RAJALAKSHMI ENGINEERING COLLEGE

An AUTONOMOUS Institution

Affiliated to ANNA UNIVERSITY, Chennai

DEPARTMENT OF CHEMICAL ENGINEERING

Regulation 2023

2023 – 2027 Batch onwards

Choice Based Credit System

(CBCS)

Curriculum and Syllabus

RAJALAKSHMI ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University Chennai)

DEPARTMENT OF CHEMICAL ENGINEERING

CURRICULUM AND SYLLABUS REGULATIONS – 2023

B.TECH – CHEMICAL ENGINEERING
CHOICE BASED CREDIT SYSTEM

VISION OF THE INSTITUTION

- To be an institution of excellence in Engineering, Technology and Management Education & Research.
- To provide competent and ethical professionals with a concern for society.

MISSION OF THE INSTITUTION

- To impart quality technical education imbibed with proficiency and humane values
- To provide right ambience and opportunities for the students to develop into creative, talented and globally competent professionals
- To promote research and development in technology and management for the benefit of the society

VISION OF THE DEPARTMENT

- To be a center of excellence in chemical engineering to provide well prepared professionals to the industries and society.

MISSION OF THE DEPARTMENT

- To provide state of art environment to the students for better learning to cater for the chemical industries and pursue higher studies.
- To provide space to the students in research to think, create and innovate things.

PROGRAM EDUCATIONAL OBJECTIVES

This program enables Chemical Engineering graduates

1. To produce employable graduates with the knowledge and competency in Chemical Engineering complemented by the appropriate skills and attributes.
2. To produce creative and innovative graduates with design and soft skills to carry out various problem solving tasks.
3. To enable the students to work as teams on multidisciplinary projects with effective communication skills, individual, supportive and leadership qualities with the right attitudes and ethics.
4. To produce graduates who possess interest in research and lifelong learning, as well as continuously striving for the forefront of technology.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to

1. Engineering Knowledge:
Apply the knowledge of mathematics, science, and engineering fundamentals, to solve the complex chemical engineering problems

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

3. Design/development of solutions:
Design solutions for complex chemical engineering problems and design system components or process 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 proceed 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 chemical 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 chemical engineering practice.

7.Environment and sustainability:

Understand the impact of the professional chemical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.

8. Ethics:

Apply ethical principles and commit to professional ethics and responsibilities and norms of the chemical 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 chemical 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 changes in chemical engineering.

Program Specific Outcomes (PSOs)

1. Graduates will be able to apply chemical engineering principles to design equipment and a process plant.
2. They will be able to control and analyse chemical, physical and biological processes including the hazards associated with these processes.
3. Will be able to develop mathematical models of real-world industrial problems and compute solutions to dynamic processes.

CURRICULUM

SEMESTER – I

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY & PRACTICALS								
1	HS23111	Technical Communication I	2	0	0	2	2	HS
2	MA23112	Algebra and Calculus	3	1	0	4	4	BS
3	PH23111	Physics for Chemical Engineering	3	0	0	3	3	BS
4	CY23132	Chemistry for Technologists	3	0	2	5	4	BS
5	GE23111	Engineering Graphics	2	0	4	6	4	ES
6	GE23121	Engineering Practices- Civil and Mechanical	0	0	2	2	1	ES
7	MC23112	Environmental Science and Engineering	3	0	0	3	0	MC
8	GE23117	தமிழர் மரபு/ Heritage of Tamils	1	0	0	1	1	HS
		TOTAL	**17**	**1**	**8**	**26**	**19**	

SEMESTER – II

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY& PRACTICALS								
1.	HS23221/ HS23222	Technical Communication II/ English for Professional Competence	0	0	2	2	1	HS
2.	MA23212	Differential Equations and Complex Variables	3	1	0	4	4	BS
3.	CH23211	Introduction to Chemical Engineering	3	0	0	3	3	PC
4.	GE23233	Problem Solving and Python Programming	2	0	4	4	4	ES
5.	PH23233	Material Science	3	0	2	4	4	BS
6.	EE23133	Basic Electrical and Electronics Engineering	3	0	2	4	4	ES
7.	GE23122	Engineering Practices – Electrical and Electronics	0	0	2	1	1	ES
8.	MC23111	Indian Constitution and Freedom Movement	3	0	0	3	0	MC
9.	GE23217	தமிழரும்தொழில் நுட்பமும்/Tamils and Technology	1	0	0	1	1	HS
		TOTAL	**18**	**1**	**12**	**26**	**22**	

SEMESTER –III

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY & PRACTICALS								
1	MA23311	Transforms and Applied Partial differential equations	3	1	0	4	4	BS
2	CY23334	Physical and Organic Chemistry	3	0	2	4	4	ES
3	CH23311	Solid Mechanics	2	1	0	3	3	ES
4	CH23312	Chemical Process Calculations	2	1	0	3	3	PC
5	CH23313	Chemical Process Industries	3	0	0	3	3	PC
6	CH23331	Fluid Mechanics for Chemical Engineers	3	0	2	4	4	PC
		TOTAL	**16**	**3**	**4**	**21**	**21**	

SEMESTER –IV

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	MA23431	Probability, Statistics and Reliability	3	0	2	4	4	BS
2	CH23411	Thermodynamics	3	0	0	3	3	PC
3	CH23412	Heat Transfer	3	0	0	3	3	PC
4	CH23431	Particle science and Technology	3	0	2	4	4	PC
5		Open Elective – 1	3	0	0	3	3	OE
PRACTICALS								
6	CS23422	Python Programming for Machine Learning	0	0	4	4	2	ES
7	GE23421	SOFT SKILLS - I	0	0	2	1	1	EEC
8	CH23421	Technical Analysis Lab	0	0	4	4	2	PC
9	CH23522	Industrial Training (2 Weeks)*						EEC
		TOTAL	**15**	**1**	**12**	**26**	**22**	

* Will be evaluated during V Sem

SEMESTER – V

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23511	Process Plant Utilities	3	0	0	3	3	PC
2	CH23512	Chemical Engineering Thermodynamics	3	0	0	3	3	PC
3	CH23513	Mass Transfer I	3	0	0	3	3	PC
4	CH23514	Chemical Reaction Engineering - I	3	0	0	3	3	PC
5		Professional Elective I	3	0	0	3	3	PE
		Open Elective - II	3	0	0	3	3	OE
PRACTICALS								
7	GE23521	SOFT SKILLS – II	0	0	2	1	1	EEC
8	CH23521	Heat Transfer Lab	0	0	4	4	2	PC
9	EC23527	Microfluidics Laboratory	0	0	2	2	1	PE
10	CH23522	Industrial Training (2 Weeks)*	0	0	0	-	1	EEC
		TOTAL	**18**	**0**	**8**	**25**	**23**	

SEMESTER – VI

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23611	Mass Transfer II	3	0	0	3	3	PC
2	CH23612	Chemical Reaction Engineering - II	3	0	0	3	3	PC
3	CH23613	Process Control and Instrumentation	3	0	0	3	3	PC
4	CH23614	Process Equipment Design	3	0	0	3	3	PC
5		Professional Elective II	3	0	0	3	3	PE
PRACTICALS								
6	GE23621	Problem Solving Techniques	0	0	2	1	1	EEC
7	CH23621	Mass Transfer Lab	0	0	4	4	2	PC
8	GE23627	Design thinking and Innovation	0	0	4	4	2	EEC
		TOTAL	**15**	**0**	**10**	**24**	**20**	

SEMESTER – VII

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23711	Transport Phenomena	3	0	0	3	3	PC
2	CH23712	Comprehension in Chemical Engineering	3	0	0	3	3	PC
3	CH23713	Process Engineering Economics	3	0	0	3	3	PC
4		Professional Elective III	3	0	0	3	3	PE
5		Professional Elective IV	3	0	0	3	3	PE
PRACTICALS								
6	CH23721	Chemical Reaction Engineering lab	0	0	4	4	2	PC
7	CH23722	Process Control Lab	0	0	4	4	2	PC
8	CH23723	Artificial Intelligence and Machine Learning for Chemical Engineers	0	0	4	4	2	PC
9	CH23724	CHEMSKILL				3	2	EEC
		TOTAL	**15**	**0**	**12**	**30**	**23**	

SEMESTER – VIII

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
PRACTICALS								
1		Professional Elective V	3	0	0	3	3	PE
2	CH23811	Project Work	0	0	24	20	10	EEC
		TOTAL	**3**	**0**	**24**	**23**	**13**	

CREDIT DISTRIBUTION

S. No	Category	Credits Per Semester								Total Credits
		I	II	III	IV	V	VI	VII	VIII	
1	**HS**	3	2	-	-	-	-	-	-	5
2	**BS**	11	8	4	4	-	-	-	-	27
3	**ES**	5	9	7	2	-	-	-	-	23
4	**PC**	-	3	10	12	14	14	15	-	68
5	**PE**	-	-	-	-	4	3	6	3	16
6	**OE**	-	-	-	3	3	-	-	-	6
7	**EEC**	-	-	-	1	2	3	2	10	18
Total		19	22	21	22	23	20	23	13	**163**

PROFESSIONAL ELECTIVE VERTICAL LIST

Vertical I Petroleum Process Technology	Vertical II Energy Engineering	Vertical III Biochemical Engineering	Vertical IV Environmental and Safety Engineering	Vertical V Computational Chemical Engineering	Vertical VI Technology Courses
CH23A11 Petroleum Chemistry and Refining Fundamentals	CH23B11 Non-renewable energy sources	CH23C11 Biosciences for Chemical Engineers	CH23D11 Air Pollution Engineering	CH23E11 Computational Techniques	CH23F11 Polymer Technology
CH23A12 Primary Refining Technology	CH23B12 Pinch technology	BT23611 Bioprocess Technology	CH23D12 Waste Water Treatment	CH23E12 Optimization of Chemical Processes	CH23F12 Fertilizer Technology
CH23A13 Secondary Refining Technology	CH23B13 Power plant systems and sustainability	CH23C13 Fermentation and Bioprocessing	CH23D13 Solid waste Management	CH23E13 Process Modeling and Simulation	CH23F13 Paper and Pulp Technology
CH23A14 Refinery Advancements and Environmental Regulations	CH23B14 Renewable energy resources	CH23C14 Bio separation and Downstream Processing	CH23D14 Environmental Impact Assessment and Management	CH23E14 Pinch Analysis and Heat Exchange Network Design	CH23F14 Electrochemical Technology
CH23A15 Petroleum Equipment Design	CH23B15 Bio Energy	CH23C15 Enzyme Immobilisation Technology	CH23D15 Process Safety Management	CH23E15 Chemical Process Flow sheeting	CH23F15 Food Technology
CH23A16 Petrochemical Technology	CH23B16 Hydrogen and fuel cell technology	CH23C16 Bioreactor Design	CH23D16 Risk and HAZOP Analysis	CH23E16 Computational Fluid Dynamics for Chemical Engineers	CH23F16 Drugs and Pharmaceutical Technology

SEMESTER I

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
HS 23111	Technical Communication I	Theory	2	0	0	2
	Common to all branches of B.E/B. Tech programmes – First Semester					

Objectives:
To facilitate students develop their comprehension skills
To enable students to improve their receptive skills
To equip learners with better vocabulary and enhance their writing skills
To aid students speak effectively in all kinds of communicative contexts.
To improve the learners' basic proficiency in workplace communication

UNIT-I	**DEVELOPING COMPREHENSION SKILLS**	6
Listening: Introduction to Informational listening – Listening to Podcasts, News **Reading**: Intentional Reading - Short Narratives and Passages. **Speaking:** Introducing Oneself, Narrating a Story / Incident. **Writing:** Sequential Writing – connecting ideas using transitional words (Jumbled Sentences), Process Description **Grammar:** Verbs – Main & Auxiliary: Simple Tenses – Form, Function and Meaning. **Vocabulary**: Word formation – Prefix, Suffix, Compound Words.		
UNIT-II	**LISTENING AND EXTENDED READING**	6
Listening: Deep Listening – Listening to Talk Shows and Debates **Reading**: In-depth Reading - Scanning Passages **Speaking**: Describing Current Issues, Happenings, etc.., **Writing**: Note Making, Note Taking – Paragraph Writing **Grammar**: Continuous Tenses, Prepositions, Articles **Vocabulary**: One Word Substitutes, Phrasal Verbs.		
UNIT-III	**FORMAL WRITING AND VERBAL ABILITY**	6
Listening: Listening to Lectures and Taking Notes **Reading:** Interpretation of Tables, Charts and Graphs **Speaking:** SWOT Analysis on Oneself **Writing:** Formal Letter Writing and Email Writing **Grammar:** Perfect Tenses, Phrases and Clauses, Discourse Markers **Vocabulary :** Verbal Analogy / Cloze Exercise		
UNIT-IV	**ENHANCING SPEAKING ABILITY**	6
Listening: Listening to eminent voices of one's interest (Martin Luther King, APJ Abdul Kalam, etc..) **Reading:** Timed Reading, Filling KWL Chart. **Speaking:** Just a Minute, Impromptu **Writing:** Check-list, Instructions. **Grammar:** 'Wh' Questions / 'Yes' or 'No' Questions, Imperatives **Vocabulary:** Synonyms, Antonyms, Different forms of the same words.		
UNIT-V	**LANGUAGE FOR WORKPLACE**	6
Listening: Extensive Listening (Audio books, rendering of poems, etc.) **Reading**: Extensive reading (Jigsaw Reading, Short Stories, Novels) **Speaking**: Short Presentations on Technical Topics **Writing:** Recommendations, Essay Writing **Grammar:** Impersonal Passive, Reported Speech, Concord **Vocabulary :** Informal Vocabulary and Formal Substitutes		
Total Contact Hours: 30		

Course Outcomes:
On completion of the course students will be able to
apply their comprehension skills and interpret different contents effortlessly
read and comprehend various texts and audio visual contents
infer data from graphs and charts and communicate it efficiently in varied contexts
participate effectively in diverse speaking situations
to present, discuss and coordinate with their peers in workplace using their language skills

SUGGESTED ACTIVITIES

- Ice breaker
- Just A Minute
- Ship wreck
- Hot seat
- Vocabulary building
- Chinese whispers
- Case study

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous Assessment Tests

Text Book(s):
1. Effective Technical Communication by M. Ashraf Rizvi (Author) 2nd Edition Paperback 2017
2. Sylvan Barnet and Hugo Bedau, 'Critical Thinking Reading and Writing', Bedford/st. Martin's: Fifth Edition (June 28, 2004)
3. Meenakshi Upadhyay, Arun Sharma – Verbal Ability and Reading Comprehension.
4. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press

Reference Books(s) / Web links:
1. Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers 2nd Edition by Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor)
2. Reading Development and Difficulties By Kate Cain
3. The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK
4. Everybody Writes: Your Go-To Guide to Creating Ridiculously Good Content Hardcover by Ann Handley (Author)

Course Code	Course Title	Category	L	T	P	C
MA23112	**ALGEBRA AND CALCULUS**	BS	3	1	0	4
Common to I sem. B.E. - AERO, AUTO, MECH, MCT, R&A, CIVIL and B.Tech. - BT, FT & CHEM						

Objectives:
● To introduce the matrix techniques and to illustrate the nature of the matrix.
● To address data and synthesis of the information to provide valid conclusions.
● To explain techniques of calculus which are applied in the solutions of engineering problems.
● To analyse special types of integrals by analytical methods and numerical techniques.
● To practice the techniques of Integration in finding area and volumes.

UNIT-I	**MATRICES**	12
Matrices - Eigenvalues and eigenvectors - Diagonalization of matrices using orthogonal transformation - Cayley-Hamilton Theorem(without proof) -Quadratic forms- Reduction to canonical form using orthogonal transformation- Numerical computation of Eigen value using Power method		
UNIT-II	**FUNCTIONS OF SEVERAL VARIABLES**	12
Partial differentiation–Total derivative–Change of variables–Jacobians–Partial differentiation of implicit functions–Taylor's series for functions of two variables–Maxima and minima of functions of two variables–Lagrange's method of undetermined multipliers.		
UNIT-III	**INTEGRAL CALCULUS**	12
Integral Calculus: Definite Integrals as a limit of sums - Applications of integration to area, volume - Improper integrals: Beta and Gamma integrals - Numerical computation of integrals: Trapezoidal rule - Gaussian Two point quadrature		
UNIT-IV	**MULTIPLE INTEGRALS**	12

Double integrals – Change of order of integration – Area enclosed by plane curves–Triple integrals–Volume of solids– Numerical computation of double integrals: Trapezoidal rule.		
UNIT-V	**REGRESSION**	12
Scatter diagram - Karl Pearson coefficient of correlation for raw data –Spearman rank correlation coefficient - Lines of regression - Regression equation X on Y and Y on X- Curve fitting by Principle of least squares - Fitting a straight line y = ax+b and a parabola $y = ax^2 + bx + c$.		
Total Contact Hours:60		

Outcomes: On completion of the course students will be able to
● Demonstrate the matrix techniques in solving the related problems in engineering and technology.
● Analyse and interpret data, and synthesize information to provide valid conclusions.
● Interpret the problems in Engineering and Technology using the principles of mathematical calculus.
● Apply the analytical methods and numerical techniques to solve the related engineering problems.
● Evaluate multiple integrals to conduct investigations of complex problems.

Text Book(s):	
1.	Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2.	Gupta S.C. and Kapoor V.K."Fundamentals of Mathematical Statistics", Sultan and Sons 10th Edition,2000.
3.	T Veerarajan, Engineering Mathematics –I , Mc Graw Hill Education, 2018.
4.	I.R. Miller, J.E. Freund and R. Johnson , "Probability and Statistics for Engineers ",4th Edition, Pearson, 2018.
5.	A. Goon, M. Gupta and B.Dasgupta , "Fundamentals of Statistics ",Vol. I & Vol. II, World Press, 2019.

Reference Books(s) / Web links:	
1.	Ramana. B.V., " Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2018.
2.	T Veerarajan ,Fundamentals of Mathematical Statistics , yesdee publications, 2017.
3.	Erwin Kreyszig ," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
4.	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 2006.
5.	N. Draper & H. Smith,"Applied Regression Analysis" III edition, Wiley, 1998.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23112.1	3	2	1	-	-	-	-	-	-	-	1	-	-	-	-
MA23112.2	3	2	-	1	-	-	-	-	-	-	1	1	1	-	-
MA23112.3	2	2	-	-	-	-	-	-	-	-	1	1	-	-	-
MA23112.4	3	3	1	-	-	-	-	-	-	-	1	1	-	-	-
MA23112.5	2	2	-	-	-	-	-	-	-	-	-	-	1	-	-
Average	2.6	2.2	1	1	-	-	-	-	-	-	1	1	1	-	-

Subject Code	Subject Name	Category	L	T	P	C
PH23111	**PHYSICS FOR CHEMICAL ENGINEERING** For Sem I- B.Tech. Chemical Engineering	BS	3	0	0	3

Objectives:

- To familiarize the characteristics of crystal structure in solids and methods of crystal growth.
- To impart knowledge on the elastic properties of solids and viscosity of liquids.
- To introduce the significance of lasers, optical fibres and their applications as sensors and tool for communication.
- To familiarize the basic principles of heat transfer and the concepts of thermal conductivity, thermal insulation and their applications.
- To introduce the fundamentals of Quantum physics and make them to comprehend the importance of quantum concepts in the field of advanced research and technology.

UNIT-I **PROPERTIES OF MATTER** **9**

Elasticity – Stress-strain diagram and its uses -twisting couple - Torsion pendulum: theory and experiment - bending of beams –area moment of inertia - bending moment – cantilever - applications – uniform and non-uniform bending I-shaped girders. Viscosity: Streamline flow, Turbulent flow, Critical velocity, Coefficient of viscosity, Poiseuille's formula for flow of liquid through a capillary tube.

UNIT-II **THERMAL PHYSICS** **9**

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints - bimetallic strips - thermal conduction, convection and radiation –thermal conductivity - Forbe's and Lee's disc method: theory and experiment - conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

UNIT-III **CRYSTAL PHYSICS** **9**

Single crystalline, polycrystalline and amorphous materials – single crystals: unit cell, crystal systems, Bravais lattices, Miller indices – inter-planar distances - coordination number and packing factor for SC, BCC, FCC, HCP and diamond structures. –crystal imperfections: point defects, line defects, surface defects and volume defects.

UNIT-IV **QUANTUM PHYSICS** **9**

Black body radiation – Planck's theory (derivation) – wave particle duality – concept of wave function and its physical significance – Schrödinger's wave equation – time independent and time dependent equations – particle in a one-dimensional box – tunneling (qualitative) – electron microscope – scanning tunneling microscope.

UNIT-V **LASERS AND FIBER OPTICS** **9**

Lasers: Characteristics, Einstein's A and B coefficients derivation – resonant cavity, optical amplification (qualitative) –CO_2 laser - Semiconductor lasers: homojunction and heterojunction. Fiber optics: principle, numerical aperture and acceptance angle - types of optical fibers (material, mode, refractive index) – losses associated with optical fibers - fiber optic sensors : pressure and displacement.

Contact Hours : 45

Course Outcomes:

On completion of the course, the students will be able to

- acquire a strong understanding on the crystal structures and various techniques of crystal growth.
- gain sound knowledge and better understanding on the elastic behaviour of ductile materials, bending of beams and viscosity of liquids.
- Appreciate the significance of Einstein's theory and to explain the working of different types of lasers, optical fibre communication and their respective applications
- Recognize the difference between conduction, convection and radiation and also able to describe various experimental methods of determining thermal conductivity of materials.
- Comprehend the role played by concepts of quantum physics in the working of advanced research equipment like tunnelling electron microscope , scanning electron microscope .

Suggested Activities

- Problem solving sessions

Suggested Evaluation Methods

- Quizzes
- Class Presentation / Discussion

Text Book(s):

1. Bhattacharya, D.K. & Poonam, T. "Engineering Physics". Oxford University Press, 2015.
2. Gaur, R.K. & Gupta, S.L. "Engineering Physics". Dhanpat Rai Publishers, 2012.

3	Pandey, B.K. & Chaturvedi, S. "Engineering Physics". Cengage Learning India, 2013.
Reference Books(s) / Web links:	
1	Halliday, D., Resnick, R. & Walker, J. "Principles of Physics". Wiley, 2015.
2	Serway, R.A. & Jewett, J.W. "Physics for Scientists and Engineers". Cengage Learning, 2017.
3	Tipler, P.A. & Mosca, G. "Physics for Scientists and Engineers with Modern Physics'. W. H. Freeman, 2007.
4	Arthur Besier and S. RaiChoudhury, Concepts of Modern Physics (SIE), 7th edition, McGraw-Hill Education, 2017.
5	R. Murugeshan and Kiruthiga Sivaprasath, Modern Physics, S. Chand, 2015.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1	3	2	1	-	-	-	-	-	-	-	-	-	1	1	-
CO 2	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	1	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	3	1	-	-	-	-	-	-	-	-	-	1	1	-
CO 5	3	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Average	3	1.8	1.6	-	-	-	-	-	-	-	-	-	1	1	-

Subject Code	Subject Name	Category	L	T	P	C
CY23132	**CHEMISTRY FOR TECHNOLOGISTS**	**BS**	**3**	**0**	**2**	**4**
Common to B.TECH. - CHEMICAL ENGG., FT & BT						

Course Objectives:

- To acquire knowledge on Surface chemistry for industrial and domestic uses.
- To impart the knowledge on principles of electrochemistry for engineering applications.
- To provide an insight into the latest Nanotechnology to pursue further research.
- To appreciate the need for and importance of Polymer materials and Heterocyclic compounds.
- To enhance the knowledge in line with the modern techniques for material analysis.

UNIT-I	**SURFACE CHEMISTRY**	**9**

Introduction – Adsorption- difference between adsorption and absorption - types of adsorption - Factors influencing adsorption - Adsorption from solutions- Types of adsorption isotherms - Freundlich adsorption isotherm - Langmuir adsorption isotherm - Industrial applications of adsorption – Adsorption Chromatography - Role of adsorption in Catalysis - Enzyme catalysis- Michael's Menten equation.

UNIT-II	**ELECTROCHEMISTRY**	**9**

Terminology involved in electrochemistry – Types of Cells - Galvanic and concentration cells- Derivation of Nernst equation - Applications of Electrochemical series - Types of Electrodes - Hydrogen, Calomel, ion-selective electrode - Determination of pH using glass electrode - Determination of electrode potentials - Conductometric titrations - Potentiometric titration-Redox titration.

UNIT-III	**NANO CHEMISTRY**	**9**

Basic Definitions - Distinction between nanoparticles and bulk materials - size-dependent properties - Mechanical, Chemical, Optical, Electrical and Magnetic properties – Nanoparticles - nanoclusters, nanorods, nanotubes and nanowires - Synthesis of nanoparticles - Precipitation method - Hydrothermal synthesis - Solvothermal synthesis - Sonochemical synthesis - Chemical vapor deposition – Electrodeposition - biogenic synthesis - Applications of nanomaterials.		
UNIT-IV	**POLYMERS AND HETEROCYCLES**	**9**
Polymers – Introduction - Polymerization - Types of Polymerization - Condensation, Addition, Coordination, Copolymerization - Mechanism of Polymerization - Free Radical Mechanism - Biopolymers - PLA and PHB - Synthesis properties and applications. Heterocyclic compounds - Synthesis and electrophilic and nucleophilic substitution reactions of pyrrole - furan - thiophene- pyridine- quinoline - isoquinoline.		
UNIT-V	**ANALYTICAL TECHNIQUES**	**9**
Electromagnetic spectrum - absorption of radiation - electronic, vibrational and rotational transitions - Thermal methods of analysis - TGA, DTA – Principle, instrumentation and applications - Spectro Analytical methods - Colorimetry, IR, UV-visible spectroscopy - Principles instrumentation and applications.		
		Total Contact Hours:45

Description of the Experiments	**Total Contact Hours:30**
1.	Construction and determination of EMF of simple electrochemical cells and concentration cells
2.	Estimation of acids by pH metry
3.	Determination of corrosion rate on mild steel by weight loss method
4.	Estimation of mixture of acids by conductometry
5.	Estimation of extent of corrosion of iron pieces by potentiometry
6.	Estimation of copper / ferrous ions by spectrophotometry
7.	Estimation of DO by using sensors
8.	Estimation of concentration of sulphate/ Chloride ions in the given sample solution.
9.	Determination of molecular weight of a polymer by viscometry method
10.	Synthesis of nanomaterials by simple precipitation method
11.	Verification of adsorption isotherms (acetic acid on charcoal)
12.	Determination of phase change temperature of a solid.

Course Outcomes: At the end of the course the student will be able to:
● Explore the applications of Surface Chemistry in domestic and industrial uses.
● Employ the basic principles of Electrochemistry in our daily life appliances.
● Synthesize Nano materials for modern engineering applications.
● Recognize the need of advanced polymer and heterocyclic compounds in industrial applications.
● Identify the structure of unknown/new compounds with the help of spectroscopy.

Text Book(s):
1. P. C. Jain and Monika Jain, “Engineering Chemistry”, DhanpatRai Publishing Company (P) Ltd,New Delhi, 2015

2. O.G.Palanna, "Engineering Chemistry", McGraw Hill Education (India) Pvt, Ltd, New Delhi, 2017
3. Shikha Agarwal "Engineering Chemistry-Fundamentals and applications", Cambridge University Press, New Delhi, 2015

Reference Books(s)
● A Text Book of Engg. Chemistry, Shashi Chawla, Dhanpat Rai & Co. (P) Ltd.
● B.K. Sharma, "Industrial chemistry", Krishna Prakashan Media (P) Ltd, Meerut, 2016.
● Polymer Science, V R Gowariker, N V Viswanathan, Jayadev, Sreedhar, Newage Int. Publishers, 4th Edition, 2021.
● PradeepT, "A Text Book of Nanoscience and Nanotechnology", Tata McGraw Hill, New Delhi, 2012
● An Introduction to nanomaterials and nanoscience (PB 2020) : Asim K DAS, Mahua Das, CBS publishers and distributors Pvt. Ltd.
● Laboratory Manual Engg. Chemistry, Anupma Rajput, Dhanpat Rai & Co

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1.	pH meter	10
2.	Ion selective electrodes for various ions in solution	10
3	Spectrophotometer	4
4	Magnetic stirrer with hot plate	10
5	Shaker	5

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CY23312.1	2	1	1	-	-	-	1	1	-	-	-	-			
CY23312.2	2	2	1	-	-	-	-	-	-	-	-	1			
CY23312.3	3	2	2	-	-	-	-	-	-	-	-	-			
CY23312.4	2	2	1	-	-	-	1	1	-	-	-	-			
CY23312.5	2	1	1	-	-	-	-	-	-	-	-	-			
AVG.	2.2	1.6	1.2	-	-	-	1	1-	-	-	-	1			

Subject Code	Subject Name	Category	L	T	P	C
GE23111	**ENGINEERING GRAPHICS**	**ES**	**2**	**2**	**0**	**4**

Objectives: On completion of the course the students are expected	
•	To understand the importance of the drawing in engineering applications
•	To develop graphic skills for communication of concepts, ideas and design of engineering products
•	To expose them to existing national standards related to technical drawings. skill in developing newproducts.

•	To improve their visualization skills so that they can apply this
•	To improve their technical communication skill in the form of communicative drawings

CONCEPTS AND CONVENTIONS (Not for Examination) 1

Importance of graphics in engineering applications–Use of drafting instruments– BIS conventions and specifications–Size, layout and folding of drawing sheets– Lettering and dimensioning. Basic Geometrical constructions.

UNIT-I PLANE CURVES AND PROJECTION OF POINTS 5+12

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

Principles of Projection and Projection of points.

UNIT-II PROJECTION OF LINES AND PLANE SURFACES 6+12

Projection of straight lines (First angle projection) 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 both the principal planes by rotating object method.

UNIT-III PROJECTION OF SOLIDS AND PROJECTION OF SECTIONED SOLIDS **6+12**

Projection of simple solids like prisms, pyramids, cylinder and cone when the axis is inclined to oneof the principal planes by rotating object method.

Sectioning of solids in simple vertical position when the cutting plane is inclined to HP and perpendicular to VP – obtaining true shape of the section.

Practicing three-dimensional modeling of simple objects by CAD software (Not for examination)

UNIT-IV DEVELOPMENT OF SURFACE AND ISOMETRIC PROJECTIONS 6+12

Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders andcones.

Principles of isometric projection–isometric scale–Isometric projections of simple solids andtruncated solids - Prisms, pyramids, cylinders and cones

Model making of isometric projection of combination of solids as assignment (Not for End semester)

UNIT-V FREE HAND SKETCHING AND PERSPECTIVE PROJECTIONS 6+12

Free Hand sketching: Freehand sketching of multiple views from pictorial views of objects - Freehandsketching of pictorial views of object from multiple views

Perspective projection of simple solids-Prisms, pyramids, cylinder and cone by visual ray method.

