation of PID, trip and interlock systems, MOC, valve selection and Types of valves , color code of pipeline, Equipment datasheets, Layout engineering (Plot Plan), Equipment layout, Process layout.

UNIT III	**MATERIALS-HANDLING EQUIPMENT & DESIGN**	**6**

Basic concepts-Piping in fluid transports processes- Pumping of fluids-Compression and expansion of fluids-Compression and expansion of fluids- Agitations and mixing of fluids-Flow measurement- Storage tanks and its classification, Dykes & containment of fluids-Transport of solids-handling of solids.

UNIT IV	**OPTIMUM DESIGN AND DESIGN STRATEGY**	**6**

Economic aspects and optimum design, practical considerations in design and engineering ethics, Break-even analysis, Optimum production rates in plant operation, Economic pipe diameter, Optimum insulation thickness, network analysis, PERT/CPM, Direct and Indirect cost, Cash flow, Organizations for presenting capital investment: estimates by compartmentalization, estimation of total product of cost direction, production costs, fixed charges, plant overhead costs, financing

UNIT V	**PLANT DESIGN, PROCESS DESIGN CASE STUDIES**	**6**

Plant design case studies for any one of the chemical, petrochemical and polymer products: process synthesis, development of process flow diagram, mass and energy balance, P& ID diagram, use of process design software‟s such as COMSOL, ASPEN HYSYS, PDMS and PMS, Technical project report writing.

TOTAL:30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Illustrate the various stages involved in a development of a process plant.	L2
CO2.	Identify various flow diagrams, drawings, standards and codes involved in process design.	L3
CO3.	Impart insights into the design of equipment pertaining to materials handling.	L3
CO4.	Outline the performance of breakeven analysis and optimum design of a process.	L3
CO5	Classify the process design software and its applicability in industries	L2

TEXT BOOKS:

REFERENCES:

1. T.T.Shen, "Industrial Pollution Prevention", Springer, 1999.
2. R.L.Stephenson and J.B.Blackburn, Jr., "Industrial Wastewater Systems Hand book", Lewis Publisher, New Yark, 1998.
3. H.M.Freeman, "Industrial Pollution Prevention Hand Book", McGraw-Hill Inc., New Delhi, 1995.
4. Bishop, P.L., "Pollution Prevention: Fundamental & Practice", McGraw-Hill, 2000.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1	1	2	1	1	2	1	1	1	1	1	1	1
CO2	1	1		2	1	2	2	1	1		2	1	1	1
CO3	2	1	2	2	1	1	1		1	1	1	1	2	3
CO4	1	2	2	1	2	2	1		1	2	1	1	2	2
CO5	2	2	1	2		2	1	1			2	2	1	1

VD22302	INTRODUCTION TO SUSTAINABILITY	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES: To understand the environmental, social and economic dimensions of sustainability and the principles evolved through landmark events so as to develop an action mindset for sustainable development.

UNIT I	SUSTAINABILITY AND DEVELOPMENT CHALLEGES	7

Definition of sustainability – Environmental, Economical and Social dimensions of sustainability - Sustainable Development Models – Strong and Weak Sustainability – Defining Development Millennium Development Goals – Mindsets for Sustainability : Earthly, Analytical, Precautionary, Action and Collaborative– Syndromes of Global Change: Utilization Syndromes, Development Syndromes, and Sink Syndromes – Core problems and Cross Cutting Issues of the 21 Century - Global, Regional and Local environmental issues – Social insecurity - Resource Degradation – Climate Change – Desertification

UNIT II	PRINCIPLES AND FRAME WORK	9

History and emergence of the concept of sustainable development - Our Common Future - Stockholm to Rio plus 20– Rio Principles of Sustainable Development – Precautionary Principle-Polluter Pays Principle – Role of Civil Society, Business and Government -Natural Step- PeoplesEarth Charter – Business Charter for Sustainable Development –UN Global Compact – Agenda 21

UNIT III	SUSTAINABILE LIVELI HOOD	5

The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution – Combating Poverty - Millennium Development Goals, Indicators, Targets, Status and intervention areas - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children,Youth, Indigenous People, Non-Governmental Organizations, Local Authorities and Industry forPrevention, Precaution , Preservation and Public participation

UNIT IV	SUSTAINABLE SOCIO-ECONOMIC SYSTEMS	12

Protecting and Promoting Human Health – Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation -Biodiversity conservation and Ecosystem integrity –Ecotourism - Urbanization and Sustainable Cities – Sustainable Habitats- Green Buildings - Sustainable Transportation – Sustainable Consumption and Production – Sustainable Mining - Sustainable Energy– Climate Change –Mitigation and Adaptation - Safeguarding Marine Resources - Financial Resources and Mechanisms