Total Contact Hours: (L=30; P=60) 90 Periods

OURSE OUTCOMES:

After learning the course, the students should be able

- To construct different plane curves and to comprehend the theory of projection
- To draw the basic views related to projection of lines and planes

- To draw the projection of simple solids and to draw the projection of development of surfacesof Sectioned solids in simple vertical position
- To draw the orthographic projection from pictorial objects and Isometric projections ofsimple solids
- To visualize Perspective view of simple solids

TEXT BOOK (S):

1. Bhatt N.D. and Panchal V.M., "Engineering Drawing", Charotar Publishing House, 50thEdition, 2010.
2. Natarajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai,2017.

REFERENCE BOOKS(S) / WEB LINKS:

1. Varghese P I., "Engineering Graphics", McGraw Hill Education (I) Pvt.Ltd., 2013.
2. V.B Sikka "Civil Engineering Drawing", S.K Kataria & Sons, New Delhi.
3. Venugopal K. and PrabhuRaja V., "Engineering Graphics", New Age International (P)Limited, 2008.
4. Gopalakrishna K.R., "Engineering Drawing" (Vol. I&II combined), Subhas Stores, Bangalore, 2017.
5. Basant Agarwal and Agarwal C.M., "Engineering Drawing", McGraw Hill PublishingCompany Limited, New Delhi, 2018.

CO PO PSO MAPPING

CO/PO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO 1	3	2	2	1	-	1	-	2	2	2	-	2			
CO 2	3	2	2	1	-	1	-	2	2	2	-	2			
CO 3	3	2	2	1	-	1	-	2	2	2	-	2			
CO 4	3	2	2	1	-	1	-	2	2	2	-	2			
CO 5	3	2	2	1	-	1	-	2	2	2	-	2			

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

Subject Code	Subject Name (Laboratory Course)	Category	L	T	P	C
GE23121	ENGINEERING PRACTICES – Civil& Mechanical	ES	0	0	2	1

Objectives:

To provide exposure to the students with hands on experience on various basic engineering practices inCivil and Mechanical Engineering.

List of Experiments	
CIVIL ENGINEERING PRACTICE	
1.	Study of pipeline joints, its location and functions: valves, taps, couplings, unions, reducers, and elbows in household fittings.
2.	Preparation of basic plumbing line sketches for wash basins, water heaters, etc.
3.	Hands-on-exercise: Basic pipe connections – Pipe connections with different joining components.
Carpentry Works:	
4.	Study of joints in roofs, doors, windows and furniture.
5.	Hands-on-exercise: Woodwork, joints by sawing, planning and chiselling.
MECHANICAL ENGINEERING PRACTICE	
6.	Preparation of butt joints, lap joints and T- joints by Shielded metal arc welding.
7	Gas welding practice.
Basic Machining:	

8	Simple Turning and Taper turning			
9	Drilling Practice			
Sheet Metal Work:				
10	Forming & Bending:			
11	Model making – Trays and funnels			
12	Different type of joints.			
Machine Assembly Practice:				
13	Study of centrifugal pump			
14	Study of air conditioner			
		Total Contact Hours	**:**	**30**

Course Outcomes:	
	Able to perform plumbing activities for residential and industrial buildings considering safety aspects while gaining clear understanding on pipeline location and functions of joints like valves, taps, couplings, unions, reducers, elbows, etc.
	Able to perform wood working carpentry activities like sawing, planning, cutting, etc. while having clear understanding of the joints in roofs, doors, windows and furniture.
	Able to produce joints like L joint, T joint, Lap joint, Butt joint, etc. through arc welding process while acquiring in depth knowledge in the principle of operation of welding and other accessories
	Able to perform operations like Turning, Step turning, Taper turning, etc. in lathe and Drilling operation in drilling machine
	Able to perform sheet metal operations like Forming, Bending, etc. and fabricating models like Trays, funnels, etc.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 2	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 3	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 4	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1
CO 5	1	1	1	-	-	2	1	-	2	-	-	2	-	2	1

Subject Code	**Subject Name (Theory course)**	**Category**	**L**	**T**	**P**	**C**
MC23112	**ENVIRONMENTAL SCIENCE AND ENGINEERING** **Common to all branches of B.E./B.Tech. courses (Except B.Tech-CSBS)**	MC	**3**	**0**	**0**	**0**

Objectives:

- To develop the understanding of environmental and associated issues
- To develop an attitude of concern for the environment
- To promote enthusiasm in participating environmental protection initiatives
- To nurture skills to solve environmental degradation issues

UNIT-I	**Air and Noise pollution**	9

Definition –sources of air pollution –chemical and photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, ozone depletion, particulate pollutants-Air quality standards-Air quality indices - control of particulate air pollutants-gravitational settling chambers, cyclone separators, wet collectors, fabric filters (Bag-house filter), electrostatic precipitators (ESP)-catalytic converters.Noise pollution –sources - health effects - standards- measurement and control methods.

UNIT-II	**Water pollution and its management**	9

Definition-causes-effects of water pollution-point and nonpoint sources of wastewater-marine pollution - thermal pollution - Control of water pollution by physical, chemical and biological methods – wastewater treatment-primary, secondary and tertiary treatment-sources and
characteristics of industrial effluents- zero liquid discharge.

UNIT-III	**Solid waste and Hazardous waste management**	9

Solid waste – types- municipal solid waste management: sources, characteristics, collection, and transportation- sanitary landfill, recycling, composting, incineration, energy recovery options fromwaste - Hazardous waste – types, characteristics, and health impact - hazardous waste management: neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal.E-waste-definition-sources-effects on human health and environment- E-waste management- steps involved - Role of E-waste management within the initiatives of the Govt. of India-Swachh Bharat Mission.

UNIT-IV	**Sustainable Development**	**9**

Sustainable development- concept-dimensions-sustainable development goals - value education- gender equality – food security - poverty – hunger - famine - Twelve principles of green chemistry - Green technology - definition, importance - Cleaner development mechanism - carbon credits, carbon trading, carbon sequestration, eco labeling-International conventions and protocols-Disaster management.

UNIT-V	**Environmental Management and Legislation**	**9**

Environmental Management systems - ISO 14000 series- Environmental audit-Environmental Impact Assessment- life cycle assessment- human health risk assessment - Environmental Laws and Policy- Objectives - Polluter pays principle, Precautionary principle - The Environment (Protection) Act 1986 - Role of Information technologyin environment and human health.

	Total Contact Hours	**: 45**

Course Outcomes: On completion of the course, the students will be able to	
CO1	associate air and noise quality standards with environment and human health.
CO2	illustrate the significance of water and devise control measures for water pollution.
CO3	analyze solid wastes and hazardous wastes.
CO4	outline the goals of sustainable development in an integrated perspective.

CO5	comprehend the significance of environmental laws.

Text Books:	
1	Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016
2	Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
3	Johri R., E-waste: implications, regulations, and management in India and current global best practices, TERI Press, New Delhi
Reference Books	
1	R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38. Edition 2010.
2	Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3	Fowler B, Electronic Waste – 1 st Edition (Toxicology and Public Health Issues), 2017Elsevier

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2	PSO3
MC23112.1	1	2	3	1	-	2	2	2	1	1	1	2			
MC23112.2	1	2	3	1	-	2	2	2	1	1	1	2			
MC23112.3	-	-	3	1	-	2	3	2	1	-	1	2			
MC23112.4	-	1	2	1	1	3	3	2	1	1	1	2			
MC23112.5	-	1	2	-	-	2	2	2	1	2	2	2			
AVG.	0.4	1.2	2.6	0.8	0.2	2.2	2.4	2	1	1	1.2	2			

GE 23117 **தமிழர் மரபு** **L T P C**

1 0 0 1

அலகு I மொழி மற்றும் இலக்கியம்: 3

இந்திய மொழிக் குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி - தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமய சார்பற்ற தன்மை - சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழிக் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II மரபு - பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை - சிற்பக் கலை: 3

நடுகல் முதல் நவீன சிற்பங்கள் வரை - ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரிமுனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்: 3

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV தமிழர்களின் திணைக் கோட்பாடுகள்: 3

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு - சங்ககாலத்தில் தமிழத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறை முகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி - கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு: 3

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு - கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr. K. K. Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr. S. Singaravelu)(Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr. S. V. Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies).
9. Keeladi – 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

SEMESTER II

Subject Code	Subject Name (Theory course)	Category	L	T	P	C
HS 23221	Technical Communication II	Theory	0	0	2	1
	Common to all branches of B.E/B. Tech programmes –Second Semester					

Objectives:
• To facilitate students to improve their vocabulary for a better communication
• To enable learners to understand and reproduce language
• To aid students to write technical reports in a convincing manner
• To expose students to different sentence structures
• To equip learners to present their ideas in an efficient manner

UNIT-I	**VOCABULARY FOR BETTER COMMUNICATION**	6
Listening: Telephonic Conversations and TV News **Reading:** Newspapers and Magazines **Speaking**: Conversational Practice: Speaking in a given situation, Asking permission and requesting etc.., **Writing:** Job Application Letter and Resume **Grammar:** Reference words: pronouns and determiners **Vocabulary:** Guessing meanings of words in different contexts.		
UNIT-II	**FUNCTIONAL LANGUAGE ASPECTS**	6
Listening: Motivational listening – listening to real life challenges **Reading:** Articles and Technical reports **Speaking:** Using Polite Expressions, Indirect Questions **Writing:** Paraphrasing a Text, Poem **Grammar:** Purpose Statements, Cause and Effect Expressions **Vocabulary:** Neologisms.		
UNIT-III	**TECHNICAL REPORTWRITING**	6
Listening: Empathetic Listening – Giving Solutions to Problems **Reading:** Inferential Reading **Speaking:** Dialogues – Interviewing Celebrities / Leaders / Sportspersons, etc.., **Writing:** Report Writing **Grammar:** Functional Usage of Expressions – used to, gone / been, etc.., **Vocabulary:** Words Often Confused		

UNIT-IV	**STRUCTURAL GRAMMAR**	6
Listening: Comprehension (IELTS practice tests) **Reading:** Intensive Reading for specific information **Speaking:** Pick and Talk **Writing:** Proposals **Grammar:** Sentence Structures – Simple, Compound, Complex Sentences **Vocabulary:** Replacing dull words with vivid ones		
UNIT-V	**PRESENTATION SKILLS**	6
Listening: Discriminative listening – sarcasm, irony, pun, etc.., **Reading:** Practice of chunking – breaking up reading materials		

Speaking: Mini presentation on some topic **Writing:** Minutes of the meeting **Grammar:** Correction of Errors **Vocabulary:** Advanced vocabulary – fixing appropriate words in the given context.
Total Contact Hours: 30

Course Outcomes:
On completion of the course students will be able to
• communicate effectively using appropriate vocabulary
• use the acquired language skills to comprehend various types of language contents
• evaluate different texts and write effective technical content
• use appropriate sentence structures to convey their thoughts in varied contexts
• present their concepts and ideas in an effective manner
SUGGESTED ACTIVITIES ● Story Lines ● One truth and two lies ● Hang Man ● Pictionary ● Case study ● Word Scramble

SUGGESTED EVALUATION METHODS
● Assignment topics ● Quizzes ● Class Presentation/Discussion ● Continuous Assessment Tests

Text Book(s):
5. Raymond Murphy, "Intermediate English Grammar," Second Edition , Cambridge University Press, 2018
6. Meenakshi Raman & Sangeeta Sharma, "Technical Communication" Third Edition, Oxford University Press, 2015
7. Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine ChuenMeng Goh, Cambridge University Press
Reference Books(s) / Web links:
• Michael McCarthy (Author), Felicity O'Dell (Author), John D. Bunting (Contributor), "Basic Vocabulary in Use: 60 Units of Vocabulary Practice in North American English With Answers" 2nd Edition
• Dale Carnegie, "The Art of Public Speaking," Insight Press
• Jack C. Richards & Theodore S. Rodgers, " Approaches and Methods in Language Teaching, Second Edition, Cambridge University Press

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
HS23221. 1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-
HS23221. 2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221. 3	-	2	-	1	-	-	-	-	-	3	-	-	-	-	-
HS23221. 4	-	-	-	1	-	-	-	-	2	3	-	-	-	-	-
HS23221. 5	-	-	-	1	-	-	-	-	2	2	-	-	-	-	-
Average	-	2	-	1	0	0	0	0	2	2.6	-	-	-	-	-

Subject Code	Subject Name	Category	L	T	P	C
HS 23222	English for Professional Competence Common to all branches of B.E/B. Tech programmes –Second Semester	HS	0	0	2	1

Objectives:

- To facilitate the learners in acquiring listening and reading competence
- To enable the learners to communicate effectively through written and oral medium
- To assist the learners in preparing for competitive examinations
- To train the students in acquiring corporate skills
- To inculcate professional standards among the students and make them realize their responsibility in addressing the challenges

UNIT-I	**RECEPTIVE SKILLS**	6

Listening – Comprehensive Listening – Watching the news – Listening to a peer giving presentation, etc. – Critical Listening – Watching a televised debate, Listening to poems – **Reading** – Extensive Reading – Short stories and One-act Plays – Intensive Reading – Articles or Editorials in Magazines, Blog posts on topics like science and technology, arts, etc.

UNIT-II	**PRODUCTIVE SKILLS**	6

Speaking – Demonstrative Speaking – Process description through visual aids – Persuasive Speaking – Convincing the listener with the speaker's view – **Writing** – Descriptive Writing - Describing a place, person, process – Subjective Writing – Autobiography, Writing based on personal opinions and interpretations

UNIT-III	**ENGLISH FOR COMPETITIVE EXAMS**	6

An introduction to International English Language Testing System (IELTS) – Test of English as a Foreign Language (TOEFL) – Graduate Record Examination (GRE) – Civil Service, Indian Economic Service Examination, Indian Statistical Service Examination, Combined Defence Services Examination, Staff Selection- (Language Related) – Aptitude tests.

UNIT-IV	**CORPORATE SKILLS**	6

Critical Thinking and Problem Solving – Case Study, Brainstorming, Q & A Discussion – **Team work and Collaboration** – Activities like Office Debates, Perfect Square, Blind Retriever, etc. – **Professionalism and Strong Work Ethics** – Integrity, Resilience, Accountability, Adaptability, Growth Mind set

UNIT-V	**PROJECT WORK**	6

Case Study based on the challenges faced by the employers and the employees – Devise Plan, Provide Solution

	Total Contact Hours	30

Course Outcomes:

On completion of the course, students will be able to

- interpret and respond appropriately in the listening and reading contexts.

• express themselves effectively in spoken and written communication
• apply their acquired language skills in writing the competitive examinations
• exhibit their professional skills in their work place
• identify the challenges in the work place and suggest strategies solutions

Reference Books	
1	How to Read Better & Faster, Norman Lewis, Goyal Publishers
2	Teaching Speaking: A Holistic Approach, Book by Anne Burns and Christine Chuen Meng Goh, Cambridge University Press
3	The Official Cambridge Guide To IELTS by Pauline Cullen, Cambridge University Press
4	The 7 Habits of Highly Effective People by Stephen Covey, Simon and Schuster, UK

Reference Books(s) / Web links:
1. Board of Editors. Sure Outcomes. A Communication Skills Course for Undergraduate Engineers and Technologists. Orient Black Swan Limited, Hyderabad, 2013.
2. Hartley, Mary. "The Power of Listening," JaicoPublishing House; First Edition (2015).
3. Chambers, Harry. "Effective Communication Skills for Scientific and Technical Professionals," Persues Publishing, Cambridge, Massachusetts, 2000.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
HS23222. 1	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 2	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
HS23222. 4	-	-	-	-	-	-	2	2	-	3	-	-	-	-	-
HS23222. 5	-	-	1	-	-	-	2	-	-	3	-	-	-	-	-
Average	0	1	1	0	0	0	2	2	0	3	0	0	-	-	-

Course Code	Course Title	Category	L	T	P	C
MA23212	**DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES**	**BS**	**3**	**1**	**0**	**4**
Common to II Sem. B.E. –AERO, AUTO, BME, CIVIL, EEE, ECE, MECH, MCT, R&A and B. Tech. - BT, FT & CHEM						

Objectives:
● To provide students with an introduction to the theory of ordinary differential equations through applications, methods of solution, and numerical approximations.
● To introduce students to how to solve linear Partial Differential with different methods.
● To enable the students to study the Laplace Transforms, properties of Laplace Transform, inverse Laplace Transform and some applications to solve the differential equations and integral equations.
● To explain the concept of a vector integration in a plane and in space.
● To describe basic properties of complex variables and to have the ability to compute complex integrals.

UNIT-I	**ORDINARY DIFFERENTIAL EQUATIONS**	**12**

Second and higher order Linear differential equations with constant coefficients - Method of variation of parameters – Legendre's linear equations – Numerical solution of ODE - Single Step methods: Taylor's series method, Euler's method.		
UNIT-II	**PARTIAL DIFFERENTIAL EQUATIONS**	**12**
Formation of partial differential equations - Classification of PDE – Solutions of standard types of first order partial differential equations - Lagrange's linear equation –Linear homogeneous partial differential equations of second and higher order with constant coefficients.		
UNIT-III	**LAPLACE TRANSFORM**	**12**
Laplace transform –Basic properties – Transforms of derivatives and integrals of functions - Transforms of unit step function and impulse functions, periodic functions. Inverse Laplace transform – Problems using Convolution theorem – Solution of linear ODE of second order with constant coefficients using Laplace transformation techniques		
UNIT-IV	**VECTOR CALCULUS**	**12**
Gradient, divergence and curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector integration – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.		
UNIT-V	**COMPLEX VARIABLES**	**12**
Analytic functions — Construction of analytic function - Bilinear transformation –Singularities – Cauchy's integral theorem (without proof) - Residues – Residue theorem (without proof) - Simple problems - Contour integral over $\|z\|=1$.		
		Total Contact Hours: 60

Course Outcomes:

On completion of the course students will be able to

- Apply the methods as a potent tool in the solution of a variety of problems in the natural sciences and technology.
- Develop specific methodologies, techniques and resources in Partial differential equations to conduct research and produce innovative results in the area of specialisation.
- Use Laplace transform and inverse transform techniques to solve the complex problems in engineering and technology.
- Apply the concepts in multivariable analysis, including space curves; directional derivative; gradient; multiple integrals; line and surface integrals; vector fields; divergence, curl ; the theorems of Green and Stokes, and the divergence theorem in different fields of engineering.
- Demonstrate the concept of Analytic functions, conformal mapping and complex integration in solving Engineering problems.

Text Book(s):	
1.	Grewal B.S., " Higher Engineering Mathematics ", Khanna Publishers, New Delhi, 43rd Edition, 2014.
2.	Veerarajan. T, Engineering Mathematics –II, Mc Graw Hill Education, 2018.
3.	Erwin Kreyszig," Advanced Engineering Mathematics ", John Wiley and Sons, 10th Edition, New Delhi, 2016.
4	Glyn James, "Advanced Modern Engineering Mathematics", Pearson Education, 4th Edition, New Delhi, 2011.
5	Jain R.K. and Iyengar S.R.K., "Advanced Engineering Mathematics", Narosa Publications, 5 th Edition, New Delhi, 2017.

Reference Books(s) / Web links:	
1.	Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
2.	T Veerarajan, Transforms and Partial Differential Equations, Third Edition, 2018.
3.	Bali, N.P. and Manish Goyal, A Text Book of Engineering Mathematics, Lakshmi Publications Pvt. Ltd., New Delhi, 4th Edition 2006.
4.	Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7th Edition, New Delhi, 2012.

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23212.1	3	2	1	-	-	-	-	-	-	-	-	1	1	-	-
MA23212.2	3	2	1	-	-	-	-	-	-	-	-	1	1	-	-
MA23212.3	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
MA23212.4	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-
MA23212.5	3	2	1	-	-	-	-	-	-	-	-	1	-	-	-
Average	2.8	2	1	-	-	-	-	-	-	-	-	1	1	-	-

Course Code	Course Title	Category	L	T	P	C
CH23211	**INTRODUCTION TO CHEMICAL ENGINEERING**	**PC**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

1. To compare and learn real-life examples with the basics of chemical engineering.
2. To study the significance of unit operations in chemical engineering.
3. To learn the concepts of heat, mass, and momentum transport processes.
4. To be exposed to the computing methods available for chemical engineering
5. To create awareness of the scope of a chemical engineer

UNIT I INTRODUCTION 9

Chemical Engineering in day to life with examples, Origin, and growth of chemical Engineers in chemical process industries, unit operations, and unit processes concepts, scaling up or down, application of mathematics in chemical Engineering, recent developments in chemical process industries

UNIT II UNIT OPERATIONS IN CHEMICAL ENGINEERING 9

Unit operations and kinetics of chemical reactions. flowsheet representation of process plants – the evolution of an industry – sulphuric acid and soda ash manufacture Process flow sheeting and symbols.

UNIT III TRANSPORT PROCESSES 9 Nature of fluid, Viscosity, Frictional losses, heat transfer operations, mass transfer operations, size reduction equipment.

UNIT IV CHEMICAL ENGINEERING COMPUTER SOFTWARE TOOLS AND APPLICATIONS 9

Introduction to Process Engineering Design Software (ASPEN, HYSYS, and PRO II), Computations Using Microsoft Excel, Origin, Computer-Aided Design & Drafting, Piping and Equipment Design Software

UNIT V CAREER DIVERSITIES IN CHEMICAL ENGINEERING 9

Career Development Leading to Specialization, Chemical Engineering Job Options, Chemical and Process Engineers, Commissioning Engineer, Process Control/Automation Engineer, Process Safety Engineer, Research & Development Engineer Pharmaceutical Engineer, Pipeline Engineer Chemical Manufacturing Engineer, and Environment Engineer.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able

1. To relate real-life examples with chemical engineering principles
2. To understand the role of unit operations in chemical engineering.
3. To understand the concepts of heat, mass, and momentum transport processes.
4. To get an overview of various computing methods available for chemical engineering
5. To get an awareness of the scope of a chemical engineer

TEXTBOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 6th Edn., McGraw-Hill, 2001.

2.Anderson, L.B., Wenzel, L.A., "Introduction to Chemical Engineering", McGraw-Hill Book Company, Inc., New York (1961).

2. Pushpavanam, S., "Introduction to Chemical Engineering", PHI Learning Pvt. Ltd.(2012).

3. Ghosal, S.K., Sanyal, S.K., Datta, S., "Introduction to Chemical Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi(1997).

REFERENCES:

1. Rao, M.G., Sittig, M., "Dryden's Outlines of Chemical Technology", East-West Press (1997).

2. Perry, R.H., Green, D.W., "Perry's Chemical Engineers' Handbook", McGraw-Hill Book Company (2008).

CO-PO MAPPING

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CH23211.1	3	2	3	1	2	1	1	1	1	1	1	1
CH23211.2	3	3	2	2	1	1	1	1	1	2	1	3
CH23211.3	3	3	2	2	2	1	1	1	1	2	1	3
CH23211.4	3	3	3	3	1	1	1	1	1	2	1	3
CH23211.5	3	3	3	3	2	1	1	2	1	2	2	3

Subject Code	Subject Name (Lab Oriented Theory Course)	Category	L	T	P	C
GE23233	PROBLEM SOLVING AND PYTHON PROGRAMMING	ES	2	0	4	4

Objectives:

- To know the basics of algorithmic problems solving
- To develop Python programs with conditionals and loops
- To define Python functions and call them
- To use Python data structures–-lists, tuples, dictionaries
- To do input/output with files in Python

UNIT-I	ALGORITHMIC PROBLEM SOLVING	6

Introduction to computers-characteristics-basic organization of a computer– algorithms-building blocks of algorithms (instructions / statements, state, control flow, functions)-notation (pseudo code, flow chart, programming language) - algorithmic problem solving - simple strategies for developing algorithms (iteration, recursion).

UNIT-II	DATA, EXPRESSIONS, STATEMENTS AND CONTROL FLOW - I	6

Python interpreter and interactive mode - values and types - data types – variables – keywords – expressions and statements- python I/O - operators- precedenceof operators– comments. Conditionals:conditional(if)-alternative(if-else)-chained conditional (if- elif- else)–nested conditional.

UNIT-III	CONTROL FLOW – II AND FUNCTIONS	7

Iteration: while – for - break – continue – pass. Illustrative programs: exchange the values of two variables- circulate the values of n variables-test for leap year. Function calls – type conversion– math function– composition- definition and use -

flow of execution - parameters and arguments. Fruitful functions: return values – parameters - scope: local and global - recursion.		
UNIT-IV	**STRINGS**	**5**
Strings: string slices – immutability - string functions and methods – string comparison. Illustrative programs: square root– GCD– exponentiation-sum the array of numbers linear search- binary search.		
UNIT-V	**LISTS, TUPLES AND DICTIONARIES**	**6**
Lists - list operations - list slices - list methods - list loop – mutability – aliasing - cloning lists - listparameters. Tuples – immutable - tuple assignment - tuple as return value. Dictionaries: operations and methods– dictionaries and tuples– dictionaries and lists. Advanced list processing- list comprehension. Illustrative programs: Sorting.		
	Contact Hours : 30	

List of Experiments

1	Introduction to Python Programming and Python IDLE/Anaconda distribution.
2	Experiments based on Variables, Data types and Operators in Python.
3	Coding Standards and Formatting Output.
4	Algorithmic Approach: Selection control structures.
5	Algorithmic Approach: Iteration control structures.
6	Experiments based on Strings and its operations.
7	Experiments based on Lists and its operations.
8	Experiments based on Tuples and its operations.
9	Experiments based on Sets and its operations.
10	Experiments based on Dictionary and its operations.
11	Functions: Built-in functions.
12	Searching techniques: Linear and Binary.
13	Sorting techniques: Bubble and Merge Sort.

	Contact Hours	**:**	**60**
	Total Contact Hours	**:**	**90**

Course Outcomes:

On completion of the course, the students will be able to

- Understand the working principle of a computer and identify the purpose of a computer programming language and ability to identify an appropriate approach to solve the problem.
- Write, test, and debug simple Python programs with conditionals and loops.
- Develop Python programs step - wise by defining functions and calling them.
- Use Python lists, tuples, dictionaries for representing compound data.
- Apply searching, sorting on data and efficiently handle data using flat files.

TextBooks:

1. Allen B. Downey, Think Python:How to Think Like a Computer Scientist, Second edition,UpdatedforPython3, Shroff/ O'Reilly Publishers, 2016 (http://greenteapress.com/wp/think-python/)
2. Guido Van Rossum and Fred L. Drake Jr, An Introduction to Python-Revised and updated for Python3.2, Network Theory Ltd., 2011.

ReferenceBooks:

1. JohnVGuttag, Introduction to Computation and Programming Using Python, Revised and expanded Edition, MIT Press, 2013.
2. Robert Sedgewick, Kevin Wayne, Robert Dondero, Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt Ltd, 2016.
3. Timothy A.Budd, Exploring Python, Mc-Graw Hill Education (India) Private Ltd., 2015.
4. Kenneth A. Lambert, Fundamentals of Python: First Programs, Cengage Learning, 2012.
5. Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem Solving Focus, Wiley India Edition, 2013.
6. Paul Gries, Jennifer Campbell and Jason Montojo, Practical Programming: An Introduction to Computer Science using Python3, Second edition, Pragmatic Programmers, LLC, 2013.

Platform needed: Python3 interpreter for Windows/Linux

CO -PO–PSO matrices of course

PO/PSOCO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
GE23233.1	2	2	2	2	1	-	-	-	1	1	1	1	3	3	-
GE23233.2	2	1	1	1	1	-	-	-	-	-	1	1	3	2	-
GE23233.3	1	1	2	1	2	-	-	-	-	-	1	1	2	3	2
GE23233.4	2	2	3	2	2	-	-	-	-	-	2	1	2	2	2
GE23233.5	2	2	3	2	3	-	-	-	-	-	2	1	2	2	2
Average	**1.8**	**1.6**	**2.2**	**1.6**	**1.8**	**0.0**	**0.0**	**0.0**	**0.2**	**0.2**	**1.4**	**1**	**2.4**	**2.4**	**2**

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

Subject Code	Subject Name	Category	L	T	P	C
PH23233	**MATERIAL SCIENCE** **For Sem II - B. Tech. Chemical Engineering**	BS	**3**	**0**	**2**	**4**

Objectives:

- To introduce different phases in an alloy system and their composition.
- To expose the equilibrium phases, invariant reactions and microstructures of ferrous alloys and their heat treatment methods.
- To understand the properties of conducting and superconducting materials.
- To teach the different types of magnetic materials and dielectric polarisations.
- To impart knowledge on ceramics and new engineering materials in the field of medicine and technology.

UNIT-I	**PHASE DIAGRAMS**	9

Solid solutions-Hume Rothery rules-Phases- Gibb's Phase rule- Phase diagram– unary system-water – binary systems-isomorphous system(Cu-Ni), eutectic system (Pb-Ag) and other invariant reactions. – Tie line rule – lever rule – Fick's laws of diffusion - Nucleation –homogeneous and heterogeneous nucleation(Qualitative)– Microstructural changes during cooling.

UNIT-II	**FERROUS ALLOYS AND HEAT TREATMENT**	9

Iron-carbon equilibrium diagram- Microstructure of slowly cooled steels-Eutectoid steel, Hypo and Hyper Eutectoid steel- T-T-T diagram for eutectoid steel-Tempering of martensite. Heat treatment and hardening process.

UNIT-III	**CONDUCTING AND SUPERCONDUCTING MATERIALS**	9

Classical free electron theory of metals –Fermi function – effect of temperature on Fermi energy – Density of energy states –Carrier concentration in metals. Superconducting Phenomena- Properties of superconductors - Type I and Type II superconductors- High Tc superconductors – Magnetic levitation and SQUID.

UNIT-IV	**DIELECTRIC AND MAGNETIC MATERIALS**	9

Dielectric – classification of insulating materials -Types of polarization – Internal field and deduction of Clausius-Mossotti equation – dielectric loss – different types of dielectric breakdown – paraelectric and ferroelectric materials-

applications. Introduction to magnetic materials – Types of magnetic materials-Domain theory of ferromagnetism-Hysteresis- Soft and Hard magnetic materials – Ferrites and its applications,		
UNIT-V	**NEW ENGINEERING MATERIALS**	9
Ceramics-types, preparation and their applications – Metallic glasses – Shape memory alloys – Copper base alloys – Nickel – Titanium alloys – Relaxor- Electro and magneto rheological fluids - Sensors and Actuators – polymer semiconductos – photoconducting polymers – liquid crystals - Bio-sensors – liquid Scintillation detectors –Bio materials – hydroxyapatite – PMMA – Silicone.		