UNIT V	ASSESSING PROGRESS AND WAY FORWARD	12

Nature of sustainable development strategies and current practice- Sustainability in global,regional and national context – Rio Plus 20 - Approaches to measuring and analyzing sustainability– limitations of GDP- Ecological Footprint- Human Development Index, Science and Technology for sustainable development – Performanceindicators of sustainability and Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning – Governance - Science andTechnology Sustainability Education

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	understand the significance of Environmental, Economical and Social dimensions of sustainability	L2
CO2.	Learn to integrate the Rio principles of Sustainable development in decision making and Contribute towards Green Economy	L2
CO3.	Ability to identify and formulate the level of sustainability globally.	L3
CO4.	Develop a fair understanding of the social, economic and ecological linkage of human production and consumption	L3
CO5	Asses the recent trend in sustainable development strategies and current practice	L3

TEXT BOOKS:

1. Barry Dalal Clayton and Stephen Bass, Sustainable Development Strategies- a resource book", Earthscan Publications Ltd, London, 2002.

2. Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide,Green Leaf Publishing, 2006.

REFERENCES:

Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide, Green Leaf Publishing, 2006.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	2	2		2		2		2	2	2	3	3
CO2	3	3	3	2	3		2	2		2	2	2	3	3
CO3	3	3	2	3	3	2	2	2	2		2		3	3
CO4	3	3	2	2	2		2				2	2	3	3
CO5	3	3		2		2			3	3	2		3	3

VD22303	MATLAB/ASPEN	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES: To provide basic knowledge on utilizing MATLAB and ASPEN software for problem solving using computers

UNIT I	**INTRODUCTION TO MATLAB**	**6**
Introduction to MATLAB software, Basic Mathematics, Data files and Data types, Operations using matrix, Plots – visualizing vector and matrix, Programming in MATLAB – Loops, M file.		
UNIT II	**PROBLEM SOLVING USING MATLAB**	**6**
Algebraic equations - Single variable, Multivariable equations. Numerical solution to equations. Solving Ordinary differential equations.		
UNIT III	**SIMULATION USING ASPEN – PART I**	**6**
Introduction to Aspen Plus, Simulation of unit operation blocks – Mixer, Splitter, Decanter, Flash drum, Heat Exchanger.		
UNIT IV	**SIMULATION USING ASPEN – PART II**	**6**
Simulation of unit process blocks – PFR, CSTR, Batch Reactor.		
UNIT V	**SIMULATION USING ASPEN – PART III**	**6**
Simulation of flowsheet; Design an heat exchanger with specification and generate TEMA sheet.		
		TOTAL:30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	To solve the programming of MATLAB	3
CO2.	To solve Chemical Engineering Problems through MATLAB	3
CO3.	Apply the simulation software and unit operations blocks	3
CO4.	Apply Aspen software and solve unit operation blocks – Mass and Energy balance	3
CO5	Design an Heat exchanger using Aspen simulation software	5

TEXT BOOKS:

1. Fausett L.V. (2007) Applied Numerical Analysis Using MATLAB, Second Edition, Pearson Education.
2. Schefflan R. (2011), Teach Yourself the Basics of Aspen Plus, John Wiley and Sons.

REFERENCES:

1. Chapra S.C. and Canale R.P. (2006) Numerical Methods for Engineers, Fifth Edition, McGraw Hill Publishers.
2. Finlayson B. A. (2006) Introduction to Chemical Engineering Computing, John Wiley and Sons.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3		3	2	2	2	3	3		3	3	3
CO2	3	3	3		3	2	2	2	3	3		3	3	3
CO3	3	3	3		3	2	2	2	3	3		3	3	3
CO4	3	3	3		3	2	2	2	3	3		3	3	3
CO5	3	3	3		3	2	2	2	3	3		3	3	3

VD22304	PACKAGING TECHNOLOGY	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES: This course provides to learn about packaging materials, technologies, design, sustainability and quality control and students gain the practical skills in packaging design, testing, and production processes, as well as a deep understanding of industry regulations and standards.

UNIT I	**7**

History and evolution of packaging. Basics of Packaging: Introduction, Classification of Packaging,Functions & roles of a packaging, Factors influencing design of a package.

UNIT II	**9**

Packaging Cycle, Product-Package Relationship, Product life cycle curve, Elements of PackageDesign, types of Packaging - Flexible package, Rigid package & semi-rigid package. Markings onpackage – Handling marks, routing marks, information marks

UNIT III	**5**

Cushioning materials – Functions, properties. Classification – space fillers, resilient cushioningmaterials, non resilient cushioning materials. Introduction to Packaging Media.