	Contact Hours	**:**	**45**

List of Experiments

1	Determination of Young's modulus by Non-Uniform bending method.
2	Determination of moment of inertia of the disc and Rigidity Modulus of the wire using Torsional Pendulum.
3	Determination of wavelength of diode laser and particle size of given powder.
4	Determination of numerical aperture and acceptance angle of the optical fiber cable.
5	Find the thermal conductivity of given bad conductor by Lee's disc method.
6	Determination of Hysteresis loss using B-H curve apparatus.
7	Determination of resonance frequency of LCR series circuits.
8	Determination of free space permeability using Helmholtz coil.
9	Determination of Hall co-efficient of the semiconducting material using Hall apparatus.
10	Determination of solar cell characteristics.

	Contact Hours	**:**	**30**
	Total Contact Hours	**:**	**75**

Course Outcomes:

On completion of the course, the students will be able to

•	analyze the composition of various phases of an alloy system and their respective invariant reactions.
•	use the microstructures of iron and their properties in industrial applications.
•	calculate the density of energy states of conducting materials and understand the properties of superconducting materials.
•	analyze the properties of dielectric and magnetic materials.
•	use the properties of ceramics and new engineering materials in the field of engineering and medicine.

Suggested Activities

•	Problem solving sessions

Suggested Evaluation Methods

•	Quizzes
•	Class Presentation / Discussion

Text Book(s):

1	Bhattacharya, D.K. &Poonam, T. "Engineering Physics".Oxford University Press, 2018.

2	Gaur, R.K. & Gupta, S.L. "Engineering Physics".DhanpatRai Publishers, 2018.
3	Raghavan, V. "Physical Metallurgy: Principles and Practice". 3rd Edition, PHI Learning, 2019.
Reference Books(s) / Web links:	
1	Balasubramaniam, R. "Callister's Materials Science and Engineering".Wiley India Pvt. Ltd., 2017
2	Resnick, R., Halliday, D., & Walker, J. "Principles of Physics", Wiley India Pvt., 2022.
3	Raghavan, V. "Materials Science and Engineering : A First course". PHI Learning, 2019.
4	https://nptel.ac.in/courses/113104068
5	https://archive.nptel.ac.in/courses/115/105/115105099/

List of Equipment Available

S.No	Name of the equipment	Quantity Required	Quantity Available	Deficiency
1	Young's modulus by Non-Uniform bending method Travelling Microscope	8	13	-
2	Rigidity Modulus - Torsional Pendulum Setup	6	19	-
3	Wavelength of Laser and Characteristics -Laser source and grating plate	6	15	
4	Laser - angle of divergence and NA acceptance angle	6	8	-
5	Thermal conductivity of bad conductor- Lee's Disc setup	8	16	-
6	B-H curve Setup and CRO	6	7	-
7	LCR circuit kit	6	7	
8	Determination of permeability of free space- Helmholtz coil setup	5	5	
9	Solar cell parameters setup	6	8	-
10	Hall coefficient of Semiconductor Setup	4	4	-

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO 2	3	2	-	-	-	-	-	-	-	-	-	-	1	1	-
CO 3	3	1	1	-	-	1	-	-	-	-	-	-	-	-	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	1	1	-	-	1	-	-	-	-	-	-	-	2	-

Average	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-

Subject Code	Subject Name (Lab oriented Theory Courses)	Category	L	T	P	C
EE23133	BASIC ELECTRICAL AND ELECTRONICS ENGINEERING	ES	3	0	2	4

Objectives:

- To provide knowledge on the analysis of DC circuits.
- To provide knowledge on the analysis of AC circuits
- To expose the principles of electrical machines and electronic devices.
- To teach the concepts of different types of electrical measuring instruments and transducers.
- To experimentally analyze the electrical circuits and machines, electronic devices and transducers.

UNIT-I DC CIRCUITS 9

Electrical circuit elements (R, L and C), Voltage and current sources, Kirchhoff ‘s laws, Analysis of simple circuits with DC excitation, Superposition, Thevenin and Norton Theorems.

UNIT-II AC CIRCUITS 9

Representation of sinusoidal waveforms, Power and Power factor, Analysis of single-phase AC circuits consisting of R, L, C, RL, RC, RLC combinations, Series resonance, Three phase balanced circuits

UNIT-III ELECTRICAL MACHINES 9

Construction, Principles of operation of DC machines, Single phase Transformers, Synchronous machines, Single phase induction motors. (Qualitative Treatment Only).

UNIT-IV ELECTRONIC DEVICES & CIRCUITS 9

Review of PN Junction diode – Forward and Reverse Bias – Bipolar Junction Transistor – Common Emitter characteristics – MOSFET - Introduction to operational Amplifier –Inverting and Non-Inverting Amplifier.

UNIT-V MEASUREMENTS & INSTRUMENTATION 9

Introduction to transducers - Classification of Transducers: Resistive, Inductive, Capacitive, Piezoelectric, - Classification of instruments - PMMC and MI Ammeters and Voltmeters – Digital Storage Oscilloscope.

Contact Hours : 45

List of Experiments

1	Verification of Kirchhoff’s Laws.
2	Load test on DC Shunt Motor (Virtual Lab)
3	Load test on Single phase Transformer (Virtual Lab)
4	Load test on Single phase Induction motor (Virtual Lab)
5	Characteristics of P-N junction Diode.
6	Characteristics of CE based NPN Transistor.
7	Characteristics of MOSFET
8	Characteristics of LVDT, RTD and Thermistor.

Contact Hours : 30

Total Contact Hours : 75

Course Outcomes:

On completion of the course, the students will be able to

- analyse DC circuits and apply circuit theorems.
- calculate the power and power factor in AC circuits
- understand the principles of electrical machines.
- comprehend the principles of different types of electronic devices, electrical measuring instruments and transducers.
- experimentally analyze the electric circuits and machines, electronic devices, and transducers.

Suggested Activities

- Problem solving sessions

Suggested Evaluation Methods

- Quizzes
- Class Presentation / Discussion

Text Book(s):

1. J.B.Gupta, “Fundamentals of Electrical Engineering and Electronics” S.K.Kataria & Sons Publications, 2010.
2. Joseph A. Edminister, Mahmood, Nahri, “Electric Circuits” – Shaum Series and Systems”, Schaum‟s Outlines, Tata McGrawHill, Indian. 5th Edison , 2017
3. Thereja .B.L., “Fundamentals of Electrical Engineering and Electronics”, S. Chand & Co. Ltd., 2008

Reference Books(s) / Web links:

1. Del Toro, “Electrical Engineering Fundamentals”, Pearson Education, New Delhi, 2015

2	John Bird, "Electrical Circuit Theory and Technology", Elsevier, First Indian Edition, 2007
3	Allan S Moris, "Measurement and Instrumentation Principles", Elseveir, Third Edition, 2006
4	Rajendra Prasad, "Fundamentals of Electrical Engineering", Prentice Hall of India, Third Edition, 2014
5	A.E.Fitzgerald, David E Higginbotham and Arvin Grabel, "Basic Electrical Engineering", McGraw Hill Education(India) Private Limited, 2009
6	D P Kothari and I.J Nagarath, "Basic Electrical and Electronics Engineering", McGraw Hill Education(India) Private Limited, Third Reprint ,2016
7	https://nptel.ac.in/courses/108108076

Lab Equipment Required:

Sl. No.	Name of the Equipment	Quantity Required (For a batch of 30 students)
1.	**Verification of ohms and Kirchhoff's Laws** 1. DC Regulated Power supply (0 - 30 V variable) 2. Bread Board 3. Resistors 4. Multimeter 5. Connecting wires	 1 1 As per Circuit diagram1 As Required
2.	**Load test on DC Shunt Motor.** 1. Ammeter MC (0-20A) 2. Voltmeter MC (0-300)V 3. Tachometer 4. Field Rheostat 500 Ω, 1.5 A 5. Connecting wires	 1 1 1 1 As Required
3.	**Load Test on Induction Motor** 1. Ammeter MI (0-20A) 2. Voltmeter MI (0-300)V 3. Wattmeter – 300V, 30 A 4. Tachometer – Digital 5. Connecting Wires 6. Single phase Induction motor	 1 1 1 1 As Required1
4.	**Load test on Single phase Transformer** 1. Ammeter (0-30) A, (0-5) A 2. Voltmeter (0-150)V, (0-300)V 3. Wattmeter – 300V, 5A, UPF 4. Autotransformer 5. Single phase Transformer 6. Connecting Wires	 **1** **1** **1** **1** **1** As Required
5.	**Characteristics of PN and Zener Diodes** 1. PN Diode (IN4007), Zener diode (6.8V, 1A) 2. Resistor 1 KΩ, 100Ω 3. Bread Board 4. DC Regulated Power supply (0 - 30 V variable) 5. Multimeter 6. Connecting wires	 1 1 1 1 1 As Required
6.	**Characteristics of BJT** 1. Transistor (BC107) 2. Resistors- 1kΩ, 470KΩ, 1MΩ 3. Bread Board 4. DC Regulated Power supply (0 - 30 V variable) 5. Multimeter 6. Connecting wires	 1 1 1 1 1 As Required

7	**Characteristics of MOSFET** 1. MOSFET (IRF510) 2. Resistors- 100kΩ, 1kΩ 3. Bread Board 4. DC Regulated Power supply (0 - 30 V variable) 5. Multimeter 6. Connecting wires	 1 1 1 1 1 As Required
7.	**Measurement of displacement of LVDT, RTD and Thermistor** 1. LVDT Kit 2. RTD 3. Thermistor 4. Multimeter	 1 1 1 1 1

COs/POs&PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	3	3	3		3	1	1	2	1	1	1			
CO 2	3	3	3	3		3	1	1	2	1	1	1			
CO 3	3	3	3	3		3	1	1	2	1	1	1			
CO 4	3	3	3	3		3	1	1	2	1	1	1			
CO 5	3	3	3	3		3	1	1	2	1	1	1			
Average	**3**	**3**	**3**	**3**		**3**	**1**	**1**	**2**	**1**	**1**	**1**			

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
GE23122	**ENGINEERING PRACTICES - ELECTRICAL AND ELECTRONICS**	**ES**	**0**	**0**	**2**	**1**

Objectives:

- To provide hands-on experience on various basic engineering practices in Electrical Engineering.
- To provide hands-on experience on various basic engineering practices in Electronics Engineering.

List of Experiments

A. ELECTRICAL ENGINEERING PRACTICE

1	Residential house wiring using switches, fuses, indicators, lamp and energy meter.
2	Fluorescent lamp wiring.
3	Stair case wiring.
4	Measurement of electrical quantities – voltage, current, power & power factor in RL circuit.
5	Measurement of earth resistance using Megger.
6	Study of Ceiling Fan and Iron Box

B. ELECTRONICS ENGINEERING PRACTICE

1	Study of electronic components and equipment – Resistor, colour coding, measurement of AC signal parameters (peak-peak, rms period, frequency) using CRO/DSO.
2	(a) Measurement of electrical quantities using Multimeter (b) Testing of electronic components.

3	Study of logic gates : AND, OR, EXOR and NOT.
4	Generation of Clock Signals.
5	Soldering practice – Components Devices and Circuits – Using general purpose PCB.
6	Measurement of ripple factor of Half-wave and Full-wave Rectifiers.

	Total Contact Hours	**:**	**30**

Course Outcomes:

On completion of the course, the students will be able to

•	fabricate the basic electrical circuits
•	implement the house wiring circuits
•	fabricate the electronic circuits
•	verify the truth table of logic gates
•	design the Half-wave and Full-wave Rectifiers using diodes and passive components

SUGGESTED EVALUATION METHODS

- Experiment based Viva

REFERENCE

1	Bawa H.S., "Workshop Practice", Tata McGraw – Hill Publishing Company Limited, 2007.
2	Jeyachandran K., Natarajan S. & Balasubramanian S., "A Primer on Engineering Practices Laboratory", Anuradha Publications, 2007.
3	Jeyapoovan T., Saravanapandian M. &Pranitha S., "Engineering Practices Lab Manual",Vikas Publishing House Pvt.Ltd, 2006.
4	Rajendra Prasad A. &Sarma P.M.M.S., "Workshop Practice", SreeSai Publication, 2002.

Lab Equipment Required:

S.	Name of the Equipment	Quantity Required
1	Residential house wiring using switches, fuse, indicator, lamp and energy	3 Nos
2	Fluorescent lamp wiring.	3 Nos
3	Stair case wiring	3 Nos
4	Measurement of electrical quantities – voltage, current, power & power	2 Nos
5	Study purpose items: Iron box, Ceiling fan.	2 each
6	Megger (250V/500V)	2 Nos.
7	Soldering guns	10 Nos.
8	Assorted electronic components for making circuits	50 Nos.
9	Small PCBs	10 Nos.
10	Multimeters	10 Nos.
11	Digital trainer kit	5 Nos.
12	CRO	8 Nos.
13	Transformer	8 Nos.
14	Function Generator	8 Nos.

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	-	-	2	-	3	2	-	3			
CO 2	3	3	2	2	-	-	2	-	3	2	-	3			
CO 3	3	3	3	2	-	-	2	-	3	2	-	3			
CO 4	3	3	3	2	-	-		-	3	2	-	3			
CO 5	3	3	3	2	-	-		-	3	2	-	3			
Average	**3**	**3**	**2.67**	**2**	**-**	**-**	**2**	**-**	**3**	**2**	**-**	**3**			

Subject Code	Course Title (Theory Course)	Category	L	T	P	C
MC23111	**Indian Constitution and Freedom Movement**	MC	3	0	0	0

Objectives:
• To apprehend the sacrifices made by the freedom fighters.
• To inculcate the values enshrined in the Indian constitution.
• To instil a sense of responsibility as the citizens of India.
• To familiarise about the functions of the various levels of Government.
• To be informed about Constitutional and Non- Constitutional bodies.

UNIT-I	**INDIAN FREEDOM MOVEMENT**	9
British Colonialism in India-Colonial administration till 1857- Revolt of 1857- Early Resistance to British Rule-Rise of Nationalism in India-I**ndian Freedom Struggle under Mahatma Gandhi-**Non- Cooperation Movement-Civil Disobedience Movement- Quit India Movement-British Official response to National movement- Independence of India Act 1947-Freedom and Partition.		
UNIT-II	**CONSTITUTION OF INDIA**	9
Historical Background – Indian Constitution: Constitution' meaning of the term, Sources and constitutional history, Constituent Assembly of India – Philosophical foundations of the Indian Constitution – Preamble – Fundamental Rights – Directive Principles of State Policy – Fundamental Duties – Citizenship – Constitutional Remedies for citizens.		
UNIT-III	**STRUCTURE AND FUNCTIONS OF CENTRAL GOVERNMENT**	9
Union Government – Structure of the Union Government and Functions – President – Vice President – Prime Minister – Cabinet – Parliament – Supreme Court of India – Judicial Review.		
UNIT-IV	**STRUCTURE AND FUNCTION OF STATE GOVERNMENT AND LOCAL BODY**	9
State Government – Structure and Functions – Governor – Chief Minister – Cabinet – State Legislature – Judicial System in States – High Courts and other Subordinate Courts- Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, Elected officials and their roles, Village level: Role of Elected and Appointed officials.		
UNIT-V	**CONSTITUTIONAL FUNCTIONS AND BODIES**	9
Indian Federal System – Centre – State Relations – President's Rule – Constitutional Functionaries – Assessment of working of the Parliamentary System in India- CAG, Election Commission, UPSC, GST Council and other Constitutional bodies-. NITI Aayog, Lokpal, National Development Council and other Non –Constitutional bodies.		
Total Contact Hours: 45		
ourse Outcomes: Upon completion of the course, students will be able to:		
• appreciate the sacrifices made by freedom fighters during freedom movement.		
• be responsible citizens and abide by the rules of the Indian constitution.		
• be aware of the functions of the Indian government.		
• be knowledgeable about the functions of the state Government and the Local bodies.		
• apply the knowledge on constitutional functions and role of constitutional bodies and non-constitutional bodies.		

SUGGESTED ACTIVITIES

- Famous speeches from around the world relating to independence
- Case study
- Quiz on Portfolio and Cabinet
- Discussions on International Associations like the UN, BRICS, QUAD
- Presentation on issues around the world

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation/Discussion
- Continuous assessments (CAT)

Text Book(s):
8. M. Laxmikanth , "Indian Polity:, McGraw-Hill, New Delhi.
9. Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi. 21st ed 2013.
10. P K Agarwal and K N Chaturvedi ,PrabhatPrakashan, New Delhi, 1st ed , 2017.

Reference Books(s) / Web links:
1. Sharma, Brij Kishore, "Introduction to the Constitution of India:, Prentice Hall of India, New Delhi.
2. U.R.Gahai, "Indian Political System ", New Academic Publishing House, Jalaendhar
3. Bipan Chandra, India's Struggle for Independence, Penguin Books, 2016.
4. Maciver and Page, "Society: An Introduction Analysis ", Mac Milan India Ltd., New Delhi.2nd ed, 2014.
5. Bipan Chandra, History of Modern India, Orient Black Swan, 2009.

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
MC23111.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MC23111.2	-	-	-	-	-	-	-	-		-	-	-	-	-	-
MC23111.3	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
MC23111.4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
MC23111.5	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-
AVERAGE	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-

GE23217 **தமிழரும் தொழில்நுட்பமும்** **L T P C**

1 0 0 1

அலகு I நெசவு மற்றும் பானைத் தொழில்நுட்பம்: 3

சங்க காலத்தில் நெசவுத் தொழில் - பானைத் தொழில்நுட்பம் - கருப்பு சிவப்பு பாண்டங்கள் - பண்டங்களில் கீறல் குறியீடுகள்.

அலகு II வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப்பொருட்களில் வடிவமைப்பு - சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் - சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் - மாமல்லபுரச் சிற்பங்களும், கோவில்களும் - சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் - நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் - செட்டிநாடு வீடுகள் - பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ - சாரோசெனிக் கட்டிடக் கலை.

அலகு III உற்பத்தித் தொழில் நுட்பம்: 3

கப்பல் கட்டும் கலை - உலோகவியல் - இரும்புத் தொழிற்சாலை - இரும்பை உருக்குதல், எஃகு - வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் - நாணயங்கள் அச்சடித்தல் - மணி உருவாக்கும் தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடி மணிகள் - சுடுமண் மணிகள் - சங்கு மணிகள் - எலும்புத்துண்டுகள் - தொல்லியல் சான்றுகள் - சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்: 3

அணை, ஏரி, குளங்கள், மதகு - சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் - கால்நடை பராமரிப்பு - கல்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் - வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் - கடல்சார் அறிவு - மீன்வளம் - முத்து மற்றும் முத்துக்குளித்தல் - பெருங்கடல் குறித்த பண்டைய அறிவு - அறிவுசார் சமூகம்.

அலகு V அறிவியல் தமிழ் மற்றும் கணித்தமிழ் : 3

அறிவியல் தமிழின் வளர்ச்சி - கணித்தமிழ் வளர்ச்சி - தமிழ் நூல்களை மின்பதிப்பு செய்தல் - தமிழ் மென்பொருட்கள் உருவாக்கம் - தமிழ் இணையக் கல்விக்கழகம் - தமிழ் மின் நூலகம் - இணையத்தில் தமிழ் அகராதிகள் - சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு - மக்களும் பண்பாடும் - கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி - வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை - ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr. K. K. Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr. S. Singaravelu)(Published by: International Institute of Tamil Studies.

7. Historical Heritage of the Tamils (Dr. S. V. Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies).
9. Keeladi – 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

III SEMESTER

Course Code	Course Title	Category	L	T	P	C
MA23311	TRANSFORMS AND APPLIED PARTIAL DIFFERENTIAL EQUATIONS	BS	3	1	0	4
Common to III sem. B.E. - AERO, MCT, R&A and B.Tech. – BT, FT and CHEM						

Objectives:

- To express Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- To show continuous function arising in wave and heat propagation, signals and systems using Fourier Transforms.
- To obtain solution of one-dimensional wave equation with finite difference techniques.
- To solve one- and two-dimensional heat flow equations using finite difference methods and numerical techniques.
- To make use of Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

UNIT-I	**FOURIER SERIES**	**12**
Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series –Parseval's identity – Harmonic analysis.		
UNIT-II	**FOURIER TRANSFORMS**	**12**
Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity - Application to boundary value problems.		
UNIT-III	**WAVE EQUATION**	**12**
Solution of one dimensional wave equation - Finite difference techniques for the solution for PDE- One Dimensional Wave Equation by Explicit method		
UNIT-IV	**HEAT EQUATION**	**12**
One dimensional equation of heat conduction – Steady state solution of two dimensional equation of heat conduction (excluding insulated edges)- Numerical computation :One dimensional heat flow equation by implicit and explicit methods		
UNIT-V	**Z-TRANSFORMS**	**12**
Z- transforms - Elementary properties – Inverse Z - transform (using residues) - Formation of difference equations – Solution of difference equations using Z- transform.		
	Total Contact Hours: 60	

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

- Demonstrate Fourier series to study the behaviour of periodic functions and their applications in engineering problems such as system communications, digital signal processing and field theory.
- Apply the shifting theorems, Fourier integral theorems, Inverse Fourier sine and cosine transforms appropriate problems in engineering and technology.
- Evaluate solution of one dimensional wave equation arising in various field of engineering using finite difference techniques.
- Apply the numerical techniques of differentiation to solution of heat flow equations arising in various branches of engineering.
- Use Z-transform to illustrate discrete function arising in wave and heat propagation, signals and systems.

Text Books:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India, 2015.
2. Veerarajan. T., "Transforms and Partial Differential Equations", Tata McGraw Hill Education Pvt.Ltd.,New Delhi, Second reprint, 2012.
3. Grewal B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014.

4	Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill Publishing Company Limited, New Delhi, 2008.
5	P. Kandasamy, K. Gunavathy, Thilagavathy., "Engineering Mathematics Transforms and Partial Differential Equations", S.Chand & Company, 2002.

Reference Books / Web links:	
1	N. Subramaniam, K. S. Ramaswami ., "Transforms and Partial Differential Equations", Pearson Education, 2018.
2	Glyn James, "Advanced Modern Engineering Mathematics", 3rd Edition, Pearson Education, 2007.
3	Ray Wylie C and Barrett.L.C, "Advanced Engineering Mathematics" Tata McGraw Hill Education Pvt Ltd, Sixth Edition, New Delhi, 2012.
4	Bali N., Goyal M. and Watkins C., "Advanced Engineering Mathematics", Firewall Media (An imprint of Lakshmi Publications Pvt., Ltd.,), 7th Edition, New Delhi, 2009.
5	Peter V.O'Neil, "Advanced Engineering Mathematics", Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi, 2012. https://drspmaths.files.wordpress.com/2020/01/advanced-engineering-mathematics-peter-v.-o-neil.pdf

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23311.1	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23311.2	3	3	3	2	1	-	-	-	-	-	-	1	2	1	2
MA23311.3	3	3	3	3	2	-	-	-	-	-	-	2	1	2	2
MA23311.4	3	3	2	3	2	-	-	-	-	-	-	2	1	-	1
MA23311.5	2	3	2	-	-	-	-	-	-	-	-	-	1	1	-
Average	2.8	3	2.6	2.5	1.5	-	-	-	-	-	-	1.5	1.2	1	2

Subject Code	**Subject Name (Theory Laboratory embedded course)**	**Category**	**L**	**T**	**P**	**C**
CY23334	**PHYSICAL AND ORGANIC CHEMISTRY**	BS	3	0	2	4

Objectives:

- To develop an understanding of the basic concepts of phase rule and its applications
- To acquire knowledge on distribution law and its applications
- To get familiarized with various industrial polymers.
- To learn about preparations and uses of synthetic intermediates.
- To impart knowledge on different types of drugs

UNIT-I	**PHASE RULE**	**9**
Phase rule - introduction, definition of terms - phase, components and degree of freedom -phase diagram- one component system (water system) - reduced phase rule - thermal analysis and cooling curves - two component systems - lead-silver system-pattinson process- compound formation with congruent melting – Mg- Zn system - vapour pressure curves and its significance.		
UNIT-II	**THE DISTRIBUTION LAW**	9
Distribution co-efficient - Distribution Law - conditions for the validity of the distribution law - I_2- CCl_4- H_2O system - nature of interaction of the solute with one of the solvents - dissociation - association - applications of distribution law and problems– Extraction process- Single and multiple- solvent extraction - principle and process - batch extraction - continuous extraction.		
UNIT III	**INDUSTRIAL POLYMERS**	**9**
Polymerisation-Methods of polymerisation (bulk polymerisation-solution polymerisation-suspension polymerisation-emulsion polymerisation)-Preparation, properties and applications of polyethylene,Teflon,PMMA,Polystytene, epoxy resins, phenol formaldehyde resins and synthetic rubbers.		

UNIT IV	PREPARATION OF SYNTHETIC INTERMEDIATES	9
Preparations of Benzil from benzyl aldehydes - Furyl from furfural, Vannilin from catechol through guaiacol, Gramine from indole, N-actetyl-5- bromo indoline from indole, Salol from phenol, Alanine from propionic acid, Heteroauxin from indole - Uses, Reaction and mechanism of acyloin condensation, Baeyer-Villigar reaction, Gabriel's synthesis of phthalimide, Bartoli Indole synthesis		
UNIT V	**PHARMACEUTICAL CHEMISTRY**	**9**
Drugs- Classification-based on origin and application – drug action-synthesis and mode of action of Antipyretics-Paracetamol, Anti-inflammatory drugs-Ibuprofen antibiotics-chloroamphenicol, antimalarial drugs-Chloroquine, antibacterial drugs-sulphonamide, anticancer drugs -Cis-platin.		
		Total Contact Hours:45

Description of the Experiments		**Total Contact Hours:15**
13.	A study of the association of benzoic acid in benzene	
14.	Determination cryoscopic constant by Rast method	
15.	Determination molecular weight by Rast method	
16.	Estimation of critical solution temperature of Phenol-Water System.	
17.	Determination of equilibrium constant	
18.	Study of simple eutectic formed by naphthalene-biphenyl system.	
7.	Determination of order of a reaction (iodination of acetone)	
8.	Effect of impurity on the CST of phenol-water system	
9.	Study of inversion of cane sugar by Polarimetry.	
10.	Determination of acid value of oils	

Course Outcomes: At the end of the course the student will be able to:
• apply the concept of phase rule in single and multi-component systems
• associate distribution law in extraction processes
• Process the polymers by various techniques
• Develop a synthetic intermediate for an organic compound at larger scale
• be capable of synthesizing drugs.

Reference Books(s)
1. Peter Atkins, Julia de Paula, Physical Chemistry, 9th Edition, Oxford University Press.
2. K.S. Tiwari, N.K. Vishnoi and S.N. Malhotra "A text book of Organic Chemistry" fourth Edition, Vikas Publishing House Pvt. Ltd. (2017) New Delhi.
3. R.T. Morrison and R.N. Boyd "Organic Chemistry" VII Edition Prentice Hall Inc (2010) USA.

Lab equipment required:

S. No	Name of the Equipment	Quantity Required
1.	Electrical shaker	3

2.	Polarimeter	2
3	Hot plate	4
4	Freezer	1

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

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1			1			1		1	1	1	
CO2	3	3	1	1			1			1	1	2	1		
CO3	3	3	1	1		1	1					1	1	1	
CO4	3	3	3	1		1	1	1		1	1	1	1	1	
CO5	3	3	3	1		1	1	1		1	1	1	1	1	
AVG.	3	3	1.8	1		1	1	1		1	1	1	1	1	

Course Code	Course Title	Category	L	T	P	C
CH23311	**SOLID MECHANICS**	**ES**	**2**	**1**	**0**	**3**

OBJECTIVE:

- To understand the theory of elasticity including strain/displacement and Hooke's law relationships.
- To solve for stresses and deflections of beams under unsymmetrical loading.
- To obtain stresses and deflections of beams on elastic foundations.
- To solve torsion problems in bars thin walled members.
- To obtain solutions to column buckling and plate problems.

UNIT I STRESS, STRAIN AND DEFORMATION OF SOLIDS 9

Rigid bodies and deformable solids – forces on solids and supports – equilibrium and stability – strength and stiffness – tension, compression and shear stresses – Hooke's law and simple problems – compound bars – thermal stresses – elastic constants and Poisson's ratio – welded joints – design.

UNIT II TRANSVERSE LOADING ON BEAMS 9

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

UNIT III DEFLECTIONS OF BEAMS 9

Double integration method – Macaulay's method – Area – moment theorems for computation of slopes and deflections in beams – conjugate beam method.

UNIT IV STRESSES IN BEAMS 9

Theory of simple bending – assumptions and derivation of bending equation (M/I = F/Y = E/R) – analysis of stresses in beams – loads carrying capacity of beams – proportioning beam sections – leaf springs – flitched beams – shear stress distribution in beams – determination of shear stress in flanged beams.

UNIT V TORSION AND COLUMNS 9

Torsion of circular shafts – derivation of torsion equation (T/J = C/R = G0/L) – stress and deformation in circular and hollow shafts – stresses and deformation in circular and hollow shafts – stepped shafts – shafts fixed at both ends – stresses in helical springs – deflection of springs – spring constant- Axially loaded short columns – Euler's theory of long columns.

TOTAL : 45 PERIODS

OUTCOMES:

On completion of this course, the students

- Will be able to determine stress, strain and elasticity with all its prerequisites.
- Will be able to design of beams.
- Will be able to design pipelines and storage tanks.
- Will be able to develop skills on designing reaction columns.
- Will be able to perform the design analysis of support column.

TEXT BOOKS:

1. Junarkar, S.B., Mechanics of Structure Vol. 1, 21st Edition, Character Publishing House, Anand, Indian, (1995)
2. William A.Nash, Theory and Problems of Strength of Materials, Schaum's Outline Series. McGraw Hill International Editions, Third Edition, 1994.

REFERENCE:

1. Rajput.R.K., A text book of Strength of Materials, S.Chand Publications, 2022.
2. Bansal, R.K., Strength of Materials, 6th Edition, Lakshmi Publications (P) Ltd, New Delhi, (2012).

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	1	1	-	-	1	-	2	1	1	1	1
CO 2	3	3	2	2	1	1	1	-	1	1	1	1	2	2	1
CO 3	3	3	3	3	1	1	-	-	1	-	2	1	2	2	1
CO 4	3	3	2	2	1	1	1	-	1	-	1	1	2	2	1
CO 5	3	3	2	2	1	1	-	-	1	-	2	1	2	2	1

3 –SUBSTANTIAL (HIGH) 2 – MODERATE (MEDIUM) 1 – SLIGHT (LOW)

Course Code	Course Title	Category	L	T	P	C
CH23312	**CHEMICAL PROCESS CALCULATIONS**	**PC**	**2**	**1**	**0**	**3**

UNIT 1 - Introduction to Basic Concepts

Units and dimensions – conversion factors – mole concept –normality, molarity, and molality – density and specific gravity – methods of expressing composition of mixtures and solutions – weight fraction – mole fraction –volumetric composition – Ideal gases – Dalton's law – Amagat's law – Humidity. **(9)**

UNIT 2 - Material Balance without Chemical Reaction

General material balance equation for steady and unsteady state - steady state material balances in distillation – absorption – extraction – crystallization – evaporator – mixer – dryer - Recycle and bypass **(9)**

UNIT 3 - Material Balance with Chemical Reaction

Stoichiometric equation – stoichiometric ratio – limiting reactant – excess reactant – percentage excess reactants – conversion – yield – selectivity – material balance for single and multiple chemical reactions. **(9)**

UNIT 4 - Energy balance

General steady state energy balance equation, heat capacity, enthalpy, heat of formation, heat of reaction, heat of combustion and Calorific values. Heat of solution, heat of mixing, heat of crystallization, determination of ΔHR from standard heat of formation and standard heat of combustion – Hess's law. **(9)**

UNIT 5 - Fuels and Combustion

Fuels, Calorific value of fuels, flue gas analysis, Orsat analysis, air/ fuel ratio calculations - theoretical and excess air requirement for solid, liquid and gaseous fuels. **(9)**

Course Objectives

1. Understand units and conversion, composition of mixtures and humidity calculations.
2. Carry out material balance for unit operations
3. Carry out product analysis for material balance with chemical reactions
4. Estimate the enthalpy change for reactions
5. Carry out combustion calculations

Course Outcomes

1. Apply mole concepts to express the composition of mixtures
2. Apply material balance for industrial processes
3. Apply material balance with chemical reactions for industrial processes
4. Apply energy balance for industrial processes
5. Solve combustion calculations of reactions.

TEXT BOOKS:

1. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", 8th Edition,Prentice Hall Inc., 2014.

2. Bhatt, B.I., and Thakore, S.B., "Stoichiometry ", 5th Edition, McGraw-Hill, 2017

3. K.V. Narayanan and B. Lakshmi Kutty," Stoichiometry and Process Calculation", 2nd Edition, PHILearning Ltd. (2016).

REFERENCES:

1. Hougen O A, Watson K M and Ragatz R A, "Chemical Process Principles Part I: Material and EnergyBalance", 2nd Edition, CBS publishers, 2004.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	2	1	-	-	1	-	1	1	3	1	1
CO 2	3	3	3	3	2	1	-	-	1	-	1	1	3	1	1
CO 3	3	3	3	3	2	1	-	-	1	-	1	1	3	1	1
CO 4	3	3	3	3	2	1	-	-	1	-	1	1	3	1	1
CO 5	3	3	3	3	2	1	1	-	1	-	1	1	3	1	1

Course Code	Course Title	Category	L	T	P	C
CH23313	CHEMICAL PROCESS INDUSTRIES	PC	3	0	0	3

OBJECTIVE:

- To learn about the production of numerous chemicals found in everyday products.
- To comprehend the numerous unit processes and unit operations, as well as the sequence involved in diverse chemical businesses.
- To outline the components, present in chemical process industries and design the chemical process plant.
- To give an exposure on aspects of safety for various chemical industries.
- To impart knowledge on fertilizer, polymers and fermentation industry

UNIT I INTRODUCTION AND CHLORO- ALKALI INDUSTRIES 9

The role of a chemical engineers in process industries, Introduction to common devices used inmanufacturing processes, block diagrams, flowcharts and standard symbols used for devices, industrial safety and pollution, outline of plant and equipment design. Manufacture of Soda ash and sodium bi carbonate, chlorine and caustic soda; bleaching powder and related bleaching agents, Sodium chloride, By-products of common salt industry.

UNIT II ACID INDUSTRIES 9

Mining and manufacture of sulphur, recovery of sulphur from polluting gases, sulphur trioxide and sulphuric acid, hydrochloric acid, synthetic ammonia, nitric acid, phosphoric acid

UNIT III SILICATE, PAPER AND SUGAR INDUSTRIES 9

Types and manufacture of Portland cement, manufacture of glasses and special glasses, ceramics and refractories, manufacture of pulp – different processes of pulping – manufacture of paper – manufactureof boards- raw and refined sugar, by products of sugar industries, Starch and starch derivatives.

UNIT IV OIL AND FIBRE INDUSTRIES 9

Hydrogenation of oils, fatty acids: soaps, synthetic detergents- manufacture of Nylon 6. 6. Polyesters fibres – manufacturer of – cellulosic fibres – viscose rayon production manufacture of films - cellulose acetate, PVC, polyesters - polyethylene

UNIT V FERTILIZER INDUSTRIES 9

NPK and functions, ammonium sulphate, ammonium nitrate, ammonium phosphate, potassium chloride, potassium sulphate, single, triple super phosphate introduction to pesticides, herbicides and bio-fertilizers.

TOTAL : 45 PERIODS

COURSE OUTCOME:

At the end of the course the students

CO 1	Ability to understand the manufacturing of various inorganic and organic chemicals
CO 2	Ability to understand the process flow diagram and various process parameters
CO 3	Ability to identify engineering problems during production of sugar
CO 4	Will be able to outline the components present in various oil & fibre industries
CO 5	Will have an understanding on manufacturing fertilizers

MAPPING OF PO'S with Course Outcome:

CO	PO/PSO														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
I	3	3	2	2	3	3	2	2	2	1	1	3	3	3	2
II	3	3	2	2	3	3	3	2	2	1	1	2	3	2	2
III	3	3	2	2	3	3	2	2	2	1	1	2	3	2	2
IV	3	3	2	2	3	3	2	2	2	2	1	2	3	2	2
V	3	3	2	2	3	3	2	2	2	1	1	2	3	2	2

TEXT BOOKS:

1. Austin, G.T., Shreve's Chemical Process Industries, Fifth Edition, McGraw-Hill International BookCo, Singapore, 2017
2. Dryden, C.E., Outlines of Chemicals Technology, Edited and Revised by Gopala Rao, M. and M.Sittig, third Edition, Affiliated East-West press,1997.

REFERENCES:

1. Shukla and G.N. Pandey "Text book on Chemical Technology", Vikas Publishing company 1997
2. Kirk and Othmer ,"Encyclopedia of Chemical Technology", III Edition,2001.
3. Srikumar Koyikkal,"Chemical Process Technology and Simulation", PHI Learning Ltd (2013).

Course Code	Course Title	Category	L	T	P	C
CH23331	**FLUID MECHANICS FOR CHEMICAL ENGINEERS**	**PC**	**3**	**0**	**1**	**4**

OBJECTIVE:

- To impart knowledge on fluid properties
- To explain the concepts of fluid static characteristics and their applications
- To explain the concepts of fluid at motion and its applications
- To explain the principles of dimensional analysis and its application
- To explain the principle of various instruments used to measure fluid properties

UNIT I BASICS OF FLUID MECHANICS 9

Methods of analysis and description - fluid as a continuum – Velocity and stress field - Newtonian and non-Newtonian fluids – Classification of fluid motion – Reynold's transport theorem.

UNIT II FLUID STATICS, KINEMATICS AND DYNAMICS 12

Fluid statics – basic equation - equilibrium of fluid element – pressure variation in a static fluid - application to manometer– Differential analysis of fluid motion – continuity equation of motion, Bernoulli equation and Navier- Stokes equation - basic of CFD modeling.

UNIT III DIMENSIONAL ANALYSIS 12

The principle of dimensional homogeneity – dimensional analysis, Rayleigh method, and the Pi-theorem

- non-dimensional action of the basic equations -similitude - relationship between dimensional analysis and similitude - use of dimensional analysis for scale up studies

UNIT IV FLOW THROUGH PIPES 15

Reynolds number regimes, internal flow - flow through pipes – pressure drop under laminar and turbulentflow conditions – major and minor losses; Line sizing; External flows - boundary layer concepts, boundary layer thickness under laminar and turbulent flow conditions- Flow over a sphere – friction andpressure drag - flow through fixed and fluidized beds.

UNIT V FLOW MEASUREMENT, VALVES AND PUMPS 12

Flow measurement - Constant and variable head meters; Velocity measurement techniques; Types, characteristics, and sizing of valves; Classification, performance characteristics, and sizing of pumps, compressors, and fans

TOTAL: 60 PERIODS

TEXTBOOKS:

1. Noel de Nevers, "Fluid Mechanics for Chemical Engineers ", Third Edition, McGraw-Hill, (2017).
2. McCabe W.L, Smith, J C, and Harriot. P "Unit Operations in Chemical Engineering", McGraw Hill, VII Edition, 2017.
3. Munson, B. R., Young, D.F., Okiishi, T.H. "Fundamentals of Fluid Mechanics", 9th Edition", John Wiley, 2021.

REFERENCES:

1. White, F.M., "Fluid Mechanics ", IV Edition, McGraw-Hill Inc., 1999.
2. James O Wilkes and Stacy G Bike, "Fluid Mechanics for Chemical Engineers' Prentice Hall PTR (International Series in Chemical Engineering) (1999).

COURSE OUTCOME: At the end of the course the students

CO 1	Can identify and obtain the values of fluid properties and understand the principles of continuity and the energy equation for fluid flow.
CO 2	Will be able to apply the principles of dimensional homogeneity
CO 3	Can understand various fluid flow phenomena under various conditions and understand theories of flow measurement equipment, pumps, and valves.
CO 4	Ability to estimate frictional losses in fluid flow and predict the coefficient of discharge for flow through pipes.
CO 5	Ability to experiment with flow measurement devices like venturi-meter and orifice meter

MAPPING OF PO'S with Course Outcome:

CO	PO/PSO														
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
I	3	3	2	2	2	-	1	-	2	1	1	3	3	2	1
II	3	3	3	3	3	-	2	-	2	1	1	2	3	2	1
III	3	3	3	1	2	-	1	-	2	1	1	3	3	3	3
IV	3	3	3	2	3	-	1	-	3	3	2	2	3	2	2
V	3	3	3	2	3	-	2	-	3	3	2	3	3	1	1

List of the Experiments

1. Calibration of Rotameter
2. Determine The Coefficient of Discharge for Venturi Meter
3. Determine The Coefficient of Discharge for Orifice Meter
4. Friction Losses in Fluid Flow in Pipes
5. Minor Losses in A Pipe
6. Determination of Viscosity of Oil by 'Redwood Viscometer
7. Determination of Viscosity of Oil by 'Ostwald Viscometer
8. Characteristics Studies of a Centrifugal Pump
9. Pressure Drop Studies in Packed Bed
10. Pressure Drop Studies in Fluidized Bed
11. Drag Coefficient of Solid Particle
12. Helical Coil

IV SEMESTER

Course Code	Course Title	Category	L	T	P	C
MA23431	PROBABILITY, STATISTICS AND RELIABILITY	BS	3	0	2	4
Common to IV sem. B.Tech. - BT, FT and CHEM						

Objectives:
● To introduce the basic concepts of probability, one dimensional random variables.
● To solve the problems those are faced in testing of a hypothesis with reference to the errors in decision making.
● To analyse the different mathematical models with the help of statistical deigns and appropriate data and made valuable conclusions by proper evaluation.
● To explain the concepts of quality control in industry and to apply various tools to examine the quality of a process and product.
● To analyse statistical experiments leading to reliability modelling and to identify reliability testing components for assessment of reliability in engineering design.

UNIT-I	PROBABILITY	9
One dimensional Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Uniform and Normal distributions, Two dimensional Discrete and continuous random variables – Conditional and Marginal densities.		
UNIT-II	**STATISTICAL TESTING**	9
Maximal Likelihood estimation – Parameters of Binomial and Poisson distribution - Tests of significance – Z test: Single mean, difference of means- Chi square - F test.		
UNIT-III	**ANOVA**	9
Design of Experiments - Completely randomized design – Randomized block design –Latin square design.		
UNIT-IV	**STATISTICAL QUALITY CONTROL**	9
Control charts for measurements ($\bar{X}$and R charts) – Control charts for attributes (p, c and np charts) – Tolerance limits - Acceptance sampling		
UNIT-V	**RELIABLITY**	9
Reliability Concepts: Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve - Failure Data Analysis: Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions - Reliability Hazard Models: Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model- Distribution functions and reliability analysis.		
Total Contact Hours: 45		

S.No	List of Experiment (using R Software)	Total Contact Hours: 30
1	Basic Functions in R and plotting	
2	Mathematical functions in R – Integration	
3	Control flow – Loops in R	
4	Probability Distributions using R- PDF, CDF for Binomial, Poisson, Exponential, Uniform and Normal Distributions.	
5	Testing of Hypothesis – Z testing	
6	Testing of Hypothesis – F and chi square testing	
7	ANOVA – one way and two way	
8	Statistical quality control – p, np , c, $\bar{X}$charts	
9	Reliability – MTTF, MTBF	
10	Reading , Writing data in R and working with inbuilt data sets in R	

Course Outcomes: on completion of the course, the students will be able to
• Have the critical thinking in the theory of probability and its applications in real life problems.
• Apply the different testing tools like t-test, F-test, chi-square test to analyse the relevant real life problems.
• Analyse the different mathematical models with the help of statistical deigns and appropriate data and made valuable conclusions by proper evaluation.
• Use various tools to examine the quality of a process and product in engineering and technology.
• Illustrate the basic concepts and techniques of modern reliability engineering tools.

Text Book(s):	
1.	Veerarajan T, 'Probability, Statistics and Random Processes with Queueing Theory and Queueing Networks'.
2.	McGraw Hill, 2016. 2 Johnson R.A. and Gupta. C.B., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 7th Edition, 2007.
3.	Srinath. L.S., "Reliability Engineering", Affiliated East west press, 1991.
4.	Kandasamy P., Thilagavathi and K. Gunavathi., "Statistics and Numerical Methods", S. Chand & Company Ltd. (2010).

Reference Books(s) / Web links:	
1.	Jhon wiley& Sons .Erwin Kreyszig., "Advanced Engineering Mathematics", Pearson Education, Asia, 7th Edition, 2007.
2.	Ramana. B.V., "Higher Engineering Mathematics ", McGraw Hill Education Pvt. Ltd, New Delhi, 2016.
3.	Gupta. R.C, "Statistical Quality control", Khanna Publishers, 1997
4.	Douglas.C. Montgomery, "Introduction to Statistical quality control", 7th edition, John Wiley 2012.

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
MA23431.1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-
MA23431.2	2	2	1		-	-	-	-	-	-	-	1	-	1	1
MA23431.3	2	2	-	2	-	-	-	-	-	-	-	1	-	1	1
MA23431.4	2	2	2	2	-	-	-	-	-	-	-	1	-	1	1
MA23431.5	2	2	2	1	-	-	-	-	-	-	-	1	-	1	1
Average	2	2	1.6	1.5	-	-	-	-	-	-	-	1	-	1	1

Course Code	Course Title	Category	L	T	P	C
CH23411	THERMODYNAMICS	PC	3	0	0	3

OBJECTIVES

- To train the students for the familiarization of heat and work transfer calculation by applying thebasic principles.
- To develop knowledge on selecting an equation of state for representing PVT behavior of fluids
- To impart knowledge on first law and second law of thermodynamics in chemical processes mainly refrigeration processes.
- To train the students to understand the different kind of thermodynamic property relationships
- To train the students for the familiarization of single stage and multistage compression process

UNIT I FUNDAMENTAL CONCEPTS 6

Scope of thermodynamics; Definition of system, control volume, state and path function, equilibrium,reversibility, energy, work and heat. zeroth law; temperature scales.

UNIT II PVT RELATIONSHIPS 7

PVT behavior of fluids; Mathematical representation of PVT behavior; Generalized compressibility factor correlation; Generalized equations of state.

UNIT III LAWS OF THERMODYNAMICS 12

Joule's experiment, internal energy, first law, energy balance for closed systems, mass and energy balancefor open systems Statements of the second law of thermodynamics, heat engine and refrigerator, Carnot cycle and Carnot theorems, thermodynamic temperature scale, entropy and its calculation, second law of thermodynamics for a control volume, Third law of thermodynamics, entropy from a microscopic point of view, Refrigeration, vapor compression and vapor absorption cycle.

UNIT IV THERMODYNAMIC REALTIONSHIPS 12

Thermodynamic potentials – internal energy, enthalpy, Helmholtz free energy, Gibbs free energy; thermodynamic property relations – Maxwell relations – partial derivatives and Jacobian method; residualproperties; thermodynamic property tables and diagrams.

UNIT V APPLICATIONS 8

Duct flow of compressible fluids, Compression and expansion processes, steam power plant, internal combustion engines, jet and rocket engines.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

- Identify the difference between heat and work, isentropic and isenthalpic processes
- Use equation of state, correlation to predict the PVT data
- Analyze the process with respect to first and second law of thermodynamics and understandentropy of the system
- Understand interrelationship of properties and their calculations
- Understand the purpose of inter cooling in multistage compressors

TEXT BOOKS:

1. Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering

Thermodynamics “, McGraw Hill Publishers, VIII Edition, 2019.
2. Rao, Y.V.C., “Chemical Engineering Thermodynamics” Universities Press, 2009.
3. Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics, Prentice Hall India, IIEdition, 2013.
4. Milo D. Koretsky, Engineering and Chemical Thermodynamics, Wiley Publishers, 2009.

REFERENCES:

1. Kyle, B.G., “Chemical and Process Thermodynamics III Edition”, Prentice Hall of India Pvt.Ltd., 1999.
2. Pradeep Ahuja,” Chemical Engineering Thermodynamics”, PHI Learning Ltd, (2009).
3. Gopinath Halder,” Introduction to Chemical Engineering Thermodynamics”, PHI Learning Ltd(2009).
4. Yunus A. Cengel, Michael A. Boles , Mehmet Kanoglu, Thermodynamics - An Engineering Approach , McGraw Hill Publishers, 9th Edition, 2019

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	1	1	1	-	1	-	2	1	3	1	1
CO 2	3	3	2	2	1	1	-	-	1	-	1	1	3	2	1
CO 3	3	3	3	3	1	1	1	-	1	-	2	1	2	3	1
CO 4	3	3	2	2	1	1	-	-	1	-	1	1	2	3	1
CO 5	3	3	2	2	1	1	1	-	1	-	2	1	2	2	2

3 –SUBSTANTIAL (HIGH) 2 – MODERATE (MEDIUM) 1 – SLIGHT (LOW)

Course Code	Course Title	Category	L	T	P	C
CH23412	**HEAT TRANSFER**	**PC**	**3**	**0**	**0**	**3**

OBJECTIVE:

- To learn steady-state and unsteady-sate heat conduction involved in unit operations.
- To understand the mechanism of heat transfer by convection in different geometry
- To be exposed to the principles of boiling and condensation heat transfer
- To understand concepts of exchange of radiation between bodies
- To design heat transfer equipment such as Shell & Tube Heat exchangers, evaporators etc.

UNIT I CONDUCTION HEAT TRANSFER 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, - Heat conduction through a series of resistances - Furnace concept
Refractory and Insulation-Thermal conductivity measurement; effect of temperature on thermal conductivity; Heat transfer in extended surfaces, Unsteady state heat conduction – flat plate and cylinder.

UNIT II CONVECTION HEAT TRANSFER 9

Concepts of heat transfer by convection - Natural and forced convection, analogies between the transfer of momentum and heat - Reynold’s analogy, Prandtl and Colburn’s analogy. Dimensional analysis in heat transfer, heat transfer coefficient for flow through a pipe and flow over a flat plate.

UNIT III HEAT TRANSFER WITH PHASE CHANGE 9

Heat transfer to fluids with phase change - heat transfer from condensing vapors, drop-wise and film-wise condensation, Nusselt equation for vertical and horizontal tubes, condensation of superheated vapors, Heat transfer to boiling liquids - mechanism of boiling, nucleate boiling, and film boiling.

UNIT IV RADIATION 9

Radiation heat transfer - Black body radiation, Emissivity, Stefan - Boltzmann law, Plank's law, radiation between surfaces.

UNIT V HEAT EXCHANGERS 9

Heat exchangers-types of heat exchangers; plate heat exchangers; use of correction factor charts; heat exchangers effectiveness; the number of transfer units - Chart for different configurations - Fouling factors- Heat exchanger networks and pinch technology. Evaporation-Theory of evaporation - single effect and multiple effect evaporation

TOTAL: 45 PERIODS

COURSE OUTCOME:

- Ability to understand steady-state and unsteady-state heat conduction and solve related problems
- Ability to understand the mechanism of heat transfer by convection in different geometry
- Will be able to understand the concepts of heat transfer involving phase change
- To understand concepts of exchange of radiation between bodies
- Ability to design heat exchangers

TEXTBOOKS:

1. Holman, J. P., Souvik Bhattacharyya 'Heat Transfer', McGraw Hill Education; 10th edition ,2017
2. Ozisik, M. N., Heat Transfer: A Basic Approach, McGraw-Hill Education / Asia ,1985
3. B.K Dutta, Heat Transfer Principles and applications, PHI learning PVT Ltd, 2016
4. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 6th Edn., McGraw-Hill, 2001.

REFERENCES:

1. Kern, D.Q., "Process Heat Transfer ", McGraw Hill Education, 2017
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering "Vol. I, Butterworth-Heinemann; 6th edition, 1999; CBS Publishers & Distributors Pvt. Ltd.

CO-PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	2	1	1	1	1	1	1	3	3	1	3
CO 2	3	3	2	2	1	1	1	1	1	2	1	3	3	1	3
CO 3	3	3	2	2	2	1	1	1	1	2	1	3	3	1	3
CO 4	3	3	3	3	1	1	1	1	1	2	1	3	3	1	1
CO 5	3	3	3	3	2	1	1	2	1	2	2	3	3	1	2

Course Code	Course Title	Category	L	T	P	C
CH23431	PARTICLE SCIENCE AND TECHNOLOGY	PC	3	0	1	4

OBJECTIVE:

- To learn the characterization of solids and size reduction techniques
- To gain knowledge on various separation processes such as solid-solid separation, Fluid-solid separation, and Mechanical-physical separation and select the appropriate separation technique or equipment based on the nature of the solution or size of the particles.
- To expose to calculation and machinery involved in various solid handling operations
- To understand the principles of mixing and agitation, including liquid-liquid, liquid-solid, and powder mixing. Also, to explore the storage and bulk transportation of solids.
- To introduce nano-technological aspects.

UNIT I SIZE ANALYSIS AND SIZE REDUCTION 9

General characteristics of solids, different techniques of size analysis, shape factor, surface area determination, estimation of particle size. Screening methods and equipment, screen efficiency, ideal and actual screens. Laws of size reduction, energy relationships in size reduction, methods of size reduction, classification of equipment, crushers, grinders, power requirement, work index; size enlargement - principle of granulation, briquetting, pelletisation, and flocculation.

UNIT II MECHANICAL SEPARATIONS 9

Gravity settling, sedimentation, thickening, elutriation, double cone classifier, rake classifier, bowl classifier. Centrifugal separation - continuous centrifuges, super centrifuges, design of basket centrifuges; industrial dust removing equipment, cyclones and hydro cyclones, electrostatic and magnetic separators, heavy media separations, floatation, jigging.

UNIT III FILTRATION 9

Theory of filtration, Batch and continuous filters, Flow through filter cake and filter media, compressible and incompressible filter cakes, filtration equipments - selection, operation and design of filters and optimum cycle of operation, filter aids.

UNIT IV MIXING, AGITATION, STORAGE AND TRANSPORTATION 9

Mixing and agitation - Mixing of liquids (with or without solids), mixing of powders, selection of suitable mixers, power requirement for mixing. Storage and Conveying of solids - Bunkers, silos, bins and hoppers, transportation of solids in bulk, conveyer selection, different types of conveyers and their performance characteristics.

UNIT V SYNTHESIS AND CHARACTERISATION OF NANOPARTICLES 9

Synthesis of Nanoparticles – Chemical and physical processing methods, Characteristics of Nanoparticles – FTIR, XRD, SEM, TEM - Applications -

LIST OF EXPERIMENTS

1. Sieve analysis
2. Batch filtration studies using a Leaf filter
3. Batch filtration studies using a Plate and Frame Filter press
4. Characteristics of batch Sedimentation
5. Reduction ratio in Jaw Crusher
6. Reduction ratio in Ball mill
7. Separation characteristics of Cyclone separator
8. Reduction ratio of Roll Crusher
9. Separation characteristics of Elutriator
10. Reduction ratio of Drop weight crusher

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

1. Sieve shaker
2. Leaf filter
3. Plate and Frame Filter Press
4. Sedimentation Jar
5. Jaw Crusher
6. Ball Mill
7. Cyclone Separator
8. Roll Crusher
9. Elutriator
10. Drop Weight Crusher
11. Test Sieves.

TOTAL : 60 PERIODS

Course Outcomes:

i. Ability to characterize particles and perform experiments to determine their size and will be able to calculate and experiment with the power required by various solid handling equipment.
ii. Will be able to select the appropriate separation technique or equipment based on the nature of the solution or size of the particles and perform experiments to determine its efficiency.
iii. Ability to identify various filtration equipment in process industries and will be able to calculate the time taken for the filtration process and carry out experiments to determine filtration characteristics.
iv. Will be able to understand the principles of mixing and agitation and explore the storage and bulk transportation of solids.
v. Will be aware of various techniques involved in synthesizing nanomaterials.

TEXT BOOKS:

1. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", VII Edition., McGraw-Hill, 2017.
2. Badger W.L. and Banchero J.T., "Introduction to Chemical Engineering", Tata McGraw Hill, 2001.
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, 2008.

REFERENCE:

Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I, VI Edition., Asian Books Pvt. Ltd., India, 1999.

CO-PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	2	2	1	1	-	2	1	-	3	3	2	1
CO 2	3	3	3	3	3	1	2	-	2	1	-	2	2	2	1
CO 3	3	3	3	1	2	1	1	-	2	1	-	3	1	2	3
CO 4	3	3	3	2	3	1	1	-	2	3	-	2	2	2	2
CO 5	3	2	3	2	3	1	2	-	-	3	-	3	-	2	-
AVG	3	2.6	2.8	2	2.6	1	1.4		1.6	1.8	-	2.6	1.6	2	1.4

Subject Code	Subject Name	Category	L	T	P	C
CS23422	**Python Programming for Machine Learning** (with effect from 2023 batch onwards)	ES	0	0	4	2

Course Objectives:

This course is aimed at enabling the students to :

- Understand the relationship of the data collected for decision making.
- Know the concept of principal components, factor analysis and cluster analysis for profiling and interpreting the data collected.
- Lay the foundation of machine learning and its practical applications and prepare students for real-time problem-solving in data science.
- Develop self-learning algorithms using training data to classify or predict the outcome of future datasets.
- Distinguish overtraining and techniques to avoid it such as cross-validation.

List of Experiments

1.	NumPy Basics: Arrays and Vectorized Computation
2.	Getting Started with pandas
3.	Data Loading, Storage, and File Formats
4.	Data Cleaning and Preparation
5.	Data Wrangling: Join, Combine, and Reshape
6.	Plotting and Visualization
7.	Data Aggregation and Group Operations
8.	Time Series
9.	Supervised Learning
10.	Unsupervised Learning and Pre-processing
11.	Representing Data and Engineering Features
12.	Model Evaluation and Improvement

Contact Hours : 60

Course Outcomes:

On completion of the course, students will be able to:

- Develop a sound understanding of current, modern computational statistical approaches and their application to a variety of datasets.
- Analyze and perform an evaluation of learning algorithms and model selection.
- Compare the strengths and weaknesses of many popular machine learning approaches.
- Appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.
- Design and implement various machine learning algorithms in a range of real-world applications.

Text Books:

1. Wes McKinney, Python for Data Analysis - Data wrangling with Pandas, Numpy, and IPython, Second Edition, O'Reilly Media Inc, 2017.
2. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python - A Guide for Data Scientists, First Edition, O'Reilly Media Inc, 2016.

Reference Books:

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media Inc, 2019.

Subject Code	Subject Name	Category	L	T	P	C
GE23327	SOFT SKILLS-I	EEC	0	0	2	1

Objectives:

- To help the students break out of shyness.
- To build confidence
- To enhance English communication skills.
- To encourage students‟ creative thinking to help them frame their own opinions.