UNIT IV	**12**

Carton Production: Carton styles. Folding cartons – Production steps, types. Corrugated containers– classifications, components in a corrugated board, flutes & stages in preparation in corrugated boards. Plastic corrugated boards-features & advantages. Introduction to Innovative Packaging Techniques/ Processes: Gas packaging – MAP & CAP, Vacuum packaging, shrink packaging, stretch wrapping, blister packaging, skin packaging, strip packaging, Aerosol packaging container.

UNIT V	**12**

Miscellaneous Polymers: Expanded Polyethylene: Properties and applications, Plastic Woven Sacks: Material, Method, construction, use, Polycarbonate: Introduction, application in packaging. Testing on Plastics: Introduction, Scope, and Preparation of sample, solubility test, melting behaviour, approximate density, Ignition test, Dry distillation test, chemical colour identification test, pyrolysis test, refractive index, basic equipments, and other testing measures for individual plastics.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Define various raw materials used in packaging industry	L1
CO2.	Describe the utilization of Product cycle and elements of package design inpackaging industry	L2
CO3.	Apply principles of engineering and sciences in the field of packaging industry	L3
CO4.	Examine most inclusive areas where various materials can be used packagingindustry	L4
CO5	Describe the utilization of various polymers in packaging industry	L2

TEXT BOOKS:

1.A text book on " Packaging Technology" Fundamentals, materials and process by Anne Emblem and Henry Emblem 2012
2.A text book on " Packaging Technology" by Ganesan.P Published in the year 2022

REFERENCES:

1.Packaging Design: Successful Product Branding from Concept to Shelf 1st Editionby Marianne R. Klimchuk and Sandra A. Krasovec 2008

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	2	1	3	2	-						3	3
CO2	3	3	3	1	3	2							1	3
CO3	3	3	2	1	3	2							3	3
CO4	3	3	2	1	2	2	2						3	3
CO5	3	3	2	1	3	2	-						3	3

VD22305	SUSTAINABLE AGRICULTURAL LAND MANAGEMENT	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES:

Toempowerthestudentswithaneconomicallyviable,sociallysupportive,andecologicallysoundeducation on sustainableagriculture.

UNIT I	INTRODUCTION TO SUSTAINABLE AGRICULTURE	6

The concept of sustainability and sustainabledevelopment-emergingissues-Sustainableagriculture-conceptthemes-differencesbetweenconventional,sustainable,andalternateagriculture-Variousalternateagriculturalsystems-Conventional,sustainable,andalternateagriculture-formsandlimitations-Modernizationofagriculture anditsrelationtosustainability

UNIT II	GOOD AGRICULTURAL PRACTICES	6

Good Agricultural Practices(GAP)- GAP certification -Improved manure handling - crop residuemanagement - strategic use of chemical fertilizers and pesticides, traps, repellants and biologicalcontrol -water conservation measures for sustainability- water harvesting - Role of water in soilandplants-Irrigatedagriculturevs.Rainfedagriculture,dryfarminganddrylandfarming-definition. Soil conservation vs. water conservation - agronomic measures- mechanical measures-Roleofgrasses and pastures in soil conservations

UNIT III	CROPPINGPATTERN	6

Introduction-importance of system approach in crop production, different cropping systems; Termsanddefinition-Croppingpattern-Multiplecroppingandvariousforms-advantagesanddisadvantages-Intercropping-ecologicalbasisofintercroppingsystems-types-sequentialcroppingand crop rotation-planned crop rotation-Mixed farming.

UNIT IV	ORGANICFARMING	6

Organicagriculture-history-concepts-philosophy-objectives,opportunities,andprioritiesCriticisms-Organicfarmingandfoodsecurity-Principlesoforganicfarming.Toolsandpracticesoforganic farming

UNIT V	INTRODUCTIONTOHORTICULTURE	6

Introduction - scope and importance - problems and prospects of protected culture in India -growing structures - green house - polyhouse - net house - basic considerations in establishmentandoperation ofgreenhouses -maintenance

TOTAL: 30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Elucidate the concept of sustainability and sustainable development.	
CO2.	List out good agricultural practices and its benefits.	
CO3.	Compare and analyze various cropping patterns.	
CO4.	Acquaint with the fundamentals of organic farming	
CO5	Outline various Horticulture practices.	