Learning and Teaching Strategy:

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	Activity Name	Description	Objective
1	Introduction	The trainer and the college facilitator talk to the students about the course and in turn the students introduce themselves.	To set expectations about the course and the students are made aware of the rules and regulations involved in this program
2	If I ruled the world	This is a quick and useful game by getting students to form a circle and provide their point of view. Each student then repeats what the other has said and comes up with their own opinion.	The aim of this activity is to for students to get to know each other and also develop their listening skills as well as learning how to agree and disagree politely.
3	Picture Narrating	This activity is based on several sequential pictures. Students are asked to tell the story taking place in the sequential pictures by paying attention to the criteria provided by the teacher as a rubric. Rubrics can include the vocabulary or structures they need to use while narrating.	The aim of this activity is to make the students develop creative way of thinking.
4	Brainstorming	On a given topic, students can produce ideas in a limited time. Depending on the context, either individual or group brainstorming is effective and learners generate ideas quickly and freely. The good characteristics of brainstorming are that the students are not criticized for their ideas so students will be open to sharing new ideas.	The activity aims at making the students speak freely without the fear of being criticized. It also encourages students to come up with their own opinions.
5	Debate	Is competition necessary in regards to the learning process?	The aim of this activity is to develop the students ability to debate and think out of the box
6	Short Talks	Here the students are given topics for which they take one minute to prepare and two minutes to speak. They can write down points but can‟t read them out they can only use it as a reference.	The activity aims at breaking the students‟ shyness and encouraging them to standup in front of the class and speak. It also aims at creating awareness that they are restricted for time so they only speak points that are relevant and important.
7	Debate	Will posting students‟ grades on bulletin boards publicly motivate them to perform better or is it humiliating?	This activity aims at enhancing the students unbiased thought process when it comes to exams and grades as well as develop their skills to debate
8	The Art of diplomacy	The facilitator proceeds to share multiple concepts of conversation and helps the	The aim of the lesson is to provide an opportunity for the participants to

		participants to identify the various methods of being diplomatic and how do deal with misinformation.	learn about body language and choosing the appropriate words for conversation.
9	Debate	Are humans too dependent on computers?	The aim of this activity is to test the students debating skills and thought process with a topic that affects everybody in daily life.
10	Story Completion	The teacher starts to tell a story but after 2 sentences he/she asks students to work in groups to create the rest of the story which includes the plot and the ending.	This activity aims at building their narrating skills as well as their creativity and ability to work in a team.
11	Role play debate	Students scrutinize different points of view or perspectives related to an issue. For example, a debate about the question "Should students be required to wear uniforms at school?" might yield a range of opinions. Those might include views expressed by a student (or perhaps two students – one representing each side of the issue), a parent, a school principal, a police officer, a teacher, the owner of a clothing store, and others.	The aim of this activity is to get students to speak based on other people‟s perspective instead of their own. The students take the role of various characters and debate accordingly.
12	I Couldn‟t Disagree More	This is a game where students practice rebuttal techniques where one student provides a thought or an idea and the other students starts with the phrase I couldn‟t disagree more and continues with his opinion	The aim of this activity is to improve general communication skills and confidence.
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits	The aim is to do both give feedback to students as well as obtain feedback on the course from them.
		Total Contact Hours	**30**

Course Outcomes: At the end of the course the student will be able to

□	Be more confident
□	Speak in front of a large audience
□	Be better creative thinkers
□	Be spontaneous
□	Communicate in English

COs/POs&PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	-	-	-	-	-	-	-	-	1	3	-	1	-	-	-
CO 2	1	-	-	-	-	-	1	-	1	3	1	1	-	-	-
CO 3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 4	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
CO 5	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
Average	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**3**	**1**	**1**	**-**	**-**	**-**

Course Code	Course Title	Category	L	T	P	C
CH23421	TECHNICAL ANALYSIS LABORATORY	PC	0	0	4	2

OBJECTIVE:

1. To train the students on basic principles involved in estimation and characterization of industrially important materials.
2. To provide clear understanding of basic concepts of scale up processes
3. To identify the pollutants present in water, waste water, solvents and fuels
4. To understand the principles of polymer synthesis and characterization
5. To train the students to identify the common impurities in domestic chemicals

LIST OF EXPERIMENTS

1. Water Analysis

a. Determination of hardness
b. Sulphate Analysis
c. Nitrate Analysis
d. Determination COD/BOD/DO
e. pH and conductivity determination
f. Total purity

2. Scale-up of the Chemical Process

a. Chemical reaction progress monitoring
b. Bulk-synthesis
c. Purification
d. Determination of yield and purity

3. Synthesis and molecular weight determination of polymers

a. Synthesis of polymers (anionic/free-radical/RAFT)
b. Molecular weight determination (viscometry/GPC)

4. Soap Analysis

a. Estimation of total fatty acid
b. Estimation of percentage alkali content

5. Oil Analysis

a. Estimation of free acid
b. Determination of Saponification value
c. Determination of iodine value

6. 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

7. Analysis of Bleaching Powder

a. Estimation of available chlorine

8. Analysis of purity of solvents

a. Estimation of purity of ethanol/acetone/chloroform

9. Analysis of fuels

a. Flash point
b. Fire point
c. Cloud point
d. Pour point
e. Purity

10. Absorption spectrometry

a. Beer-Lamberts Law
b. Determination of absorption coefficient
c. Determination of absorption wavelengths of dyes.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of this practical course

1. The student would have a thorough understanding on the estimation and analysis of water pollutants.
2. The student would have a clear understanding of scale up of industrial processes
3. The student could acquire skills in polymer synthesis and characterization
4. The students will be able to analyze the common composition of domestic utilities
5. The students would be aware of handling spectroscopic instruments for their research projects

CO/PO Mapping

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

SEMESTER – V

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23511	Process Plant Utilities	3	0	0	3	3	PC
2	CH23512	Chemical Engineering Thermodynamics	3	0	0	3	3	PC
3	CH23513	Mass Transfer I	3	0	0	3	3	PC
4	CH23514	Principles of Chemical Reaction Engineering	3	0	0	3	3	PC
5		Professional Elective I	3	0	0	3	3	PE
		Open Elective - II	3	0	0	3	3	OE
PRACTICALS								
7	GE23521	SOFT SKILLS – II	0	0	2	1	1	EEC
8	CH23521	Heat Transfer Lab	0	0	4	4	2	PC
9	EC23527	Microfluidics Laboratory	0	0	2	2	1	PE
10	CH23522	Industrial Training (2 Weeks)*	0	0	0	-	1	EEC
		TOTAL	**18**	**0**	**8**	**25**	**23**	

CH23511 PROCESS PLANT UTILITIES L T P C
3 0 0 3

OBJECTIVES:

On completion of the course the students are expected,

- To understand the importance of utilities and the requisites of industrial water.
- To select a suitable boiler for the process and to know about the boiler operations.
- To realize the working principles of Refrigeration and liquefaction.
- To understand the operations of compressors and its applications.
- To acquire knowledge on fuels and waste disposal.

UNIT I IMPORTANCE OF UTILITIES 9

Hard and Soft water, 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. Cooling water treatment and boiler feed water treatment, Effects of impure Boiler Feed Water.

UNIT II STEAM AND STEAM GENERATION 9

Properties of Steam, problems based on Steam, Types of Steam Generator such as Solid Fuel Fired Boiler, Waste Gas Fired Boiler and Fluidized Bed Boiler. Scaling and Trouble Shooting. Steam Traps and Accessories.

UNIT III REFRIGERATION SYSTEMS 9

Refrigeration Cycles, Methods of Refrigeration used in Industry and Different Types of Refrigerants such as Monochlorodifluro Methane, Chlorofluro Carbons and Brins. Refrigerating Effects and Liquefaction Processes.

UNIT IV AIR COMPRESSION AND HUMIDIFICATION 9

Classification of Compressor, Centrifugal compressor and screw compressor, Reciprocating Compressor, Single Stage and Two Stage Compressor, Velocity Diagram for Centrifugal Compressor, Silp Factor, Impeller Blade Shape. Properties of Air –Water Vapors and use of Humidity Chart. Equipment's 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. Internal Combustion Engine, Petrol and Diesel Engine. Waste Disposal.

TOTAL : 45 PERIODS

OUTCOMES:

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

- To understand the importance of health, safety and the environment in process industries.
- To identify a suitable boiler for the process and boiler operations.
- To acquire knowledge on the working principles of Refrigeration and liquefaction.
- To know about the operations of compressors and its applications.
- To understand the principles involved in handling of fuels and waste disposal.

TEXTBOOKS:

1. Eckenfelder, W. W, Jr. "Industrial Water Pollution Control" McGraw-Hill: New York, 1999. 3rd Edition.

2. P. L. Ballaney, "Thermal Engineering", Khanna Publisher New Delhi, 1986. 25th Edition.

3. Perry R. H. Green D. W. "Perry's chemical Engineer's Handbook", McGraw Hill, New York, 2008. 8th Edition.

REFERENCES:

1. P. N. Ananthanarayan, "Basic Refrigeration & Air conditioning", TataMcGraw Hill, New Delhi, 2007.
2. Sathiyamoorthy Manickam, "Chemical Plant Utilities", Lambert Academic Publishing, ISBN: 978-3-659-97828-9, 2016.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	1	1	1	1	1	1	3	3	2	2
CO 2	2	3	3	3	3	2	2	1	1	1	1	2	1	1	1
CO 3	2	3	3	1	2	1	1	1	1	1	1	1	3	2	1
CO 4	2	3	3	2	3	2	1	1	2	1	1	2	3	2	3
CO 5	2	2	3	2	3	2	2	1	2	1	2	1	3	2	2

CH23512 CHEMICAL ENGINEERING THERMODYNAMICS **L T P C**

3 0 0 3

OBJECTIVES

- To understand the theory and applications of thermodynamic properties of solutions
- To understand the methods used to describe and predict phase equilibria
- To understand the various activity coefficient correlations for non-ideal solutions
- To understand and estimate the reaction rate constant at various conditions
- To understand the ideal and vapor compression cycles and liquefaction process

UNIT 1 PROPERTIES OF SOLUTIONS 09

Partial molar properties, ideal and non-ideal solutions, standard states definition and choice, Gibbs-Duhem equation, excess properties of mixtures.

UNIT II PHASE EQUILIBRIA 09

Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity, application of phase rule, vapor-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.

UNIT III CORRELATION AND PREDICTION OF PHASE EQUILIBRIA 09

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.

UNIT IV CHEMICAL REACTION EQUILIBRIA 09

Definition of standard state, standard free energy change and reaction equilibrium constant, evaluation of reaction equilibrium constant, prediction of free energy data, equilibria in chemical reactors, calculation of equilibrium compositions for homogeneous chemical reactors, thermodynamic analysis of simultaneous reactions.

UNIT V REFRIGERATION 09

Principles of refrigeration, methods of producing refrigeration, liquefaction process, co-efficient of performance, evaluation of the performance of vapor compression and gas refrigeration cycles.

45 PERIODS

TEXT BOOKS:

- Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics ", McGraw Hill Publishers, VII Edition, 2012.
- Rao, Y.V.C., "Chemical Engineering Thermodynamics" Universities Press, 2005
- Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics, 2nd edition, Prentice Hall India, 2013.

REFERENCES:

- Kyle, B.G., "Chemical and Process Thermodynamics III Edition", Prentice Hall of India Pvt. Ltd., 2015.
- Pradeep Ahuja," Chemical Engineering Thermodynamics", PHI Learning Ltd, (2009).
- Gopinath Halder," Introduction to Chemical Engineering Thermodynamics", PHI Learning Ltd (2009).

OUTCOMES

On the completion of course, student

- Will be able to calculate thermodynamic properties of solutions and mixtures
- Will be able to apply solution thermodynamics fundamentals to solve VLE, LLE, SLE, and GLE problems including bubble point, dew point and flash calculations.

- Will be able to correlate and predict phase equilibria in Chemical engineering systems
- Will be able to understand and apply the fundamental principles of chemical reaction equilibria including extent of reaction, equilibrium constant and its temperature-dependence, equilibrium conversion.
- Will be able to analyze the ideal and actual vapor-compression refrigeration cycle and evaluate the performance of Liquefaction processes

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	1	-	2	-	1	2	-	1	2	2	2
CO 2	3	3	2	2	1	-	2	-	1	2	-	1	1	1	2
CO 3	3	3	2	2	1	-	2	-	1	2	-	1	1	2	3
CO 4	3	3	2	2	1	-	2	-	1	2	-	1	2	2	3
CO 5	3	3	2	2	1	-	2	-	1	2	-	1	2	2	3

CH23513 MASS TRANSFER I L T P C

3 0 0 3

OBJECTIVES:

- To impart the knowledge on diffusion under various conditions.
- Ability to determine mass transfer rates under laminar and turbulent conditions.
- Ability to apply mass transfer theories in various mass transfer operations such as humidification.
- Ability to understand the concept involved in drying and its applications.
- Ability to understand the concepts in crystallization and design a crystallizer.

UNIT I DIFFUSION 9

Introduction to mass transfer operations; Molecular diffusion in gases, liquids and solids; diffusivity measurement and prediction; multi-component diffusion.

UNIT II MASS TRANSFER CO-EFFICIENTS 10

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 contactors.

UNIT III HUMIDIFICATION 9

Humidification – Equilibrium, humidity chart, adiabatic and wet bulb temperatures; humidification operations; theory and design of cooling towers, dehumidifiers and humidifiers using enthalpy transfer unit concept.

UNIT IV DRYING 9

Drying– Equilibrium; classification of dryers; batch drying – Mechanism and time of cross through circulation drying, continuous dryers – material and energy balance; Determination of length of rotary dryer using rate concept.

UNIT V CRYSTALLIZATION 8

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:

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

- Understand the concepts of diffusional mass transfer.
- Use the correlations in calculating the mass transfer coefficients.
- Apply the mass transfer concepts in the design of humidification columns.
- Understand the mechanism of crystallization and absorption.
- Design driers and crystallizers.

TEXTBOOKS:

1. Treybal R.E., "Mass transfer operation", 3rd edition., McGraw Hill New York, 1980.
2. Dutta, Binay K. "Principles Of Mass Transfer And Seperation Processes". India: PHI Learning, 2007.
3. Narayanan, K. V. "Mass Transfer: Theory and Applications". India: CBS Publishers & Distributors, 2017.

REFERENCES:

1. King, C. J., "Separation Processes ", 2nd Edition, Tata McGraw-Hill 1980.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II, Butterworth Heinemann , 6th Edition, October 1993.
3. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice Hall m Inc., New Jersey, 2003.
4. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.

CO PO/PSO's MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	1	2	2	-	-	1	1	2	3	2	2
CO 2	3	3	2	2	1	2	3	-	-	1	1	2	3	2	2
CO 3	3	2	2	2	1	2	3	-	-	1	2	2	3	3	2
CO 4	3	2	2	2	1	2	3	-	-	1	2	2	3	3	2
CO 5	3	2	2	2	1	2	3	-	-	1	2	2	3	3	2

CH23514 CHEMICAL REACTION ENGINEERING – I **L T P C**
3 0 0 3

OBJECTIVES:

On completion of the course the students are expected,

- To enable the students to gain knowledge on the fundamentals of chemical kinetics
- To design the chemical reactors
- To acquire knowledge on multiple reactor systems
- To design the chemical reactors for multiple reactions
- To learn the basics of non-isothermal homogeneous reactor systems

UNIT I INTRODUCTION TO REACTION ENGINEERING 9

Rate equation, Rate constant, elementary and non-elementary reactions, Temperature dependent rate theories, constant and variable volume reactions, Integral and differential analysis.

UNIT II DESIGN OF IDEAL REACTORS 9

Operation and Design of Batch reactor, Semi-batch reactor, continuous reactors – Mixed flow reactor and plug flow reactor, recycle reactors, combination of reactors, size comparison of reactors.

UNIT III MULTIPLE REACTOR SYSTEMS 9

Mixed flow reactors in Series and parallel connection , plug flow reactors in series and parallel connection, reactors of different types in series, Size comparison of Reactors

UNIT IV DESIGN OF REACTORS FOR MULTIPLE REACTIONS 9

Series reactions, Parallel reactions and Series-Parallel reactions, - factors affecting optimum yield and conversion, selectivity and fraction of impurities

UNIT V NON-ISOTHERMAL REACTORS 9

Equilibrium Conversion, Temperature effects on chemical Reaction Rates, optimum temperature progression, Size of the Reactor, Design procedure for adiabatic and non-adiabatic operation of reactors.

TOTAL : 45 PERIODS

OUTCOMES:

On completion of this course, the students

- To apply the basic concepts of reaction kinetics
- To design performance equations of ideal reactors

- To analyze design aspects for multiple reactors
- To evaluate product distribution of multiple reactions
- To demonstrate the effect of temperature and pressure on conversion

TEXT BOOKS:

1. Levenspiel O, "Chemical Reaction Engineering", Wiley Eastern Ltd., II Edition, 2000.
2. Fogler.H.S., "Elements of Chemical Reaction Engineering", Prentice Hall of India Ltd., III Edition, 2000
3. Smith, J.M, "Chemical Engineering Kinetics", McGraw Hill, III Edition, 1981.

REFERENCE:

1. Froment. G.F. & K.B.Bischoff, "Chemical Reactor Analysis and Design", John Wiley and Sons, Singapore, II Edition,1990.

CO PO/PSO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	3	2	2	2	1	1	3	1	-	1	1	2	3	2	2
CO 3	3	3	2	2	1	1	3	1	-	1	1	2	2	3	2
CO 4	3	2	2	2	1	1	3	1	-	1	1	2	3	3	2
CO 5	3	3	2	2	1	1	3	1	1	1	1	2	3	3	2

GE23521 SOFT SKILLS II L T P C
0 0 2 1

OBJECTIVES

The major course objectives are:

- To help students break out of shyness.
- To build confidence
- To enhance English communication skills.
- To encourage students' creative thinking to help them frame their own opinions,

Learning and Teaching Strategy:

The program is completely student centric where the focus is on activities led by students which include role plays, discussions, debates other games as well. These activities would be supplemented by interactive use of technology and brief trainer input.

Week	Activity Name	Description	Objective
1	The News hour	Students are made to read news articles from the English newspapers. The students also have to find words and their meaning from the article they have not come across before and share it with the group. They then use these words in sentences of their own	The aim of this activity is not only to get the students to read the newspaper but also aims at enhancing the students' vocabulary.
2	Court Case	The facilitator provides the participants the premise of a story and proceeds to convert the story into a court case. The students are required, department-wise to debate and provide their points to win the case for their clients.	The aim of the lesson is to encourage creative and out-of-the -box thinking to ensure a good debate and defense skills.
3	The ultimate weekend	The students design activities they are going to do over the weekend and they have to invite their classmates to join in the activity. The students move around the class and talk to other students and invite them.	The aim of this activity is to develop the art of conversation among students. It also aims at practicing the grammatical structures of "going to" "have to" and asking questions.
4	The Four Corners	This is a debate game that uses four corners of the classroom to get students moving. The following is written on the 4 corners of the room "Strongly Agree, Somewhat Agree, Somewhat Disagree and Strongly Disagree". The topics are then given to the class and students move to the corner that they feel best explains their opinions	This activity aims at getting students to come up with their own opinions and stand by it instead of being overshadowed by others and forcing themselves to change based on others opinions.
5	Debate	Boarding school or day school? Which is more beneficial for a student?	The aim of this activity is to encourage students to draw up feasible points on the advantages and benefits of both. And enhance their debating ability
6	Grand Master	The facilitator starts the session by keeping an individual in mind, upon which the students guess it only through "Yes or No" questions. Post few trials the students are given same opportunity to do the same with the crowd.	The aim of the lesson is designed to teach the art of questioning. It also helps to enhance the students' speaking and listening skills.
7	Debate	Does violence on the TV and Video games influence children negatively?	This activity aims at encouraging the students to

			debate on real life scenarios that most students spend a lot of time on.
8	Turn Tables	This is a speaking activity where the students need to speak for and against the given topics when the facilitator shouts out 'Turn Table'.	The aim of this activity is to make the participants become spontaneous and have good presence of mind.
9	Debate	Do marks define the capabilities of a student?	This debate activity aims at allowing the students to argue on this worrisome adage of marks.
10	FictionAD	The Participants are asked to create an Ad for a challenging topic only using fictional characters.	The activity aims at developing their creativity and presentation skills.
11	Debate	Are social networking sites effective, or are they just a sophisticated means for stalking people?	This activity aims at refining the students debating skills on a very real life situation
12	Talent Hunt	Talent Hunt is a fun activity where the students are selected at random and supported to present any of their own skills.	The aim of this activity is designed to evoke their inner talents and break the shyness and the fear of participating in front of a crowd
	Feedback	At the end of the session in the final week (12) the trainer would provide feedback to the students on best practices for future benefits.	The aim is to do both give feedback to students as well as obtain feedback on the course from them.

COURSE LEARNING OUTCOMES:

On successful completion of the course, students should be able to:

- Be more confident
- Speak in front of a large audience without hesitation
- Think creatively
- Speak impromptu
- Communicate in English

CH23521 HEAT TRANSFER LAB L T P C
0 0 4 2

OBJECTIVES:

On completion of the course the students are expected,

- To learn the fundamentals of heat transfer by carrying out experiments on heat transfer equipment's.
- To practically demonstrate the heat transfer principles on the various heat transfer equipment's.
- To learn on the concepts of conduction, Thermal conductivity, convection and radiation etc.
- To understand the working principle of a Heat exchanger and carry out heat transfer studies in a double pipe heat exchanger.
- To acquire knowledge on the heat transfer through packed bed, Condenser and agitated vessels.

LIST OF EXPERIMENTS

- Heat transfer in Natural Convection
- Heat transfer in Forced Convection
- Heat Transfer through Packed Bed
- Heat Transfer in a Double Pipe Heat Exchanger
- Heat Transfer in a Bare and Finned Tube Heat Exchanger
- Heat Transfer in a Condenser
- Heat Transfer in Helical Coils
- Heat Transfer in Agitated Vessels
- Radiation heat transfer studies using Stefan Boltzmann Law
- Thermal Conductivity measurement

LIST OF EQUIPMENTS

- Natural Convection setup
- Forced Convection setup
- Packed Bed
- Double Pipe Heat Exchanger
- Bare and Finned Tube Heat Exchanger
- Condenser setup with mini boiler
- Helical Coil
- Agitated Vessel setup with mini boiler

- Radiation experiment setup
- Thermal Conductivity measurement Setup

OUTCOMES:

- The students will be able to understand the basics of Heat transfer and its importance in Chemical Process Industries
- The students will be able to apply the concepts in carrying out heat transfer experiments in the laboratory
- The students will be able learn about conduction, thermal conductivity, convection, and radiation.
- The students will be able to carry out heat transfer studies in a various types of heat exchanger
- To successfully incorporate all the fundamentals learnt in understand the heat transfer in a packed bed, Condenser, and agitated vessels.

REFERENCES:

1. Heat and Mass Transfer Data Book. by C.P. Kothandaraman, January 2022,10th Edition.
2. Chemical Engineers' Handbook, by Robert H. Perry / Cecil H. Chilton McGraw – Hill Book Company, 6th Edition.
3. Frank Kreith, Mark Bohn, Principles of Heat Transfer, Brroks/Col Publications, 2001.
4. Donald Q. Kern, Kern's Process Heat Transfer, Wiley-Scrivener , 2nd Edition, 2019.

CO PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	2	2	1	1	-	1	-	-	3	3	2	2
CO 2	2	3	3	3	3	2	2	-	-	-	1	2	3	2	2
CO 3	2	3	3	1	2	1	1	-	1	-	-	1	2	3	2
CO 4	2	3	3	2	3	2	1	-	2	-	1	2	3	2	1
CO 5	2	2	3	2	3	2	2	-	2	-	2	1	3	3	2

Subject Code	Subject Name	Category	L	T	P	C
EC23527	MICROFLUIDICS LABORATORY	PE	0	0	2	1

Objectives:

- To introduce and strengthen the concept of microfluidic technology
- To gain clear understanding of various fabrication techniques in microfluidics
- To familiarize the ways to analyse various applications of microfluidics
- To impart knowledge on the CAD design of microfluidic devices
- To empower the students to design and fabricate novel microfluidic devices

Experiments

- Microfluidic Technology - Introduction, definitions and applications
- Materials for microfluidic device fabrication
- Fabrication Techniques for Microfluidics - Soft Lithography Technique in detail
- CAD design of microchannels – Y -structure and T-structure – 2D and 3D models
- Simulation of micro-mixers
- Demonstration of Prime mould fabrication
- Demonstration of Replica fabrication by casting
- Demonstration of sealing of microchannels with a cover glass with plasma bonding technique
- Demonstration of leak testing of microfluidic channels
- Applications of microfluidics – recent reports

Total contact hours : 30

Course Outcomes:

On completion of the course, students will be able to

- understand the fundamentals of microfluidic technology.
- familiar with various fabrication techniques for microfluidics.
- design microfluidic devices using CAD software.
- simulate the micro-mixers with FEA
- fabricate a microfluidic device using soft-lithography technique

References:

1. Albert Folch, "Introduction to BioMEMS", CRC press, Taylor and Francis group, 2013.
2. Yujun Song, Daojian Cheng, Liang Zhao, "Microfluidics: Fundamentals, Devices, and Applications", Wiley VCH publications, 2018.
3. Patrick Tabeling, Suelin Chen," Introduction to Microfluidics", Oxford University press,first edition 2005, reprint 2011.
4. Suman Chakraborty, Microfluidics and Microfabrication, Springer, 2014, ISBN-10:9781489984609

CO PO MAPPING

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	-	3	-	-	-	-	3	-	3	3
CO 2	3	3	3	3	3	-	3	-	-	-	-	3	-	3	3
CO 3	3	3	3	3	3	-	3	-	3	-	3	3	-	3	3
CO 4	3	3	3	3	3	3	3	-	3	-	3	3	-	3	3
CO 5	3	3	3	3	3	3	3	3	3	3	3	3	-	3	3

SEMESTER – VI

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23611	Mass Transfer II	3	0	0	3	3	PC
2	CH23612	Chemical Catalysis and Reaction Engineering	3	0	0	3	3	PC
3	CH23613	Process Control and Instrumentation	3	0	0	3	3	PC
	CH23614	Process Equipment Design	3	0	0	3	3	PC
4		Professional Elective II	3	0	0	3	3	PE
PRACTICALS								
5	GE23621	Problem Solving Techniques	0	0	2	1	1	EEC
6	CH23621	Mass Transfer Lab	0	0	4	4	2	PC
7	GE23627	Design thinking and Innovation	0	0	4	4	2	EEC
		TOTAL	**15**	**0**	**10**	**24**	**20**	

CH23611 MASS TRANSFER II L T P C
3 0 0 3

OBJECTIVES:

- To understand the concepts of absorption and its application in process industries
- To analyze the different parameters in the design of a distillation column.
- To understand the concepts involved in liquid -liquid extraction.
- To study the concepts solid-liquid extraction.
- To learn the concepts involved in adsorption and other separation processes.

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; packed tower absorber – rate-based approach; 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 multi-component distillation, azeotropic and extractive distillation.

UNIT III LIQUID-LIQUID EXTRACTION 9

Liquid - liquid equilibria - solvent characteristics-equilibrium stage wise contact calculations for batch and continuous extractors- differential contact equipment spray, packed and mechanically agitated contactors - Pulsed extractors, centrifugal extractors-Supercritical extraction.

UNIT IV LEACHING 9

Solid-liquid equilibria- leaching equipment for batch and continuous operations. Calculation of number of stages - Leaching - Leaching by percolation through stationary solid beds, moving bed leaching, counter current multiple contact (shank's system), equipment for leaching operation, multi stage continuous cross current and counter current leaching, stage calculations, stage efficiency.

UNIT V ADSORPTION AND ION EXCHANGE & MEMBRANE 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, Regeneration of adsorbents. Principle of Ion exchange, techniques, and applications. Solid and liquid membranes; concept of osmosis; reverse osmosis; electro-dialysis; ultra-filtration.

45 PERIODS

OUTCOMES:

On completion of this course, the students will be able

• To design an absorber based on mass transfer principles.
• To perform design calculations of distillation column.
• To understand the principles of separation by Liquid-Liquid extraction.
• To gain knowledge on design of leaching equipment.
• To understand the principles of other separation processes.

TEXT BOOKS:

1. Treybal R.E., "Mass transfer operation", 3rd edition., McGraw Hill New York, 1980.
2. Dutta, Binay K. "Principles Of Mass Transfer And Seperation Processes". India: PHI Learning, 2007.
3. Narayanan, K. V. "Mass Transfer: Theory and Applications". India: CBS Publishers & Distributors, 2017.

REFERENCES:

1. King, C. J., "Separation Processes ", 2nd Edition, Tata McGraw-Hill 1980.
2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering" Vol. I and II, Butterworth Heinemann , 6th Edition, October 1993.
3. Geankoplis, C.J., "Transport Processes and Unit Operations", 4th Edition, Prentice Hall m Inc., New Jersey, 2003.
4. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", 7th Edn., McGraw-Hill, 2005.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	3	2	1	2	2	-	-	1	2	2	3	3	2
CO 2	3	3	3	2	1	3	3	-	-	1	2	2	3	3	2
CO 3	3	3	2	2	1	2	2	-	-	1	1	2	3	2	2
CO 4	2	2	2	2	1	2	2	-	-	1	1	2	3	2	1
CO 5	3	2	2	2	1	2	2	-	-	1	1	2	3	2	1

CH23612 CHEMICAL REACTION ENGINEERING - II

L T P C
3 0 0 3

OBJECTIVES:

On completion of the course the students are expected,

- To acquire knowledge on non-ideal behavior of reactors.
- To gain knowledge on the synthesis of catalysts and their properties.
- To acquire knowledge on Fluid solid catalytic reactions.
- To learn the industrial significance of industrial reactors.
- To acquire knowledge on gas-solid non catalytic reactors.

UNIT I NON-IDEAL FLOW SYSTEMS 12

Non-ideal flow in Reactors, RTD of fluid in reactors, Age Distribution, F Curve, C Curve and E Curve, Parameter Models, Dispersion Model, Tanks-in -series Model, Conversion in Non-ideal reactors

UNIT II INTRODUCTION TO CATALYSIS 9

Nature of catalysts, Shape of catalyst and Sintering, surface area and pore-volume distribution, catalyst preparation, Promoters, Inhibitors, poisons, Isotherms

UNIT III FLUID-SOLID CATALYTIC REACTIONS 9

Diffusion within catalyst particle, pore diffusion resistance combined with surface kinetics, effective thermal conductivity, mass and heat transfer within catalyst pellets, effectiveness factor, Thiele Modulus, fixed bed reactors.

UNIT IV INDUSTRIAL CATALYTIC REACTORS 9

Packed Bed Reactor, Fixed bed, Fluidized Bed, Trickle bed, slurry Reactor, Bioreactor, Industrial Significance, Troubleshooting

UNIT IV GAS-SOLID NON-CATALYTIC REACTORS 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.

TOTAL : 45 PERIODS

OUTCOMES:

On completion of this course, the students

- To analyze the behviour of real reactors.
- To analyze the catalyst reaction mechanism and apply the concepts learnt in synthesis of any novel catalysts.
- To acquire sound knowledge on heat and mass transfer studies within a catalyst pellet.
- To apply the concepts learnt in operating the industrial reactors in practice.
- To recall the concepts learnt in mass transfer and connect it with reaction kinetics.

TEXT BOOKS:

1. Levenspiel, O., “Chemical Reaction Engineering “, III Edition, John Wiley,2000.
2. Fogler. H. S. “Elements of Chemical Reaction Engineering “, III Edition., Prentice Hall of India, 2000.