REFERENCES:

1) Veeresh,G.K.,Shivashankar,K.andSinglachar,M.A.1997.OrganicFarmingandSustainableAgriculture, AssociationforPromotionofOrganic Farming,Bangalore.
2) Palaniappan,S.PandAnandurai,K.1999.OrganicFarming-TheoryandPractice,Scientific Pub., Jodhpur..
3) GurmelSingh,C. Venkataraman, G., Sastry,B.andJoshi, P.1990.ManualofSoil andWaterConservationPractices.OxfordandIBH PublishingCo., New Delhi.
4) Roy.A.Larson.,1992.IntroductionofFloriculture.InternationalBookDistributingCo., Lucknow.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2					3	3	2			2	3	3	3
CO2	2					3	3	2			2	3	3	3
CO3	2					3	3	2			2	3	3	3
CO4	2					3	3	2			2	3	3	3
CO5	2					3	3	2			2	3	3	3

VD22306	WASTE UTILIZATION	L	T	P	C
		2	0	0	2

COURSE OBJECTIVES: To impart the students with knowledge and state-of-the-art in waste recovery and utilizationpertaining to process industries.

UNIT I	**WASTE REDUCTION STRATEGIES AND POLICIES**	**6**

Definition, classification and characterization of waste, Environmental, health impact and economical of waste, Waste collection, storage and handling, Waste reduction: Material substitution, Dematerialization, Process substitution, Zero waste and Zero landfill programs and policy, Waste minimization: Integrated planning, process intensification, recycle and reuse.

UNIT II	**SYNTHETIC ORGANIC WASTES TO ENERGY**	**6**

Principle and operation of equipments and processes for energy production from synthetic organic waste through incineration, gasification, pyrolysis, plasma arc waste destruction– Case study: Incineration of non-biodegradable municipal waste, plastic waste to energy using plasma gasification and plasma pyrolysis.

UNIT III	**BIOLOGICAL ORGANIC WASTE TO ENERGY**	**6**

Principle and operation of equipments and processes for energy production from biological organicwaste through Anaerobic digestion, Fermentation, Transesterification, Biomass gasification and pyrolysis – Case study: Treatment and utilization of wastewater, Energy production from algal biomass and bagasse.

UNIT IV	**ENERGY AND MATERIALS FROM GASEOUS POLLUTANTS**	**6**

Principle and operation of equipments and processes for recovery and reuse of gaseous pollutants (CO_2, SO_2, NH_3) and heat from flue gas. Case study: Energy using CO_2 Fuel cells, Plastics from CO_2, gypsum from flue gas desulfurization. Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers.

UNIT V	**CASE STUDIES OF WASTE TO ENERGY**	**6**

Success/failures of waste to energy; Global Best Practices in Waste to energy production distribution and use. Indian Scenario on Waste to Energy production distribution and use in India. Success and Failures of Indian Waste to Energy plants. Role of the Government in promoting ‘Waste to Energy’.

TOTAL: 30 PERIODS

OUTCOMES:

Upon successful completion of the course, the students should be able to

CO'S	STATEMENT	RBT LEVEL
CO1.	Outline the minimization and management of wastage strategies in process industries.	2
CO2.	Understand various methods for generation of energy from industrial organic waste.	2
CO3.	Understand processes for generation of energy from biological organic wastes.	2
CO4.	Illustrate the concepts on recovery and repurposing of gaseous pollutants.	2
CO5	Outline the significance of waste to Energy practices.	2

TEXT BOOKS:

1) Eduardo Jacob-Lopes, Leila Queiroz Zepka, and Maria Isabel Queiroz, "Waste-to-Energy", Nova Science Publisher, 2019.
2) Abd El-Fatah Abomohra, Qingyuan Wang, Jin Huang, "Waste-to-Energy: Recent Developments and Future Perspectives towards Circular Economy", Springer International Publishing, 2022.
3) Marc J. Rogoff **,** Francois Screve, "Waste-to-Energy Technologies and Project Implementation", William Andrew Publishing; 2nd edition, 2011.

REFERENCES:

1) Lisa Branchini, "Waste-to-Energy: Advanced Cycles and New Design Concepts for Efficient Power Plants", Springer International Publishing, 2015.
2) Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo and Constantine Yapijakis, "Waste Treatment in the Process Industries", CRC Press, 2005
3) Arda Işildar, Metal Recovery from Electronic Waste: Biological Versus Chemical Leaching, CRC Press, 2018.

COURSE ARTICULATION MATRIX

CO	PO												PSO	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2					3	3	2			2	3	3	3
CO2	2					3	3	2			2	3	3	3
CO3	2					3	3	2			2	3	3	3
CO4	2					3	3	2			2	3	3	3
CO5	2					3	3	2			2	3	3	3