REFERENCES:

1. Smith J.M., “Chemical Engineering Kinetics “, III Edition, McGraw-Hill, NewYork, 1981.
2. Froment G.F & K.B. Bischoff, “Chemical Reaction Analysis and Design”,John Wiley and Sons, 1990.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 3	3	3	2	2	2	1	3	1	1	1	1	1	3	3	2
CO 4	2	2	2	2	2	1	3	-	1	1	1	2	3	3	2
CO 5	3	3	2	2	2	1	3	-	1	1	1	2	3	3	2

CH23613 PROCESS CONTROL & INSTRUMENTATION L T P C
3 0 0 3

OBJECTIVES:

The course is aimed to

- Understand the basic concepts of measuring instruments used in process industries
- To study dynamics of processes
- Explain the importance of process control mechanism and their applications in chemical process industries
- Describe principles of modes of controllers and their general characteristics, design and study the stability analysis of digital control system
- Study advanced process control and PID enhancement

UNIT I PROCESS INSTRUMENTATIONS 9

Process Instrumentation - Principles and classification of process control instruments - Temperature - Pressure - Fluid Flow Rate - Liquid Level - pH - Viscosity - Humidity of gases and Concentration by Spectroscopy and Chromatography methods, Differential equations, Discretization- Finite Difference method- Forward; Backward and Central difference schemes- Finite volume Finite element techniques

UNIT II DYNAMIC SYSTEMS 9

Introduction to Process Control - Need for process control – Hierarchical decomposition of control functions – Servo and regulatory operations – Continuous and Batch processes – Mathematical Modeling of Processes: Level, Flow and Thermal processes – Lumped and Distributed parameter models – Degrees of Freedom - First order and Higher order system dynamics – Interacting and non-interacting systems – Self regulation – Linearization of non-linear systems

UNIT III CONVENTIONAL CONTROLS 9

Feedback Control- Closed loop system – Controllers & Control Actions - Transfer function of controllers and control valve - Characteristics of ON-OFF, Proportional, Integral and Derivative control modes - P - PI - PD - PID control modes, Practical forms of PID Controller –PID Implementation Issues: Bumpless Auto/manual Mode transfer, Anti-reset windup Techniques and Direct/reverse action - Principles of Pneumatic and Electronic Controllers - I/P converter - Control valve - Construction - Sizing - Characteristics.

UNIT IV STABILITY ANALYSIS 9

Time & Frequency domain Analysis - Stability criteria- Routh's stability criteria - Root locus diagram - Frequency response analysis - Gain margin - Phase margin and cross over frequency - Bode plot - Polar plot and Nyquist plot. Controller Tuning- Process reaction curve - Cohen-Coon method - IMC tuning, Continuous cycling method and Damped oscillation method, Auto tuning, Ziegler Nichols method

UNIT V ADVANCED PROCESS CONTROL & ENHANCEMENT 9

Advanced Process Control - Introduction to multivariable control - Computer applications in process control - Advanced control strategies – Smith predictor, Cascade control - Ratio control - Feed-Forward control - Inferential control - Adaptive control- multiloop control- Control of Reactor - Distillation towers - Heat Exchangers **TOTAL 45 PERIODS**

TEXT BOOKS:

1. Process Control: Modeling, Design and Simulation, 2nd Edition, B. Wayne Bequette, 2023, Pearson
2. Chemical Process Control, James B Riggs, 2nd Edition, Ferret Publications, 2002
3. An Introduction to Process Modelling Identification and Control for Engineers, Rames Chandra Panda, T. Thyagarajan, Narosa Publishing House, Alpha Science, 2017

REFERENCE BOOKS:

1. Process Dynamics and Control, Dale E Seborg, TF Edgar, DA Mellichamp, 4th Edition, Wiley, 2021
2. Instrument and automation Engineer's handbook: Process measurement and analysis, 5th Eds, Bela G Liptak, CRC Press, 2016
3. Essentials of Process Control, W Luyben, Mcgraw-Hill, 2002

OUTCOMES:

Upon completion of the course, the student will have the

- Ability to suggest measuring instruments and to develop models using first principles approach for processes such as level, flow, temperature, and pressure as well as analyze models.
- Ability to solve dynamic equations to obtain process dynamics and analyse stability for a given application.
- Ability to design & implement a suitable control scheme for a given process and validate through simulations.
- Ability to analyze various control schemes and recommend the right control strategy for a given application.
- Ability to use appropriate software tools (MATLAB) for analysis, design and implementation of Process Control System.

MAPPING OF Cos with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	2	1	2	1	-	2	2	3	2
CO2	3	3	3	3	2	1	2	1	2	1	-	2	2	3	2
CO3	3	2	3	1	3	1	1	1	2	1	-	2	2	3	2
CO4	3	2	3	1	3	1	1	1	2	1	-	2	2	3	2
CO5	3	3	3	3	2	1	1	1	2	1	-	3	2	3	2

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

CH23614 PROCESS EQUIPMENT DESIGN L T P C
3 0 0 3

COURSE OBJECTIVES:
On completion of the course the students are expected,

- To apply the key concepts learnt in plant equipment design.
- To design equipment used in process plants.
- To make decisions on operating conditions and costs involved.
- To be aware of safety measures while operating any equipment.
- To know the practical use of equipment's in process industries.

UNIT I INTRODUCTION 9

Fundamental principles, equations, general design and drawing considerations of primary equipment's evaporators, driers, Pressure Vessel and Storage Vessel.

UNIT II DESIGN OF HEAT TRANSFER EQUIPMENTS 9

Fundamental principles, equations, general design and drawing considerations of Heat exchangers, condensers and reboilers.

UNIT III DESIGN OF MASS TRANSFER EQUIPMENTS 9

Fundamental principles, equations, general design and drawing considerations of Absorption column, Distillation Column, Extraction Column, Adsorption column

UNIT IV DESIGN OF HETEROGENEOUS REACTORS 9

Fundamental principles, equations, general design and drawing considerations of Packed and fluidized bed Reactors.

UNIT V PIPING AND LAYOUT 9

Design of Plant Layout, Pipe Lines and Pipe Layouts, Schematics and Presentation
Materials of Construction and Selection of process equipment's

45 PERIODS

OUTCOMES:
Upon completion of the course, the student will have the

- Ability to design evaporators, drier, Pressure Vessel and Storage Vessel
- Ability to design double pipe and shell and tube heat exchangers according to standards such as BIS, TEMA.
- Process and Equipment Design of separation equipment's such as absorbers, distillation

column, extractors.

- Calculate the design specifications of packed bed reactor and fluidized bed Reactors.
- Determine sizes, materials, and capital and operating costs of equipment commonly used in the chemical processing industries.

TEXT BOOKS:

1. M.V.Joshi and V.V. Mahajan, "Process Equipment Design", MacMillan India Ltd. 2009, 4th Edition
2. S.D.Dawande, "Process Design of Equipment's", Central Techno Publications, Nagpur, 2000.
3. J.D. Seader, Ernest.J. Henley, "Separation Process Principles", Wiley India Pvt Ltd Publications, 2006, 2nd Edition.

REFERENCES:

1. Indian Standard Specifications IS-803, 1962; IS-4072, 1967; IS-2825, 1969.Indian Standards Institution, New Delhi.
2. R.H. Perry, "Chemical Engineers' Handbook", McGraw-Hill. 2008, 8th Edition
3. W.L.McCabe, J.C.Smith and Harriet, "Unit Operation of Chemical Engineering", McGraw-Hill. 2017, 7th Edition.
4. Robert Treybal, "Mass Transfer Operations", McGraw-Hill. 2017, 3rd Edition.
5. J.M. Coulson and J.Richardson, "Chemical Engineering", Vol. 6, Asian Books Printers Ltd. 1997, 2nd Edition.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	2	3	3	-	-	-	2	2	3	3	-
CO 2	3	3	3	2	2	3	3	-	2	2	2	2	3	3	2
CO 3	3	3	3	2	2	-	-	-	-	-	2	2	3	3	-
CO 4	3	3	3	2	2	-	-	-	-	-	2	2	3	3	-
CO 5	3	3	3	2	2	3	3	-	2	2	2	2	3	3	2

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

GE23621 PROBLEM SOLVING TECHNIQUES L T P C
0 0 2 1

COURSE OBJECTIVES:

- To improve the numerical ability.
- To improve problem-solving skills.

COURSE TOPICS:

S.No.	Topics
1	Numbers system
2	Reading comprehension
3	Data arrangements and Blood relations
4	Time and Work
5	Sentence correction
6	Coding & Decoding, Series, Analogy, Odd man out and Visual reasoning
7	Percentages, Simple interest and Compound interest
8	Sentence completion and Para-jumbles
9	Profit and Loss, Partnerships and Averages
10	Permutation, Combination and Probability
11	Data interpretation and Data sufficiency
12	Logarithms, Progressions, Geometry and Quadratic equations.
13	Time, Speed and Distance

COURSE OUTCOMES:

On successful completion of the course, students should be able to:

- Have mental alertness
- Have numerical ability
- Solve quantitative aptitude problems with more confident

CH23621 MASS TRANSFER LAB L T P C
0 0 4 2

OBJECTIVES:

- To train the students to develop knowledge on different types of mass transfer equipment.
- To perform the rate studies of different types of dryers
- To train on understanding the parameters in different types of columns like absorption, distillation and packed bed distillation.
- To emphasis on the concept on stage wise performance on extraction and leaching
- To carry out the adsorption studies

LIST OF EXPERIMENTS

1. Separation of binary mixture using Simple Distillation
2. Separation of binary mixture using Steam Distillation
3. Separation of binary mixture using Packed Column Distillation
4. Liquid-Liquid Extraction
5. Drying characteristics of Vacuum Dryer
6. Drying characteristics of Tray Dryer
7. Drying characteristics of Rotary Dryer
8. Water purification using Ion Exchange Columns
9. Estimation of mass/heat transfer coefficient for cooling tower
10. Demonstration of Gas – Liquid Absorption
11. Vapor liquid Equilibrium
12. Solid Liquid Extraction - Leaching
13. Adsorption
14. Distribution Coefficient
15. Liquid Liquid Equilibrium

LIST OF EQUIPMENTS

- Simple Distillation Setup
- Steam Distillation Setup
- Packed Column Distillation Setup
- Extraction Column Setup
- Vacuum Dryer
- Tray Dryer
- Rotary Dryer
- Ion Exchange Columns
- Cooling tower
- Gas – Liquid Absorption Setup
- Vapor liquid Equilibrium Setup

OUTCOMES:

On successful completion of the course, students should be able to:

- Identify and apply the data for separation process using different distillation method
- Understand and apply the data for the given binary mixture in the liquid extraction process
- Apply and interpret the data for different dryer types

- Apply and infer the parameters for separation process using different process equipment's like ion exchange and cooling tower.
- Illustrate the data for the absorption phenomena.

REFERENCES:

1. Treybal R.E., "Mass transfer operation", 3rd edition., McGraw Hill New York, 1980.
2. Dutta, Binay K. "Principles Of Mass Transfer And Seperation Processes". India: PHI Learning, 2007.
3. Narayanan, K. V. "Mass Transfer: Theory and Applications". India: CBS Publishers & Distributors, 2017.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	1	2	2	3	3	3	2	2	3	2	3
CO 2	3	2	2	2	1	2	2	2	2	2	1	2	3	2	3
CO 3	3	2	1	2	2	1	3	1	2	1	2	2	3	1	2
CO 4	3	2	2	2	3	2	2	1	2	1	1	2	3	1	2
CO 5	3	1	1	2	2	1	2	1	1	1	1	2	3	2	3

Subject Code	Subject Name	Category	L	T	P	C
GE23627	**Design Thinking and Innovation (Type - Project based learning)**	**EEC**	**0**	**0**	**4**	**2**

Objectives:	
•	To understand the design thinking concepts and deep understanding of user needs and experiences.
•	To find the problem statement and to develop innovative design solutions that address identified user challenges
•	To master the process of prototyping and iterating on designs.
•	To conduct thorough market analysis and financial planning
•	To effectively communicate design concepts and findings.

Unit-I: Introduction to Design Thinking: The design thinking concepts - Different design thinking models - Details of Stanford Design thinking process: Empathize, Define, Ideate, Prototype, Test

Activities:

- Case studies of successful domain-based Design Thinking and Innovative projects
- Group discussions on design thinking

Unit 2: Empathize and Define : User research methods (interviews, surveys, observation, contextual inquiry) - Persona development- Journey mapping – Brainstorming Defining the design problem statement

Activities:

- Conducting user interviews and surveys
- Creating user personas and journey maps
- Identifying key user needs and pain points
- Analyze the user needs and Brainstorming to define problem statement

Unit 3: Ideate and Create : Brainstorming techniques (e.g., mind mapping, SCAMPER) - Ideation tools (e.g., design thinking tools, concept sketching) - Concept generation and evaluation (e.g. Brainstorming)

Activities:

- Group brainstorming sessions to select the best idea
- Creating concept sketches and prototypes
- Evaluating ideas based on user needs and feasibility

Unit 4: Prototype and Test : Low, Medium and high level fidelity for prototyping-Usability testing -Iterative design

Activities:

- Building low-fidelity prototypes (e.g., paper prototypes)
- Conducting usability tests with users
- Iterating on designs based on feedback

Unit 5: Market Analysis and Implementation: Market research and analysis - Business model development- Financial Planning-Implementation strategies

Activities:

- Conducting market research
- Developing a business model canvas
- Creating a financial projection
- Developing an implementation plan

Course Outcomes: On completion of the course, the students will be able to	
CO1	Construct design challenge and reframe the design challenge into design opportunity.
CO2	Interview the user, and know the feelings of users to foster deep user understanding and be able to uncover the deep user insights and needs.
CO3	Develop ideas and prototypes by brainstorming.
CO4	Organize the user walkthrough experience to test prototype
CO5	Develop smart strategies and implementation plan that will deliver/achieve the idea/solution deduced from earlier phases.

Assessment:

- Encourage students to work on real-world design challenges based on the user needs
- Group presentations
- Quizzes and exams
- Evaluation of Project report and viva and also encourage the students for filing patent/ copyright / presenting in conference / publishing in journal.

Text Book(s):	
1	Handbook of Design Thinking by Christian Müller-Roterberg, Kindle Direct Publishing, 2018**.**
2	Design Thinking – A Beginner's Perspective, by E Balagurusamy, Bindu Vijakumar, MC Graw Hill, 2024

Reference Books:	
1	Design Thinking for Entrepreneurs and Small Businesses: Putting the Power of Design to Work – by Beverly Rudkin Ingle, Apress; 1st ed. Edition, 2013
2	Design Thinking: Understanding How Designers Think and Work by Nigel Cross, Bloomsbury Visual Arts; 2 edition 2023

Web links	
1	Design thinking Guide https://www.rcsc.gov.bt/wp-content/uploads/2017/07/dt-guide-book-master-copy.pdf
2	NPTEL Course on Design Thinking and Innovation By Ravi Poovaiah ; https://onlinecourses.swayam2.ac.in/aic23_ge17/preview
3	IITB Design course tools and Resources https://www.dsource.in/

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
CO2	3	2	3	3	3	2	2	3	3	3	3	3	2	2	2
CO3	3	2	3	3	3	2	2	3	3	3	3	3	3	1	2
CO4	3	2	3	3	3	2	2	3	3	3	3	3	3	2	2
CO5	3	2	3	3	3	2	2	3	3	3	3	3	3	3	2

1-Slight (Low), 2- Moderate (Medium), 3- Substantial (High) , "-" No correlation

SEMESTER – VII

Sl. No	COURSE CODE	COURSE TITLE	L	T	P	Total Hours	Total Credits	Category
THEORY								
1	CH23711	Transport Phenomena	3	0	0	3	3	PC
2	CH23712	Comprehensive Chemical Engineering	3	0	0	3	3	PC
3	CH23713	Process Engineering Economics	3	0	0	3	3	PC
4		Professional Elective III	3	0	0	3	3	PE
5		Professional Elective IV	3	0	0	3	3	PE
PRACTICALS								
6	CH23721	Chemical Reaction Engineering lab	0	0	4	4	2	PC
7	CH23722	Process Control Lab	0	0	4	4	2	PC
8	CH23723	Artificial Intelligence and Machine Learning Lab for Chemical Engineers	0	0	4	4	2	PC
9	CH23724	CHEMSKILL				3	2	EEC
		TOTAL	**15**	**0**	**12**	**30**	**23**	

CH23711 TRANSPORT PHENOMENA LT P C
3 0 0 3

OBJECTIVES:

CO1: To understand molecular momentum transport and develop velocity distribution in laminar flow.
CO2: To study the molecular energy transport and temperature distribution in solids and laminar flow.
CO3: To study the mechanism of mass transport and concentration distribution in solids and laminar flow.
CO4: To study the equation of change for different coordinate systems in momentum, mass and heat transport.
CO5: To study the analogy between transports and understand the turbulence and boundary layer concepts.

UNIT I MOMENTUM TRANSPORT 9

Viscosity, temperature and pressure effect on viscosity of gases and liquids, Newton's law, mechanism of momentum transport, shell momentum balance method, Shear stress and velocity distributions in falling film, circular tube, annulus, slit.

UNIT II ENERGY TRANSPORT 9

Thermal conductivity, temperature and pressure effect on thermal conductivity of gases and liquids, Fourier's law, mechanism of energy transport, shell energy balance method, Energy flux and temperature distribution in solids and laminar flow with electrical, nuclear, viscous, chemical heat source, heat conduction through composite walls, cylinders, spheres, fins, slits.

UNIT III MASS TRANSPORT 9

Diffusivity, temperature and pressure effect on diffusivity, Fick's law, mechanism of mass transport, shell mass balance method, Mass flux and concentration distribution in solids and in laminar flow: stagnant gas film, heterogeneous and homogeneous chemical reaction systems, falling film, porous catalyst.

UNIT IV EQUATIONS OF CHANGE AND THEIR APPLICATIONS 9

Momentum: Equations of continuity, motion and mechanical energy (Isothermal), Energy: Equation of energy (non-isothermal). Mass: Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component). Solutions of momentum, heat and mass transfer problems discussed under shell balance by applications of equation of change, dimensional analysis of equations of change.

UNIT V TRANSPORT IN TURBULENT FLOWS AND ANALOGIES 9

Comparison of laminar and turbulent flows, time-smoothed equations of change, empirical expressions. Comparison of laminar and turbulent hydrodynamics, thermal and concentration boundary layer and their thicknesses. Development and applications of analogies between momentum, heat and mass transfer.

Total : 45 periods

TEXT BOOKS:

1. Bird, R. B., Stewart, W. E. and Lighfoot, E. W., "Transport Phenomena", Revised 2nd Edn., John Wiley & Sons, New York, An Indian Adaptation 2021. (**ISBN-13** 978-9354244452).
2. William M. Deen, "Analysis of Transport Phenomena" Oxford University, 2nd Edition, 2011.
3. Brodkey, R. S., and Hershey, H. C., "Transport Phenomena", McGraw-Hill, 1988

REFERENCES:

1. Welty, J. R., Wilson, R. W., and Wicks, C. W., "Fundamentals of Momentum Heat and Mass Transfer", 3rd Edition. John Wiley, New York, 1984.
2. Slattery, J. S., "Advanced Transport Phenomena", Cambridge University Press, London, 1999.
3. C. J. Geankopolis, "Transport Processes in Chemical Operations", 3rd Edn. Prentice Hall of India, New Delhi, 1996.

OUTCOMES:

At the end of the course the students will

CO1: Develop shell momentum balance and obtain velocity profiles for flow through different system
CO2: Develop shell energy balance and obtain temperation profiles for flow through different modes.
CO3: Develop shell mass balance and obtain concentration profiles for diffusion through reacting and non reacting systems.
CO4: Apply the equation of change for different coordinate systems in momentum, mass and heat transport and solve problems
CO5: Analyse the analogy between momentum, heat and mass transports.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	1	1	1	-	2	1	2	3	3	3	3
CO 2	3	3	3	3	1	1	1	-	2	1	2	3	3	3	3
CO 3	3	3	3	3	1	1	1	-	2	1	2	3	3	3	3
CO 4	3	3	3	3	1	1	1	-	2	1	2	3	3	3	3
CO 5	3	3	3	3	1	1	1	-	2	1	2	3	3	3	3

CH23712 COMPREHENSION IN CHEMICAL ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To learn the fundamental concepts of thermodynamics and material and energy balance calculations on process systems.
- To impart the knowledge on chemical kinetics, residence time distribution and design of the real reactors.
- To gain the knowledge on closed loop system and various controllers and also apply the principles of heat transfer to real industry scenario.
- To explain the principle of various instruments used to measure fluid properties and also to select the appropriate separation technique or equipment based on nature of the solution or size of the particles.
- To train the students on different separation techniques in mass transfer

UNIT 1 Thermodynamics and Process Calculations 08

Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium. Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis.

UNIT II Chemical Reaction Engineering 09

Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, kinetics of enzyme reactions (Michaelis-Menten and Monod models), non-ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis; rate and performance equations for catalyst deactivation.

UNIT III Instrumentation and Process Control and Heat Transfer 10

Measurement of process variables; sensors and transducers; P&ID equipment symbols; process modeling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; transducer dynamics; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control. Equation of energy, steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process

calculations; design of double pipe, shell and tube heat exchangers, and single and multiple effect evaporators.

UNIT IV Fluid Mechanics and Mechanical Operations 08

Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell-balances including differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis and similitude, flow through pipeline systems, velocity profiles, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop. Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

UNIT V Mass Transfer 10

Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations (micro-filtration, ultra-filtration, nano-filtration and reverse osmosis).

TOTAL: 45 PERIODS

TEXT BOOKS:

1. GATE way to Chemical Engineering by M. Subbu (5 Volumes), Rishi Publications, 2018.
2. Objective Type Questions and Answers in Chemical Engineering by O.P. Gupta, Khanna Publishers, 2016 edition.
3. Objective Type Questions and Answers in Chemical Engineering by Ram Prasad, Khanna Publishers, 2017 edition.

REFERENCES:

- K.V. Narayanan and B. Lakshmi Kutty," Stoichiometry and Process Calculation", II Edition, PHI Learning Ltd. (2016).
- Smith, J.M., Van Ness, H.C and Abbot M.M "Introduction to Chemical Engineering Thermodynamics ", McGraw Hill Publishers, VII Edition, 2012.
- Narayanan, K.V. A Textbook of Chemical Engineering Thermodynamics, II Edition Prentice Hall India, 2013.

- Fogler. H. S. "Elements of Chemical Reaction Engineering ", VI Edition., Pearson Education Limited, 2022.
- Holman, J. P., Souvik Bhattacharyya 'Heat Transfer', McGraw Hill Education; X Edition ,2017.
- McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", VI Edition, McGraw-Hill, 2001.
- Process Dynamics and Control, Dale E Seborg, TF Edgar, DA Mellichamp, IV Edition, Wiley, 2021.
- Noel de Nevers, "Fluid Mechanics for Chemical Engineers ", III Edition, McGraw-Hill, (2017).
- Treybal, R.E., "Mass Transfer Operations", III Edition, McGraw-Hill, 2017.
- Geankoplis, C.J., "Transport Processes and Unit Operations", IV Edition, Prentice Hall m Inc., New Jersey, 2003.

OUTCOMES:

At the end of the course the students

CO1 Will be able to do the degrees of freedom analysis and solve the material and balance problems and analyze the process with respect to first and second law of thermodynamics and understand entropy of the system and able to predict and correlate the Phase and Chemical reaction equilibria.

CO2 Will be able to analyze design of ideal reactors for single and complex reactions and also design of non-isothermal reactors.

CO3 Will be able to select a suitable controller for the process & design and analyze the stability of a system and also ability to understand the basic principles of heat transfer and develop correlations to solve industrial problems.

CO4 Will be able to analyze various fluid flow phenomenon at various conditions and understand theories of flow measurement equipment's, pumps and valves.

CO5 Will be able to understand the principles of different separation techniques in mass transfer

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	2	1	-	2	-	1	2	-	1	2	2	2
CO 2	3	3	2	2	1	-	3	-	-	1	1	2	3	3	3
CO 3	3	3	3	3	2	1	2	-	2	1	1	3	3	3	3
CO 4	3	3	3	1	2	-	2	-	2	1	1	3	3	3	3
CO 5	3	3	2	2	1	-	2	-	-	1	1	2	3	2	2

CH23713 PROCESS ENGINEERING ECONOMICS L T P C

3 0 0 3

OBJECTIVES

- To enable the students to understand the various concepts of economics.
- To understand process development and financial ratios.
- To understand basic design consideration and economic balance in equipment.
- To inculcate the knowledge required to solve cost estimation in chemical industry.
- To understand the work measurement techniques, motion study principles in chemical industry.

UNIT I INTEREST AND PLANT COST 09

Time value of money - equivalence, Depreciation, Depletion, estimation of capital cost, Capital requirement for complete plant, cost indices, capital recovery.

UNIT II PROJECT PROFITABILTY AND FINANCIAL RATIOS 09

Estimation of project profitability, Investment alternatives, income statement and financial ratios, balance sheet preparation- problems.

UNIT III ECONOMIC BALANCE IN EQUIPMENTS 09

Essentials of economic balance, economic balance in batch operations, cyclic operations, economic balance for insulation, evaporation, heat transfer equipment's.

UNIT IV PRINCIPLES OF MANAGEMENT 09

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

UNIT V PRODUCTION PLANNING & CONTROL 09

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

45 PERIODS

OUTCOMES

CO1: Students can understand the various concepts of economics.
CO2: Students can understand process development and financial ratios.
CO3: Students will be able to understand basic design consideration and do economic balance in equipment accordingly.
CO4: Students can inculcate cost estimation in chemical industry
CO5: Students can inculcate the work measurement techniques, motion study principles in chemical industry.

TEXT BOOKS:

1. Peters and Timmerhaus, Plant design and Economics for Chemical Engineers, McGraw Hill 5th Edition, 2017.
2. Ahuja K.K, Industrial management, Khanna publishers, New Delhi, 1998.
3. Schweyer. H.E, "Process Engineering Economics", Mc Graw Hill, 1969

REFERENCE:

- F.C. Jelen and J.H. Black, “Cost and Optimization Engineering”, McGraw Hill, 3rd Edn., 1992

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	2	2	-	2	-	2	3	3	3	3
CO 2	3	3	3	3	3	2	2	-	2	-	2	3	3	3	3
CO 3	3	3	3	3	3	2	2	-	2	-	2	3	3	3	3
CO 4	3	3	3	3	3	2	2	-	2	-	2	3	3	3	3
CO 5	3	3	3	3	3	2	2	-	2	-	2	3	3	3	2

CH23721 CHEMICAL REACTION ENGINEERING LAB LT P C

0 0 4 2

OBJECTIVE:

On completion of the course the students are expected,

- To familiarize with experimental techniques in a batch reactor, plug flow reactor and a mixed flow reactor.
- To enable the importance of special reactors such as Sono-chemical and photochemical reactor.
- To provide knowledge on the measurement of reaction rates experimentally under different conditions.
- To understand the performance characteristics of different reactors.
- To develop the skills to analyze experimental data and to draw meaningful conclusions about reactor behavior.

LIST OF EXPERIMENTS

1. Kinetic studies in a Batch reactor
2. Kinetic studies in a Plug flow reactor (PFR)
3. Kinetic studies in a Continuous Stirred Tank Reactor (CSTR)
4. Kinetic studies in a Packed bed reactor
5. Kinetic studies in a PFR followed by a CSTR
6. RTD studies in a PFR
7. RTD studies in a Packed bed reactor
8. RTD studies in a CSTR
9. Study of temperature dependence of rate constant using CSTR.
10. Kinetic studies in Sono chemical reactor
11. Batch reactive distillation
12. Kinetics of photochemical reaction

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

1. Batch Reactor
2. Plug flow reactor
3. Continuous Stirred Tank Reactor
4. Sono-chemical reactor
5. Photochemical reactor
6. Packed bed reactor

OUTCOMES:

- The students will become proficient in using various industrially important reactors.
- The students can gain knowledge on analyzing and predicting the behavior of batch reactor, plug flow reactor and a mixed flow reactor, Sono-chemical and photochemical reactor.
- The students can develop skills in reactor design considering factors such as residence time distribution, mixing effects, heat and mass transfer.
- The students can demonstrate the awareness of safety protocols and procedures on working with chemicals and glassware's in the laboratory.
- The students will develop critical thinking skills and the ability to develop specific research challenges in reaction engineering.

REFERENCES:

1. Levenspiel O, "Chemical Reaction Engineering", Wiley Eastern Ltd., II Edition, 2000.
2. Fogler.H.S., "Elements of Chemical Reaction Engineering", Prentice Hall of India Ltd., III Edition, 2000
3. Smith, J.M, "Chemical Engineering Kinetics", McGraw Hill, III Edition, 1981.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	3	3	2	3	1	1	3	1	3	3	1	1	3	3	1
CO 3	3	3	3	3	1	1	3	1	3	3	1	1	3	3	1
CO 4	3	3	2	3	1	1	3	1	3	3	1	2	2	3	1
CO 5	3	3	3	3	1	1	3	1	3	3	1	2	3	3	1

CH23722 PROCESS CONTROL LABORATORY

L T P C

0 0 4 2

COURSE OBJECTIVES

To Study the

- Dynamic response of first and second order processes.
- Difference between interacting and non-interacting systems.
- Characteristics of various controller modes.
- Method and significance of stability and controller tuning.
- Relation between valve stem position and the fluid flow through a control valve.

LIST OF EXPERIMENTS

1. Response of the first-order system – step input
2. Response of second order system
3. Response of Non-Interacting Level System
4. Response of Interacting level system
5. Open loop study on a thermal system – sinusoidal input
6. Closed loop study on a Level system
7. Closed loop study on a Flow system
8. Closed loop study on a Thermal system
9. Closed loop study of a Pressure system
10. Tuning of controllers
11. Study on characteristics and flow coefficient of control valves
12. Closed loop response of a cascade control system
13. Optimum Controller Tuning using Ziegler Nichols method

Course Outcomes:

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

CO 1: To determine the response of a first order and second order system for various input.

CO 2: To determine the response of an interacting and non- interacting system for various inputs.

CO 3: To understand the difference between an open loop and closed loop system.

CO 4: To understand the concept of three classical controller P, PI, PID controller.

CO 5: To understand about the different type of control valves.

REFERENCES:

1. Johnson .C.D, "Process Control Instrument Technology", Prentice Hall Inc., 2004.
2. Bequette. B.W, "Process Control Modeling, Design and Simulation", Prentice Hall ofIndia, 2004.

CO mapping to PO/PSOs

CO	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	2	3	3	2	1	1	1	1	1	1	2	3	1
CO 2	3	3	2	3	3	2	1	1	1	1	1	1	2	3	1
CO 3	3	3	2	3	3	2	1	1	1	1	1	1	2	3	1
CO 4	3	3	2	3	3	2	1	1	1	1	1	1	2	3	1
CO 5	2	2	2	3	2	2	1	1	1	1	1	1	2	3	1

CH23723 ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LAB FOR CHEMICAL ENGINEERS

L T P C

0 0 4 2

OBJECTIVES

1.	To introduce students to basic concepts of Machine Learning
2.	To enhance their knowledge on chemical engineering using various simulation tools such as working of the decision tree.
3.	To develop process optimization and build an Artificial Neural Network by implementing the Back propagation algorithm.
4.	To develop conventional and hybrid models to solve chemical engineering problems by applying the naïve Bayesian classification methods.
5.	To learn about new equipment optimization and dynamic simulation tools

List of Programs

Sl. No	Name of Experiment	CO
1	Implement and evaluate AI and ML algorithms in Python programming language Implement A* Search algorithm.	CO1
2	Implement AO* Search algorithm	CO1
3	For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all hypothesis consistent with the training examples.	CO1
4	Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decisiontree and apply this knowledge to classify a new sample.	CO2
5	Build an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets.	CO3
6	Write a program to implement the naïve Bayesian classifier for asample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.	CO4
7	Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare theresults of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.	CO4
8	Write a program to implement k-Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions.Java/Python ML library classes can be used for this problem.	CO5
9	Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set foryour experiment and draw graphs	CO5
10	Implement Gradient Boosting Algorithm to predict the yield of a chemical reaction based on several input parameters, such as temperature, pressure, and concentrations of reactants.	**CO5**

OUTCOMES

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

•	To introduce students to basic concepts of AIML such as A* and AO*, Candidate- Elimination
•	To enhance their knowledge on chemical engineering using various simulation tools such as working of the decision tree.
•	To equip students to develop process optimization and build an Artificial Neural Network by implementing the Back propagation algorithm.
•	To develop conventional and hybrid models to solve chemical engineering problems by Applying the naïve Bayesian classification methods.
•	To learn about new equipment optimization and dynamic simulation tools

REFERENCES:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. S. Russell and P. Norvig, “Artificial Intelligence: A Modern Approach”, Prentice Hall, Third Edition, 2015.

CO mapping to PO/PSOs

CO	POs												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3	3	3	3	3	2	2	3	2	3	3	3	2	3
CO 2	3	3	3	3	3	3	2	2	3	2	3	3	3	2	3
CO 3	3	3	3	3	3	3	2	2	3	2	3	3	3	2	3
CO 4	3	3	3	3	3	3	2	2	3	2	3	3	3	2	3
CO 5	3	3	3	3	3	3	2	2	3	2	3	3	3	2	3

PROFESSIONAL ELECTIVE COURSES

VERTICAL I: PETROLEUM PROCESS TECHNOLOGY

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1	CH23A11	Petroleum Chemistry and Refining Fundamentals	3	0	0	3	3
2	CH23A12	Primary Refining Technology	3	0	0	3	3
3	CH23A13	Secondary Refining Technology	3	0	0	3	3
4	CH23A14	Refinery Advancements and Environmental Regulations	3	0	0	3	3
5	CH23A15	Petroleum Equipment Design	3	0	0	3	3
6	CH23A16	Petrochemical Technology	3	0	0	3	3

CH23A11 PETROLEUM CHEMISTRY AND REFINING FUNDAMENTALS L T P C

3 0 0 3

OBJECTIVES

The course is aimed

- To enable the students to learn the fundamental and methodologies in the petroleumrefining processes.
- To enable students to examine how each refinery process works.
- To enable students to express the objectives of petroleum refining and classify the processes used in petroleum refining.
- To enable students, learn how physical and chemical principles are applied to achieve theobjectives of each refinery process.

UNIT I CRUDE CHEMISTRY AND PRODUCTS 9

Origin, Formation and Evaluation of Crude Oil - Indian petroleum industries - types of Hydrocarbons - composition of crude oil - Thermo-physical and physical properties of crude oil -petroleum standards - chemical analysis data - Testing methods of petroleum products - Chemicalquality of products - Types of crude - Crude assay - selection of crude based on product yield.

UNIT II BASICS FOR REFINING 9

Properties of gas - Ideal gas laws - partial pressure - specific gravity - density -Properties of liquid - viscosity and index - boiling point - pressure of fluid at rest - flow resistance - static/induced pressure - specific/latent heat/condensation - modes of heat transfer - diffusion mass transfer - properties of solid.

UNIT III PETROLEUM THERMODYNAMICS AND CALCULATION 9

First/second law - behavior of gas and liquid - PVT relationship - equation of state - VLE equilibriumconstant - Multi component liquid vapor composition calculation - specific gravity calculation - TBP distillation - ASTM conversion to pseudo – components - Molecular weight calculation – pseudo critical properties - calculation of enthalpy of petroleum fractions - Generalized equation for thermo physicalproperties of petroleum.

UNIT IV REFINERY UNIT OPERATIONSAND CALCULATION 9

Distillation types - column internals - multi component distillation - relative volatility - azeotropic mixture - absorption - desorption - adsorption - refrigeration - extraction - drying curve - humfidicationprinciple - crystallization - stripping operation -.boiling curve - application of all operation in refinery and its basic design calculations.

UNIT V REFINERY PROCESSES AND CATALYST FUNDAMENTAL 9

Treating processes of petroleum products - Thermal/catalytic/hydro cracking -reforming/ isomerization /alkylation - principles and reactions - Catalyst phenomenon and theory - surface area/void volume/porosity - catalyst classification and preparation/selectivity/yield/reactivity - heterogeneous reactions - catalytic reactor types (packed bed/moving bed/fluidized bed) - residence time - space velocity - Catalyst loading techniques.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1: Understand the classification, composition and testing methods of crude petroleum and itsproducts. Learn the mechanism of refining process.

CO2: Understand the insights of primary treatment processes to produce the precursors.

CO3: Study the secondary treatment processes cracking, vis-breaking and coking to producemore petroleum products.

CO4: Appreciate the need of treatment techniques for the removal of sulphur and otherimpurities from petroleum products.

CO5: Understand the societal impact of petrochemicals and learn their manufacturing processesand learn the importance of optimization of process parameters for the high yield of petroleum products.

TEXT BOOKS

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press, 5th Edition, 2007.
2. Jyoti Sharma, Handbook of Petroleum Analysis, Scitus Academics LLC; UK Edition, 2016.
3. R.N. Watkin, Petroleum Refinery Distillation, Gulf Publishing Co, Houstan, Texas, USA, 2nd edition, 1981.

REFERENCES

1. B K Bhaskara Rao, Modern Petroleum Refining Processes, OXFORD & IBH PUBLISHING; 6th edition, 2020.
2. Ram Prasad, Petroleum Refining Technology, Khanna Publishers, New Delhi, 2000.
3. W. L. Nelson, Petroleum Refinery Engineering, Mc Graw-Hill Book Co, 1969.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	1	2	1	-	1	1	1	1	1	1	2	2	1	1
CO 2	2	1	1	1	2	1	1	1	1	1	2	2	2	1	1
CO 3	1	1	2	1	2	1	-	1	1	1	1	1	2	1	1
CO 4	1	2	2	2	1	1	2	2	2	1	2	1	2	2	2
CO 5	1	2	2	1	1	1	1	2	2	-	1	1	2	1	2

CH23A12 PRIMARY REFINING TECHNOLOGY L T P C

3 0 0 3

OBJECTIVES

- To enable the students to learn the methodologies in the primary petroleum refining processes like crude preparation, atmospheric and vacuum distillation, Lube, asphalt andwax processing.
- To enable students to examine how each refinery process works.
- To enable students to learn each operating variables are applied to achieve the objectives of each refinery process.
- To enable students to learn the methodologies of processing and blending.
- To apply the concepts in asphalt processing and wax treatment technology.

UNIT I FEED PREPARATION 9

Pipelines from port to tank farm - safety and regulations - storage techniques in crude oil - impuritiesremoval - measuring by dipping - spiking techniques - types of salts in crude - desalting process - electric desalter - preheating train and design - furnace and its operation.

UNIT II ATMOSPHERIC DISTILLATION 9

Operation and process description of ADU - design characteristics of ADU tower –cut points - degreeof fractionation - over flash column pressure and overhead temperature - overhead system - side streams - intermediate pump around and reflux systems - Refinery off gas - LPG treatment - Naphtha stabilizer and splitter - side stripping sections - operating variables.

UNIT III VACUUM DISTILLATION 9

Operation of VDU - Need of vacuum - ejectors and its types/principle - Overhead ejector system- flash zone - draw off temperature - internal flow in VDU - light/middle/heavy cuts - routing to secondary units - lube based treatments - packing section tower loading of VDU.

UNIT IV LUBE OIL BASE STOCKS(LOBS) 9

Viscosity index calculation and pour point - LOBS processing by solvent treatment and hydro treatment - solvent selection - solvent extraction by NMP (N-methyl 2-pyrrolidone), furfural – MEK (Methyl ethyl ketone) solvent dewaxing- refrigerating and filtration - hydro finishing - types of LOBS based on VI types or groups of lube processing - spindle/LN/IN/HN/BN (Low nitrogen, Inert nitrogen, high nitrogen and Boron Nitride) processing and blending.

UNIT V ASPHALT AND WAX TECHNOLOGY 9

Vacuum residue properties - propane deasphalting - asphalt processing and types - chemical structure - air blowing of bitumen - slack wax processing - wax and

types/properties - wax de-oiling - unit operations in wax plants - refrigerating and filtration/ hydro treating of wax - molding and storage.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1: Understand the methodologies in the primary petroleum refining processes like crudepreparation, atmospheric and vacuum distillation, Lube, asphalt and wax processing.

CO2: Understand how each refinery process works.

CO3: Learn the operating variables which are applied to achieve the objectives of each refineryprocess.

CO4: Understand the methodologies of processing and blending.

CO5: Apply the concepts in asphalt processing and wax treatment technology.

TEXT BOOKS

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press, 5th Edition, 2007.
2. Jyoti Sharma, Handbook of Petroleum Analysis, Scitus Academics LLC; UK Edition, 2016.
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- Ram Prasad, Petroleum Refining Technology, Khanna Publishers, New Delhi, 2000.
- W. L. Nelson, Petroleum Refinery Engineering, Mc Graw-Hill Book Co, 1969.

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CO 1	2	1	1	1	-	1	2	2	2	1	-	1	1	1	2
CO 2	2	1	2	1	2	1	2	1	2	1	1	1	1	1	1
CO 3	2	1	2	1	2	1	2	1	2	1	1	1	2	2	2
CO 4	2	1	2	2	2	1	2	1	2	1	1	1	1	-	-
CO 5	2	1	2	2	2	2	2	1	2	1	1	1	2	1	1

CH23A13 SECONDARY REFINING TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To enable the students to learn the methodologies in the secondary petroleum refiningor upgrading processes like thermal cracking, coking, catalytic cracking, hydrocracking, hydro treating, reforming, isomerization, alkylation, and sulfur finishing processes.
- To enable students to learn refinery operation on FCC, Vis breaker, DCU, Reformer,etc. and operation on utilities likes steam, cooling water, instrument air, H_2, N_2 etc.
- To enable students, to learn each operating variables of all units.
- To enable students to gain basic knowledge on isomerization, alkylation, and reforming.
- To enable students to acquire knowledge in the finishing processes and their operations in refiningindustries.

UNIT I THERMAL CRACKING AND COKING 9

Cracking - thermal cracking - mechanism/principle/reactions - process variables - Vis breaking - soaker process - coil Vis breaker - Disadvantages - Coking - thermodynamics and mechanism of coking - delayed coking - operation - fluid coking -flexicoking - types of coke and properties - yield pattern of cracking and coking.

UNIT II CATALYTIC CRACKING 9

Principles of catalytic cracking - mechanisms - FCC - main reaction of FCC - role of FCC in refinery – Fluidization- feedstocks/products/yield pattern - Kinetics and thermodynamics of FCC reactions - FCC catalyst - reaction/regeneration/fractionation sections - slide valves and its importance - riser/cyclone separator/reactor internals.

UNIT III HYDROGEN AND HYDROCONVERSION 9

Hydrogen requirements - steam reforming and shift conversion - operation and thermodynamics of reformer - Hydro treatment processes - catalyst and reaction chemistry - Naphtha/Diesel/lube/wax/gasoline hydro treatment - Hydrocracking process - Typical hydrocrackerin refinery - catalyst/Temperature profile for yield pattern -reaction kinetics of hydrocracker - Operation and variables.

UNIT IV REFORMING/ISOMERISATION/ALKYLATION 9

Reforming feed index - (Research Octane Number) RON various reforming technologies - kinetics and thermodynamics of Pt catalyst reactions - Operation in Straight Run and Continuous Run mode - yield calculation - Isomerization techniques - reactions and

kinetics - importance of catalyst - hexane production - Alkylation process - process variables in reforming.

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UNIT V FINISHING PROCESSES AND UTILITIES 9

Sources of sulfur in refinery - types of sulfur compounds in crude - sweetening processes - varioussulfur treatment process in products - H_2S properties and removal by physical and chemical process - Amine selection - amine absorption and regeneration -sour water stripping - Merox process - Sulfur recovery from H_2S by Claus /super Claus/ modified Claus technology/(Shell Claus off-gas Treating process) SCOT Process; Electricity and steam generation by Gas turbine/boiler - Cooling tower operation - Fuel oil - Cryogenic distillation of air to N_2 and O_2 production - Instrument air operation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1: A cquires knowledge on different methodologies in the secondary petroleum refiningprocesses like thermal cracking, coking, catalytic cracking, hydrocracking.

CO2: Understand the operation on FCC, Vis breaker, DCU, Reformer.

CO3: Helps to understand the operation on utilities like steam, cooling water, instrument air, H_2,N_2.

CO4: Understand the basic knowledge on isomerization, alkylation and reforming process.

CO5: Gather some knowledge in the finishing processes and their operations in refining industries.

TEXT BOOKS

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press, 5th Edition, 2007.
2. Jyoti Sharma, Handbook of Petroleum Analysis, Scitus Academics LLC; UK Edition, 2016.
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CO mapping to PO/PSOs

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CO 1	2	2	1	1	2	2	2	2	2	1	2	1	1	2	1
CO 2	1	2	1	2	2	2	2	1	1	2	2	2	1	1	1
CO 3	2	1	1	2	2	2	1	2	2	2	2	1	1	2	2
CO 4	1	2	1	1	2	1	1	2	1	2	2	1	1	1	2
CO 5	1	1	1	1	2	2	1	1	2	1	1	2	1	1	2

CH23A14 REFINERY ADVANCEMENTS AND ENVIRONMENTAL REGULATIONS

L T P C

3 0 0 3

OBJECTIVES

- To enable the students to learn the advanced techniques, automation, units integration andinstrumentation techniques in refinery.
- To enable students to understand the environmental regulations, safety and governmentpolicies on refinery.
- To enable students to learn the energy saving techniques and refinery economics.
- To enable students to gain knowledge on unit integrations in refineries.
- To enable students to understand the basis on energy saving techniques and refinery economics.

UNIT I ENVIRONMENTAL REGULATION AND GOVERNMENT POLICIES 9

Classes of petroleum based on flash point - storage tank design - GAS/LIQUID/SOLID wastes form refinery units - environmental standards on air and water pollution and control - Solid waste management - Sludge conditioning and treatment and disposal - Effluent treatment plant - (Textile Processing Plants) TTP - greenhouse gases - Bharat stages and its regulations - Recent modification for BS-6 - Policies on biofuel - (Ethanol Blended Program) EBP Biodiesel.

UNIT II CORROSION AND SAFETY 9

Corrosion - reaction and types - refinery corrosion tests - controlling parameters - corrosion controlin equipment and pipelines - Types of fire - Safety triangle - Firefighting equipment - PPE -(Hazard and Operability Study) HAZOP studies - Petroleum disasters case study

- process safety protocol - pressure relief systems - flare systems -(Closed Blowdown system/Oil water separator) CBD/OWS - MSDS (Material safety data sheet) for units - oil spilling and skimming.

UNIT III ADVANCEMENTS IN REFINERY 9

Instrumentation - Flow/pressure/temperature/level transmitter - Control systems and logics - controller types - mode of controllers - cascade, split range, ratio etc. - P/PI/PID controllers and control tuning - process optimization by (Advanced process control/ Dynamic Matrix Control) APC/DMC - (Distributed Control System/ Programmable Logic Controller) DCS/PLC systems.

UNIT IV REFINERY UNIT INTEGRATION AND RECENT TRENDS 9

Overall modern refinery flow sheet - products routing - naphtha utilization route up and integration - Diesel/gasoline/(Aviation Turbine Fuel)ATF/kerosene route up to blending header - Blending processes - line blending - Blending of diesel and (Mild steel) MS calculation - (Linear Programming) LP model for blending operation - Recent trends in ADU with pre flash - (Resid Fluid catalytic cracking) RFCC- (Octane improvement catalyst unit) OHCU - Blue H_2 process - Pre reforming - moving bed in (Catalytic Reforming Unit) CRU and isom-Advanced lube processing.

UNIT V ENERGY SAVING AND REFINERY ECONOMICS 9

Furnace efficiency calculation - steam utilization - plume length - insulation of pipelines - heat tracing - steam traps - Standard Refinery Fuel Tonnage - Fuel and loss - operational cost - margin cost - refining capacity - complexity factor - crude oil evaluation and procurement - monthly production planning - Gross Refinery Margin -operation optimization by Linear Programming model - shutdown planning - Refinery Transfer Price.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1: Understanding the regulations and government policies in refining industries.

CO2: Acquire some knowledge on advanced techniques, automation and instrumentation techniques.

CO3: Understand the different controllers and automated control systems in refineries.

CO4: Gathering knowledge on unit integrations in refineries.

CO5: Understand the basis on energy saving techniques and refinery economics.

TEXT BOOKS

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press, 5th Edition, 2007.
2. Jyoti Sharma, Handbook of Petroleum Analysis, Scitus Academics LLC; UK Edition,

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3. R.N. Watkin, Petroleum Refinery Distillation, Gulf Publishing Co, Houstan, Texas, USA, 2nd edition, 1981.

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3. W. L. Nelson, Petroleum Refinery Engineering, Mc Graw-Hill Book Co, 1969.

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CO 2	1	1	1	1	1	2	2	1	2	2	2	2	1	2	1
CO 3	1	2	1	2	1	2	2	1	2	1	2	2	1	2	1
CO 4	2	2	1	2	2	2	2	1	2	1	1	2	1	2	1
CO 5	2	2	1	2	2	2	2	2	2	1	1	2	1	2	1

CH23A15 PETROLEUM EQUIPMENT DESIGN L T P C 3 0 0 3

OBJECTIVES:

- To enable students to gain knowledge on drill bit fundamentals, codes and standards
- To enable students to acquire facts on design of production and processing equipment.
- To enable students to know about Capstone design in reservoir engineering.
- To enable students to design of Oil and Gas Treatment Equipment
- To enable students to understand the design of pipe systems.

UNIT I INTRODUCTION 9

Casing program, casing and tubing design, principles of cementing, completion added skin, well perforating, hydraulic fracturing. Drill Bit Design, Roller Cone Bits, PDC (Polycrystalline Diamond Compact) Drill Bits, Nomenclature and IADC (International Association of Drilling Contractors) Codes for drill bits, BHA (Bottom hole assembly). ESP (Electrical submersible pumps). SRP (Sucker rod pumping) unit design

UNIT II DESIGN OF SURFACE FACILITIES 9

Design of Surface Facilities, Design of production and processing equipment, including separationproblems, treating, and transmission systems.

UNIT III RESERVOIR ENGINEERING DESIGN 9

Capstone design in the areas of geology, reservoir engineering, production, drilling and well completions to practical design problems based on real field data with all of the associated shortcomings and uncertainties.

UNIT IV DESIGN OF STABILIZER 9

Oil desalting, horizontal and spherical electrical dehydrators, Natural Gas Dehydration, Horton sphere, Natural Gas Sweetening. Crude and Condensate Stabilization, design of stabilizer, Oil and Gas Treatment.

UNIT V REFINERY EQUIPEMENT DESIGN 9

Refinery Equipment Design, atmospheric distillation column, Design and construction of on/ offshore pipelines, Fields Problems in pipeline, Hydrates, scaling and wax etc and their mitigation.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1: Understand the drill bit fundamentals, codes and standards
CO2: Understand design of production and processing equipment.
CO3: Understand the Capstone design in reservoir engineering.
CO4: Understand the design of Oil and Gas Treatment Equipment
CO5: Understand the design of pipe systems.

TEXT BOOKS

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press, 5th Edition, 2007.
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3. W. L. Nelson, Petroleum Refinery Engineering, Mc Graw-Hill Book Co, 1969.

CO mapping to PO/PSOs

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CO 2	3	2	3	3	2	-	3	-	-	-	-	-	3	-	2
CO 3	3	2	3	-	2	-	2	-	-	2	-	-	3	1	-
CO 4	3	2	3	2	-	-	3	-	-	-	1	-	3	-	-
CO 5	3	3	3	-	3	-	2	-	-	-	-	-	3	-	-

CH23A16 PETROCHEMICAL TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To enable the students to learn the operation and methodologies in petrochemicalindustries
- To enable students to learn the application of petrochemicals in all process fields
- To enable students, learn each product of petrochemical industries and its applicationwith production techniques in detail.
- To enable students to know about the petrochemical industries and its application with production techniques in polymers.
- To enable students to find the application of petrochemicals in all process fields

UNIT I PETROCHEMICALS EVOLUTION 9

Petrochemical Industries and their feedstock selection, History, Economics, Growth of petrochemical industry, structure of Petrochemical complexes, Classification of petrochemicals, Basic building processes, Integration with refinery, Petroleum product regulations..

UNIT II INTERMEDIATES FOR PETROCHEMICALS INDUSTRIES 9

Production Methods, Reforming and cracking of feed stocks, Sources: Chemicals from synthesis gas, olefins and aromatics, Ethylene, Propylene, C_4 hydrocarbons, higher olefins, Benzene, Toluene, Xylene and their derivatives.

UNIT III COMPLEX PETROCHEMICAL PRODUCTS 9

Acrylonitrile, Acrylic acid, dimethyl terephthalate, ethanol, ethylene glycol, linear alkylbenzene, methyl tertiary butyl ether, vinyl acetate, vinyl chloride, Maleic and phthalic anhydride, ethyl benzene, Phenol, Cumene, Styrene, Bisphenol, Aniline, Process flow scheme, various technology, advantages, yield pattern, process variables.

UNIT IV POLYMERS 9

Polymers production: Fibers, Rubbers and Plastics. Acrylonitrile butadiene styrene (ABS), polyethylene, LDPE (Low density Polyethylene), HDPE (High density Polyethylene), Polypropylene, PVC, PS (Polystyrene), SAN (Styrene Acrylonitrile), SBR (Styrene Butadiene Rubber), PAN (Polyacrylonitrile), Nylon and Polycarbonates.

UNIT V GLOBAL CHEMICALS 9

Petrochemicals, Lubricants, additives, adhesives, agrochemicals, cosmetics raw materials, electronic chemicals, detergents, paint, healthcare and pharmaceuticals, Fertilizers, Ammonia, Urea, NPK.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1: Able to understand the basic knowledge on petrochemical industry and their growth, history.

CO2: Understand the different methods of production in petrochemical products and their derivatives.

CO3: Gather knowledge on the production of complex petrochemical products

CO4: Able to understand the petrochemical industries and its application with production techniques in polymers.

CO5: To understand the application of petrochemicals in all process fields

TEXT BOOKS

1. J. H. Gary, H. Hanwerk and M. J. Kaiser, Petroleum Refining Technology and Economics, CRC Press, 5th Edition, 2007.
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- Robert A. Meyers, "Handbook of Petrochemicals Production Processes", McGraw-HillEducation: New York, 2nd edition, 2019.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 4	2	2	2	1	2	2	1	1	3	1	2	1	2	2	1
CO 5	1	2	1	1	2	2	1	1	3	1	2	1	2	2	1

PROFESSIONAL ELECTIVE COURSES

VERTICAL II: ENERY ENGINEERING

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1	CH23B11	Non- renewable energy sources	3	0	0	3	3
2	CH23B12	Pinch technology	3	0	0	3	3
3	CH23B13	Power plant systems and sustainability	3	0	0	3	3
4	CH23B14	Renewable energy resources	3	0	0	3	3
5	CH23B15	Bio Energy	3	0	0	3	3
6	CH23B16	Hydrogen and fuel cell technology	3	0	0	3	3

CH23B11 NON- RENEWABLE ENERGY SOURCES L T P C

3 0 0 3

OBJECTIVES

- To provide detailed understanding of the global and Indian energy landscapes focusing on demand and supply dynamics
- To explore the prospects of shale gas extraction
- To examine the potential and challenges of gas hydrate exploration
- To understand the basics and prospects of coal bed methane
- To understand the influence of coal properties

UNIT 1 INTRODUCTION 9

Energy Facts Global vs Indian energy scenario – demand and supply, and future projection; relation between GDP and energy demand; introduction to conventional, unconventional, renewable, non-renewable energy resources in general, and unconventional hydrocarbon energy resources in particular; climate – Keeling curve; clean and sustainable energy resources; comparison between formations and mode of occurrences of various conventional and unconventional energy resources.

UNIT 2 OIL SHALE, SHALE GAS, AND TAR SAND OIL SHALE 9

Definition and prospect, geological conditions for formation of oil shale, oil shale recovery technology, ex-situ and in-situ extraction processes of shale oil, various retorting processes, processes leading to maximization of shale oil production Shale Gas: Definition and prospect, the conditions of formation of shale gas, debate over extraction of shale gas from the subsurface, environmental issues, hydro fracturing, composition of fracking fluid, water management, shale gas – Indian perspective; Tar Sand

UNIT 3 DEEPWATER OIL AND GAS TECHNOLOGY 9

Deepwater exploration and production in the world, role of geophysical methods, technological challenges in Deepwater drilling and production. Heavy oil: world resources of heavy oil, production technology and challenges. Gas Hydrate Definition, types of methane hydrate deposits, chemistry and structure of natural methane hydrate, Necessary Conditions for Methane Hydrate Formation, typical conditions of methane hydrate formation in nature vs different gas hydrate stability zones, physical properties of hydrates and ice, geology of methane hydrates, exploration for methane hydrates – geological, geochemical and geophysical, gas hydrate – Indian perspective.

UNIT 4 COAL BED METHANE 9

Introduction to Coal Bed Methane Definition and prospect, CBM, CMM, and AMM; an Overview on CBM vs. Conventional Reservoir –Gas Composition, Adsorption, Water Production, Gas Flow, Rock Physical Properties, Gas Content, Coal Rank, Gas Production, Liquefied Gas (LG),

Liquefied Natural Gas (LNG), and Synthetic Natural Gas (SNG). Fundamentals of Coal Geology: Genesis of Coal; Major Stratigraphic Periods of Coal Formation; Gondwana and Tertiary Coals of India

UNIT 5 CONVENTIONAL POWER PLANTS 9

Conventional energy resources, Thermal, hydro and nuclear reactors, thermal, hydro and nuclear power plants, efficiency, merits and demerits of the above power plants, combustion processes, fluidized bed combustion.

TOTAL:45 PERIODS

OUTCOMES:

On completion of the course, student will able to,

- Understand the present global energy scenario, future need and various unconventional hydrocarbon resources
- Analyze the Geo-mechanical properties of unconventional reservoirs
- Outline the fundamental of hydraulic fracturing
- Characterize the unconventional reservoirs and discuss available production methods
- Apply safety and environmental features in hydraulic fracturing, gas production, and water production

TEXT BOOKS

1. Zou, C et al (2013) Unconventional Petroleum Geology, Elsevier;

2. Max, M. D. (2003) Natural Gas Hydrate in Oceanic and Permafrost Environments, Kluwer Academic Publication

REFERENCE BOOKS

1. Petroleum and Petrochemical Technology by Yokesh A.Karpe, 2020

2. A Text on Petro Chemical, Dr. B.K. Bhaskararao, 2004

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	1	1	1	2	3	1	-	1	1	2	2	1	-
CO 2	3	2	2	-	1	3	3	1	-	1	1	2	2	1	1
CO 3	3	2	2	-	1	3	3	1	-	1	1	2	2	1	1
CO 4	3	2	2	-	1	3	3	1	-	1	1	2	2	1	-
CO 5	3	3	1	-	1	1	3	1	-	1	1	2	2	1	-

CH23B12 PINCH TECHNOLOGY **L T P C**

3 0 0 3

OBJECTIVES:

- To understand the basics of Pinch Technology
- To design heat exchanger networks
- To optimize energy consumption in industrial processes
- To develop student's ability to integrate various process streams effectively
- To identify energy bottlenecks within the process

UNIT-I INTRODUCTION TO PINCH TECHNOLOGY 9

Definition of pinch technology. Basis of Pinch Technology. Objectives of Pinch Analysis. Process Integration by Pinch Analysis. Development of Pinch Technology. Areas of applications of Pinch Technology. The concept of process synthesis. The role of thermodynamics in process design.

UNIT-II HEAT RECOVERY 9

Basic concepts of heat exchange, the temperature-enthalpy diagram, Composite curves, A targeting procedure. The grand composite curve and shifted composite curves. The pinch and its significance. Heat exchanger network design: Network grid representation, design for maximum energy recovery. Methodology of Pinch Analysis: The range of pinch analysis techniques, and application of pinch study.

UNIT-III DATA EXTRACTION 9

Data extraction: Heat and mass balance, stream data extraction, calculating heat loads and heat capacities, choosing streams, mixing, heat losses. Organics distillation plant-a case study. Energy targeting: dTmin contributions for individual streams, Threshold problems. Organics distillation plant - a case study.

UNIT-IV PROCESS CHANGE AND EVOLUTION 9

Process changes and evolution: Basic objective, The plus-minus principle, appropriate placement applied to unit operations, reactor systems, distillation columns.

UNIT-V CASE STUDIES 9

Case studies: Crude preheat train, Aromatics plant.

OUTCOMES

On completion of the course, the students will be able to

CO1. Understand the pinch concept and process thermodynamics.

CO2. Identify minimum energy targets.

CO3. Classify different choices and constraint during heat exchange networking.

CO4. Apply strategies for retrofitting existing process plant, integration of energy demands of multiple processes.

CO5: Analyze the concepts in various chemical processes.

TEXT BOOKS

1. A user guide on process integration for the efficient use of energy, B. Linnhoff, David W. Townsend, D. Boland and G.F. Hewitt.
2. Pinch Analysis and Process Integration, second edition: A user guide on process integration for the efficient use of energy, Ian C. Kemp, IChemE

REFERENCE BOOK

1. Chemical Process: Design& Integration, Robin Smith, John Wiley and Sons.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	3	2	2	-	1	3	3	1	1	1	2	1	3	2	1
CO 3	3	2	2	-	1	3	3	1	1	1	2	1	3	2	1
CO 4	3	2	2	-	1	3	3	1	1	1	1	1	3	2	1
CO 5	3	3	1	-	1	1	3	1	1	1	1	1	3	2	1

CH23B13 POWER PLANT SYSTEMS AND SUSTAINABILITY L T P C

3 0 0 3

OBJECTIVES

- To understand the working of various components, operations and maintenance of Steam powerplants
- To know the various open and closed cycles and working of diesel and gas turbine power plants
- To understand the working of various types of nuclear power plant and its safety issue
- To understand the construction and working of various types of renewable power plants
- To gain knowledge about energy, economic and environmental issues of power plants.

UNIT-I INTRODUCTION & COAL BASED THERMAL POWER PLANTS 9

Power plants-Features - Components and layouts-Rankine cycle- Reheat and Regenerative cycles, Layout of modern coal power plant, Super Critical Boilers, FBC Boilers, Turbines, Condensers, Steam & Heat rate, Subsystems of thermal power plants – Fuel and ash handling, Draught system, Feed water treatment.

UNIT-II DIESEL, GAS TURBINE AND COMBINED CYCLE POWER PLANTS 9

Otto, Diesel, Dual & Brayton Cycle – Analysis & Optimisation. Components of Diesel and Gas, Turbine power plants. Combined Cycle Power Plants. Integrated Gasifier based Combined Cycle.

UNIT-III NUCLEAR POWER PLANTS 9

Basics of Nuclear Engineering, Layout and subsystems of Nuclear Power Plants, Working of Nuclear Reactors: Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), Canada Deuterium-Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors. Safety measures for Nuclear Power plants.

UNIT-IV POWER FROM RENEWABLE ENERGY 9

Hydro Electric Power Plants – Classification, Typical Layout and associated components including Turbines. Principle, Construction and working of Wind, Tidal, Solar Photo Voltaic (SPV), Solar Thermal, Geo Thermal, Biogas.

UNIT-V ENERGY,ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS 9

Power tariff types, Load distribution parameters, load curve, Comparison of site selection criteria, relative merits & demerits, Capital & Operating Cost of different power plants. Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants.

OUTCOMES:

On successful completion of this course, students will be able to

- Describe the working of various components, operations and maintenance of Steam power plant
- Analyse various open and closed cycles relating to diesel and gas turbine power plants & working of this power plants.
- Explain the working of various types of nuclear power plants and its safety issue.
- Describe the construction and working of various types of renewable power plants.
- Explain about energy, economic and environmental issues of power plants.

TEXT BOOK (s):

1 P. K. Nag, (2017), Power Plant Engineering: Steam and Nuclear, Tata McGraw-Hill Publishing Company Ltd., Fourth Edition.

2 Paul Breeze, ―Power Generation Technologies‖, Elsevier Ltd., 2014

REFERENCE BOOKS(S) / WEB LINKS:

1 El-Wakil. M.M., ―Power Plant Technology‖, Tata McGraw – Hill Publishing Company Ltd., 2010.

2 Black & Veatch, Springer, ―Power Plant Engineering‖, 1996.

3 Thomas C. Elliott, Kao Chen and Robert C. Swanekamp, ―Power Plant Engineering‖, Second Edition, Standard Handbook of McGraw – Hill, 1998

4 Godfrey Boyle, ―Renewable energy‖, Open University, Oxford University Press in association with the Open University, 2004

5 https://archive.nptel.ac.in/courses/112/107/112107291/

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	3	2	3	-	2	2	2	-	-	1	-	3	1	2	1
CO 3	3	2	2	-	1	2	1	-	-	1	-	3	1	2	1
CO 4	3	2	2	-	1	1	2	-	-	1	-	3	1	3	1
CO 5	3	2	2	-	1	2	3	-	-	1	-	3	1	3	1

CH23B14 RENEWABLE ENERGY RESOURCES L T P C

3 0 0 3

OBJECTIVES

- To identify the sources available to mankind, in relation to available technologies.
- To discuss the human being‘s, need for energy.
- To Understand basic characteristics of renewable sources of energy and technologies for their utilization.
- To Apply the principle of energy conversion technologies of various renewable energy resources.
- To give effective review on utilization trends of renewable sources of energy.

UNIT-I ENERGY SCENARIO 9

Introduction to Energy – Present Energy Status - Indian Energy Scenario – Sector-wise Energy Consumption in India – Energy Needs of Growing Economy – Long-term Energy Scenario for India – Global Energy Scenario - Energy Security.

UNIT-II SOLAR ENERGY 9

Spectral Distribution of Solar Radiation - Solar Radiation Measurement - Solar Thermal Collectors –Flat Plate and Concentrating Collectors - Basics of Solar Concentrators - Solar Thermal Power Generation - Solar Thermal Energy Storage - Solar Thermal Applications - Solar Stills - Solar Pond - Physics of Solar Cells - Cell Types - Fundamentals of Solar Photo Voltaic Conversion - PV System Configurations - System Components: Battery, Charge Controller and Inverter - Solar Fuels (Carbon Capturing and Storage).

UNIT-III WIND ENERGY 9

Power in the Wind- Wind Data and Energy Estimation – Wind Rose Diagram - Betz Limit - Site Selection for Windfarms - Types of Wind Mills - Horizontal Axis - Vertical Axis Wind Turbines - Components of Wind Mill – Wind Mill Performance - Indian Wind Potential - Introduction to On-shore Off-shore Wind Farms.

UNIT-IV BIOENERGY 9

Bioresources - Biomass Direct Combustion - Biochemical Conversion - Thermochemical Conversion - Mechanical Conversion - Biomass combustion and power generation- Biomass Gasifier – Types of Gasifiers - Cogeneration - Carbonization - Pyrolysis - Biogas plants - Digesters - Biodiesel Ethanol production - Waste to Energy Technologies.

UNIT-V OCEAN ENERGY 9

Tidal energy - Types of Tidal Energy – Tidal Energy Conversion - Ocean Thermal Energy - Open and Closed Ocean Thermal Energy Conversion (OTEC) – Geothermal energy – Types - Geothermal Energy Conversion – Environmental Impact Assessment.

Course Outcomes:

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

- Describe the current energy scenario in terms of conventional renewable energy and future plan.
- Define basic properties of different renewable sources of energy and technologies for their utilization
- Describe main elements of technical systems designed for utilization of renewable source of energy.
- Explain the correlation between different operational parameters.
- Select Engineering approach to problem solving when implementing the projects to renewable sources of energy.

TEXT BOOKS:

1 John Twidell, Tony Weir, and Anthony D. Weir, Renewable Energy Resources, Taylor &Francis, 2006.

2 G.D. Rai, ―Non-Conventional Energy Sources‖, Standard Publishers Distributors, 1992.

REFERENCE BOOKS(S) / WEB LINKS:

1 N.K. Bansal, Non-Conventional Energy Resources, Vikas Publishing House, 2014.

2 Godfrey Boyle, ―Renewable Energy, Power for a Sustainable Future‖, Oxford University Press, 20

3.Gilbert M. Masters (2004), Renewable and Efficient Electric Power Systems, Wiley Interscience.

4. Frank Kreith and D.Yogi Goswami (2007), Handbook of Energy Efficiency and Renewable Energy,CRC Press.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	3	-	-	1	2	1	2	1	-	-	-	2	1	2	1
CO 3	3	-	-	1	1	1	1	1	-	-	-	2	1	2	1
CO 4	3	-	-	-	1	1	2	1	-	-	-	2	1	3	1
CO 5	3	-	-	-	1	1	1	1	-	-	-	2	1	3	1

CH23B15 BIO ENERGY L T P C

3 0 0 3

OBJECTIVES:

- To provide a comprehensive understanding of biomass as a renewable energy source
- To understand the biochemical processes involved
- To explore the thermochemical processes involved
- To identify the impact of key variables on gasification
- To equip students with the skill to design and optimize equipment's for combustion

UNIT I BIOMASS ENERGY 9

Sources and Classification. Chemical composition, properties of biomass. Energy plantations. Size reduction, Briquetting, Drying, Storage and handling of biomass.

UNIT II BIOGAS PRODUCTION 9

Feedstock for biogas, Microbial and biochemical aspects- operating parameters for biogas production. Kinetics and mechanism- High rate digesters for industrial waste water treatment.

UNIT III THERMOCHEMICAL CONVERSION 9

Thermo chemical conversion of lignocelluloses biomass. Incineration, Processing for liquid fuel production. Pyrolysis -Effect of particle size, temperature, and products obtained.

UNIT IV INFLUENCE OF PARAMETERS 9

Thermo chemical Principles: Effect of pressure, temperature , steam and oxygen. Fixed and fluidized bed Gasifiers- Partial gasification of biomass by CFB.

UNIT V COMBUSTION AND COGENERATION 9

Combustion of woody biomass-Design of equipment. Cogeneration using bagasse- Case studies: Combustion of rice husk.

TOTAL:45 PERIODS

OUTCOMES:

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

- Gain a comprehensive understanding of biomass and its properties
- Identify the feedstocks suitable for biogas production
- Understand the methods and technologies involved
- Analyse the different operational parameters on biogas production
- Select Engineering approach to design the equipment's using principles of chemical engineering.

TEXT BOOKS:

1.Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass

or Agricultural Wastes", Oxford & IBH publishing Co, 1989.

2. D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis, 2000, Indian reprint, 2003[chapter 10]

3. Mital K.M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd., 1996.

4.Nijaguna, B.T.,Biogas Technology, New Age International publishers (P) Ltd.,2002

REFERENCES:

1. VenkataRamana P and Srinivas S.N, "Biomass Energy Systems", Tata Energy Research

Institute, 1996.

2. Rezaiyan. J and N. P. Cheremisinoff, "Gasification Technologies, A Primer for Engineers

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	3	2	2	-	1	3	3	1	1	1	2	1	3	2	1
CO 3	3	2	2	-	1	3	3	1	1	1	2	1	3	2	1
CO 4	3	2	2	-	1	3	3	1	1	1	1	1	3	2	1
CO 5	3	3	1	-	1	1	3	1	1	1	1	1	3	2	1

CH23B16 HYDROGEN AND FUEL CELL TECHNOLOGY **L T P C**

3 0 0 3

OBJECTIVES:

- To introduce the concept of hydrogen as renewable and green fuel, and its electro-chemical conversion into electricity.
- To explore the hydrogen storage methods.
- To understand the fundamentals of Fuel cells.
- To gain a comprehensive understanding of fuel cell components.
- To analyze the applications of fuel cells.

UNIT I: HYDROGEN GENERATION **9**

Hydrogen – Zero-Carbon Fuel - Hydrogen Production from Fossil Fuels: Hydrocarbon Reforming – Coal Gasification – Pyrolysis. Hydrogen Production from Biomass - Biological Bio-photolysis - Dark Fermentation - Photo Fermentation - Microbial Electrolysis – Thermochemical Biomass Gasification - Water Splitting using Alkaline – Proton Exchange Membrane (PEM) - Solid Oxide Electrolyzer Cells (SOEC) - Photoelectrochemical (PEC) and Thermochemical Water Splitting.

UNIT II: HYDROGEN STORAGE **9**

Physical and Chemical Methods of Hydrogen Storage – Cryo-compressed – Compressed – Liquid Hydrogen. Adsorbent – Interstitial Hydrides – Complex Hydrides – Chemical Hydrogen – Liquid Organic Hydrogen Carrier (LOHC) Chemical Methods.

UNIT III: HYDROGEN TRANSPORTATION **9**

Gaseous – Liquid – Solid – Chemical Conversion Methods of Transportation - Modes of Transportation.

UNIT IV: FUEL CELL TECHNOLOGY **9**

Basics - Fuel cell definition - Difference between Batteries and Fuel Cells - Nernst Equation - Electrochemical Kinetics - Butler-Volmer Equation – Electrodics. Construction of Fuel Cells - Alkaline – Polymer - Molten Carbonate - Phosphoric Acid Electrolytes - Electrodes – Membranes –Stacks – Fuel Cell Assembly – Types of Fuel Cells - H2-O2 - Methanol-Oxygen - High Temperature Solid Oxide Fuel Cells.

UNIT V: APPLICATIONS OF H_2 AND FUEL CELLS 9

Applications of Hydrogen in Industry for Ammonia, Methanol Production, and Direct Reduction in Steel – Buildings as Hydrogen Blend in City-Gas Networks Transportation as HCNG. Applications of Fuel Cells in Passenger Cars – Commercial Vehicles and Ships – Stationary Fuel Cells for Power Production.

TOTAL:45 PERIODS

OUTCOMES:

On completion of this course, the students are able to,

- To identify the potential of Hydrogen as renewable and green fuel, and also to suitable production systems.
- To analyze various storage methods available for hydrogen fuel to act as feedstock for energy conversion.
- To understand the thermodynamics and working principles of fuel cell.
- To understand the various fuel cell designs and its losses involved in the operation.
- To describe the application of fuel cells in industrial and commercial areas.

TEXT BOOK

1. 'Hydrogen and Fuel Cells: Emerging Technologies and Applications', Bent Sørensen, Academic press, 2012.

REFERENCE BOOKS

1. 'Principles of Fuel Cells', by Xianguo Li, Taylor & Francis, 2006

2. 'Fuel Cells, Principles and Applications', Viswanathan, B. and Scibioh, Aulice M, Universities Press, 2006.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 3	3	2	2	-	1	3	3	1	1	1	2	1	3	2	1
CO 4	3	2	2	-	1	3	3	1	1	1	1	1	3	2	2
CO 5	3	3	1	-	1	1	3	1	1	1	1	1	3	2	1

PROFESSIONAL ELECTIVE COURSES

VERTICAL III: BIOCHEMICAL ENGINEERING

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1	CH23C11	Biosciences for Chemical Engineers	3	0	0	3	3
2	BT23611	Bioprocess technology	3	0	0	3	3
3	CH23C13	Fermentation and bioprocessing	3	0	0	3	3
4	CH23C14	Bioseparation and downstream processing	3	0	0	3	3
5	CH23C15	Enzyme immobilization technology	3	0	0	3	3
6	CH23C16	Bioreactor design	3	0	0	3	3

CH23C11 BIOSCIENCES FOR CHEMICAL ENGINEERS

OBJECTIVES:

- To introduce cells and their functions and to understand the biological importance of water, pH and buffers.
- To provide an overview of structure and functions of biomolecules.
- To analyze the importance of metabolic pathways.
- To elucidate the mechanism of ATP production, the energy currency of the cell.
- To apply the knowledge of basic microbiology in Bioprocess Technology.

UNIT I INTRODUCTION 9

Introduction-cells-prokaryotic and eukaryotic – structure and functions, Water and its structure and biological importance of pH and buffers.

UNIT II BIOMOLECULES 9

Biomolecules-overview of structure of functions of CHs, proteins, lipids and nucleic acids.

UNIT III METABOLISM 9

Introduction to metabolism-anabolism, catabolism, glycolysis, β.oxidation, TCA cycle.

UNIT IV BIOENERGETICS 9

Bioenergetics-structure of mitochondria cellular respiration, ATP. Yield of glucose and palmitic acid oxidation.

UNIT V FUNDAMENTALS OF MICROBIOLOGY 9

General properties of Bacteria, fungi and algae. Growth curve of bacteria and yeast.

Screening of bacterial factors – primary and secondary, strain important of industrial strains, primary and secondary metabolis.

TOTAL: 45 PERIODS

OUTCOMES:

This course will enable students to

- Apply the knowledge of buffers in bioprocesses.
- Analyze the structure and functional relationship of biomolecules.
- Illustrate the role of metabolic pathways in bioprocess.
- Evaluate the application of ATP production in biological system.

- Screen for improved strains of microbes for innovative product development.

TEXT BOOKS:

1. Satyanarayana and Chakrapani Essentials of Biochemistry, 3rd Edition, Book and Allied Pvt. Ltd.2021.
2. A.H.Patel, Industrial Microbiology, 2nd Edition, Trinity press,2022

REFERENCES

1. Emine Ercikan Abali, Susan D. Cline, David S. Franklin and Susan M. Viselli. Lippincott's Illustrated Reviews, Biochemistry, Eighth Edition, Lippincott Williams & Wilkins 2021.
2. Peter Kennelly, Kathleen Botham, Owen McGuiness, Anthony Weil and Rodwell V.W. Harpers Biochemistry. Appleton and Lange, Stanford, Conneticut, 32nd Edition, McGraw Hill Education.
3. Joanne W., Kathleen S and Dorothy W., Prescott's Microbiology, 12th Edition, Mc Graw Hill, New York, 2023

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	2	1	1	2	1	1	2	-	1	-	1	2	2	2	2
CO 2	2	2	2	2	1	1	2	-	2	-	1	2	2	2	2
CO 3	2	3	3	2	2	1	2	-	2	-	1	2	2	2	2
CO 4	2	3	3	2	2	1	2	-	2	-	2	2	2	2	2
CO 5	2	1	1	2	2	1	2	-	3	-	2	2	2	2	2

BT23611 BIOPROCESS TECHNOLOGY

OBJECTIVES:

- To understand the fundamentals of bioprocesses.
- To define the basics of media formulation and sterilization methods.
- To emphasis on the types and its significance in bioreactors.
- To understand the production process of biomolecules.
- To impart knowledge on the bioethics and biosafety in the bioprocess technology.

UNIT I INTRODUCTION TO BIOPROCESS 9

Biologists and Engineers, comparison of chemical and biochemical processing overview of biological basics, About cells and its growth, the stoichiometry of microbial growth and product Bioprocesses: Regulatory Constraints

UNIT II MEDIA FORMULATION AND DEVELOPMENT 9

Media formulation, Media Sterilization: Methods of heat sterilization of media, thermal death kinetics, design criteria, batch and continuous sterilization. Air Sterilization: Methods of air sterilization, mechanism of air sterilization, solid and liquid handling. Industrially fermented broth

UNIT III BIOREACTORS 9

Purpose and importance of bioreactors, Classification of bioreactors, bioreactors for animal cells, bioreactors for plant cells, bioreactors for immobilized cells, operations of bioreactors, stirred tank reactor, plug flow reactor (PFR), fluidized bed reactor, bubble column, airlift reactor, Agitation, and Aeration: Mechanical agitation, power consumption in agitation, bubble aeration, bioreactors for waste management

UNIT IV TRANSPORT PROCESSES 9

Aspects of rheology, Fluid flow in packed-bed and Fluidized bed columns, Gas-liquid mass transfer in cellular systems Diffusivity and mechanism of mass transfer - derivation of the equations of mass transport by diffusion-stationary and unsteady mass transport by diffusion, mass transfer coefficient, macroscopic balances for mass transport. Mechanisms and applications of heat transfer-mode of heat transfer-conduction, convection and radiation, Application of Heat and Mass transfer in biochemical processes.

UNIT V BIOETHICS AND BIOSAFETY 9

Introduction to Bioethics. Social and ethical issues, the process of biotechnology involved in generating new forms of life for informed decision making, Definition of Biosafety. Biosafety for human health and environment. Social and ethical issues. Use of genetically modified organisms and their release into the environment.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1- Understand the fundamental knowledge on bioprocess technology

CO2- Learn the the production process of biomolecules

CO3- Gather knowledge on the operations of bioreactors and their purposes

CO4- Understand the transportation processes in reactors and their behaviors

CO5- Knowledge on the biosafety and information on bioethics.

TEXT BOOKS:

1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996.
3. Pauline M. Doran. Bioprocess Engineering Principles. 2nd ed. Elsevier Science & Technology Books. 1995

REFERENCES

1. Transport Phenomena, by Bird R.B., Steward W.E., and Lightfoot E.N., John Wiley & sons, Inc., New York, 2002
2. C J Geankoplis, Transport Processes and Separation Processes Principles, 4th Edition, New Jersey, PHI Publishers, 2010

CO mapping to PO/PSOs

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CO 1	2	1	1	2	1	1	2	2	1	1	1	2	2	2	2
CO 2	2	2	2	2	1	1	2	2	2	1	1	2	2	2	2
CO 3	2	3	3	2	2	1	2	2	2	1	1	2	2	2	2
CO 4	2	3	3	2	2	1	2	2	2	1	2	2	2	2	2
CO 5	2	1	1	2	2	1	2	3	3	2	2	2	2	2	2

CH23C13 FERMENTATION AND BIOPROCESSING **L T P C**

3 0 0 3

COURSE OBJECTIVES:

- To understand fermentation and its kinetics
- To emphasis on the basics of microbial growth kinetics and its mathematical models
- To design fermenter with auxiliaries
- To understand structural and functional properties of microbes with process instrumentation

- To discuss on the production of different fermentation and commodity products

UNIT I FERMENTATION PROCESSES 9

Importance of fermentation, Fermentation and redox potential, solid-liquid fermentation, solid state fermentation, Kinetics of fermentations, Biosensors for fermentations, Production processes in fermentation.

UNIT II MICROBIAL GROWTH KINETICS 9

Diversity of patterns of microbial growth in situ and ex situ, Microbial growth under homogeneous conditions, Heterogeneous microbial growth, Growth kinetics, Derivation of mathematical models, and identification

UNIT III DESIGN OF FERMENTERS 9

Fermentation processes, Fermentation processes and microorganisms, Kinetics and stoichiometry, Mass balances and design for batch, continuous and fed-batch reactors, Comparison of batch, continuous and fed-batch reactors, Heat generation and heat balances, examples of industrial fermentation processes

UNIT IV INSTRUMENTATION AND CONTROL 9

Common Instruments for Process Automation — Temperature, Gas Flowrate, Liquid Flowrate, Off- Gas Analysis, pH, Dissolved Oxygen, Pressure, Foam Level, Stirring , Redox Potential, Advanced Instrumentation for Bioprocess Control and Automation - Flow Injection Analysis, Sequential Injection Analysis Fluorescence, Mass Spectrometry, Near Infrared Spectroscopy, Soft sensors, Biomass, Bioreactor automation

UNIT V FERMENTATION AND COMMODITY PRODUCTS 9

Engineering of Secretory Pathways, production of heterologous proteins, fungal, yeast fermentation of industrial products.

TOTAL : 45PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1- Understand the structural, functional properties of microbes.

CO2- Learn the growth kinetics of microorganisms.

CO3- Understand the basic concepts in designing of fermenters.

CO4- Gather knowledge on the operation of control systems in fermentation and bioprocess industry.

CO5- Acquire knowledge on the commodity, fermentation production and their production pathways.

TEXTBOOKS:

1. Essentials in Fermentation Technology, Aydin Berenjian, Springer ,2019.
2. Principles of Fermentation Technology (Second Edition), Peter F. Stanbury, Allan Whitaker and

Stephen J. Hall, Pergamon, 1995

REFERENCES:

1. Fermentation and Biochemical Engineering Handbook; Editors-in-Chief: Henry C. Vogel and Celeste M. Todaro, Third Edition, Elsevier, 2014.
2. Fermentation Biotechnology: Principles, Processes, and Products (Prentice Hall advanced references series), Owen P. Ward, Prentice Hall, 1989

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1	1	1	1	1	2	2	2	2	1	1	2	1	-	-
CO 2	1	2	1	2	2	2	2	2	2	1	1	2	1	2	1
CO 3	1	2	3	3	3	2	2	2	2	1	2	2	1	2	1
CO 4	1	2	3	3	3	2	2	2	2	2	2	2	1	2	1
CO 5	1	2	2	2	3	2	2	2	2	2	2	2	1	2	1

CH23C14 BIOSEPARATION AND DOWNSTREAM PROCESSING

L T P C
3 0 0 3

COURSE OBJECTIVES:

- To learn the fundamentals of bio separations
- To design unit operations steps for downstream purification steps like centrifugation and filtration
- To discuss on the absorption in the Bioseparation applications.
- To emphasis on the basics involved in the extraction for downstream processing
- To gain knowledge on theory, design, and application of bioprocessing.

UNIT I INTRODUCTION **9**

Introduction to By-products and Bioseparation: Range and characteristics of bio products, Characteristics of Fermentation Broth, Selection of unit operation with due consideration of the physical, chemical and biochemical aspects of biomolecules. Stages of Downstream Processing

UNIT II CENTRIFUGATION AND FILTRATION **9**

Primary Separation: Removal of insoluble and Biomass (and particulate debris) separation techniques, Flocculation and sedimentation, Centrifugation-Ultracentrifugation, Gradient centrifugation, Filtration: Theory of Filtration, Pre-treatment of Fermentation Broth, Filter Media and Equipment, Conventional and Cross-flow Filtration, Continuous Filtration, Filter cake resistance, specific cake resistance, Washing and dewatering of filter cakes

UNIT III ABSORPTION 9

Gas Absorption: Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, absorption factor, stripping factor, minimum gas liq ratio, Single stage gas absorption Cross Current, Co- current, Countercurrent, Multistage Counter current Operation, Absorption with Chemical Reactions, Related problems

UNIT IV EXTRACTION 9

Liquid-Liquid Separation Process: Single Stage Operation, Equipments for liquid-liquid extraction. Types of extraction processes: Reactive extraction, Aqueous two-phase systems, Reverse micellar extraction, solid-liquid extraction, Supercritical fluid Extraction. Different types of extractors and designing of extractors. Distillation: Simple, Steam and Equilibrium distillation, Fractionation, Mccabe Thiele method, azotropes,

UNIT V CHROMATOGRAPHY AND MEMBRANE SEPARATION 9

Theory of chromatography, Shape and yield of a chromatographic peak, Binary chromatography, Hydrodynamic chromatography. Membrane-based bioseparation - Classification of membrane processes, Ultrafiltration, Microfiltration, Dialysis, Liquid membrane processes, Membrane chromatography, Electrophoresis, Affinity ultrafiltration, Field-flow fractionation

TOTAL :45 PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1- Understand the basic concept of bioseparation processes.

CO2- Acquire knowledge on theory, design, and application of bioprocessing.

CO3- To understand the basic concepts absorption and their problems in bioprocessing.

CO4- Gather knowledge on extraction of bioproducts using different methods.

CO5- A cquire knowledge on chromatography techniques and their analysis, membrane separation process.

TEXT BOOKS:

1. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, Bio separations Science and Engineering, Oxford University Press, 2015.
2. Treybal R.E., Mass transfer operation, 3rd edition., McGraw Hill New York, 1980.
3. Shivashankar, Bioseparations: Principles and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
4. Subramanian Ganapathy, Bioseparation & B ioprocessing 2-Volume set: v.1, Wiley-VCH, (2007)

REFERENCES:

1. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley Interscience Publication, 1988.
2. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.

Scopes Ak, Protein Purification, IRL Press, 1993
3. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993
4. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989
5. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag, 2013.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	2	2	2	2	3	1	2	2	2	2	2	2	2	2	2
CO 3	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2
CO 4	2	2	2	2	3	2	2	2	2	1	2	2	2	2	2
CO 5	2	3	2	3	3	2	2	2	2	1	2	2	2	2	2

CH23C15 ENZYME IMMOBILISATION TECHNOLOGY L T P C

3 0 0 3

COURSE OBJECTIVES:

- To understand Enzymes, homogeneity, and heterogenicity.
- To understand structural, functional properties, and metabolic pathways.
- To learn immobilization procedures, and types.
- To describe on the heterogenous enzyme kinetics and its effects.
- To design enzyme reactors.

UNIT I INTRODUCTION 9

Catalysis and biocatalysis, Enzyme classification and nomenclature, enzyme structure, functionality and relationship, enzyme activity, enzyme sources, synthesis, recovery and purification, enzymes as process catalysts.

UNIT II HOMOGENEOUS ENZYME KINETICS 9

Hypothesis of enzyme kinetics, rapid equilibrium and steady-state hypothesis, determination of kinetic parameters, various types of kinetic inhibition, reactions with more than one substrate, effect of environmental variables- pH, temperature, and ionic strength.

UNIT III BASICS OF IMMOBILISATION 9

Immobilisation — Functional properties, Classification of Immobilisation techniques — Adsorption, matrix entrapment, crosslinking, covalent binding- advantages & disadvantages of each method, selection and characterisation of matrices for immobilisation, effect of physico chemical parameters on immobilised enzymes.

UNIT IV HETEROGENEOUS ENZYME KINETICS 9

Mass transfer effects in heterogeneous biocatalysis, partition effects, Immobilised enzyme kinetics

- external (film) diffusion, internal (pore) diffusional kinetics, Thiele modulus and Effectiveness factor. Effects of electrostatic potential of the micro environment.

UNIT V ENZYME REACTORS & APPLICATION OF IMMOBILISED ENZYMES 9

Design of reactors with immobilised enzymes, Design of advanced immobilized enzyme systems, Application of immobilised enzymes in food industry, textile industry, Pharmaceutical industry & in medicine, in the production of biofuels, detergent industry, production of various bio-products, as biosensors.

TOTAL :45 PERIODS

OUTCOMES:

On completion of the course, the students will be able to

CO1 – Understand the basic knowledge on classification of enzymes and their nomenclature.

CO2 - Understand Enzymes, homogeneity, and heterogenicity.

CO3 - Understand structural, functional properties, and metabolic pathways of enzymes. CO4 - Learn immobilization procedures, and their different types.

CO5 – Knowledge on designing enzyme reactors.

TEXT BOOKS:

1. "Enzyme Technology" by M.F.Chaplin and C.Bucke, Cambridge University press, 1990. (Website for the book, www:lsbu.ac.uk/biology/enztech/)
2. "Biocatalysts and Enzyme Technology" by K. Buchholz,V. Kasche and U.T. Bornscheur, Wiley,2005

REFERENCE BOOKS:

1. "Enzyme Technology", by Shanmugam,S. and Satish Kumar,T.,IK International Pvt. Ltd, New Delhi, 2008
2. Enzyme Biocatalysis: Principles and Applications' by A.Illanes, Springer,2008

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	2	-	-	1	-	1	1	2	1	1	-	1	2	1	1
CO 2	2	-	1	1	1	1	1	2	1	1	-	1	2	1	1
CO 3	2	-	1	1	1	1	1	2	1	1	-	1	2	1	1
CO 4	2	2	2	1	2	1	1	2	1	1	-	1	2	1	1
CO 5	2	2	3	2	2	2	1	2	2	1	2	1	2	1	1

CH23C16	BIOREACTOR DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of bioreactor design.
- To discuss on the different design equation involved for bioreactors.
- To signify the various parameters involved for the configuration of bioreactors.
- To design single and multiple bioreactors.
- To design a bioprocess system.

UNIT I BIOREACTOR & MEDIA REQUIREMENTS 9

Microbial growth and product formation kinetics, Bioreactor Selection, Reactor operational mode and selection.

UNIT II DESIGN EQUATIONS FOR BIOREACTORS 9

Basic Design Equations/ Mole Balances: Batch, Fed-Batch and Repetitive Batch Reactors, Continuous: Stirred tank and tubular flow reactors, Microbial death kinetics, Design criterion for sterilization, Batch and continuous sterilization of medium, Multiple reactions-series, parallel and mixed-mode, Air sterilization.

UNIT III BIOREACTOR REQUIREMENTS 9

Process-General requirements; Basic design and construction of bioreactors and their ancillaries; Material of construction, Vessel geometry, Bearing Assemblies, Motor drives, Aseptic seals; Flow measuring devices, Valves, Agitator and Sparger Design, Sensors, Non-isothermal homogeneous reactor systems. Adiabatic reactors, batch and continuous reactors, optimum temperature progression.

UNIT IV DESIGN OF BIOREACTORS 9

Process and mechanical design of Bioreactors, volume, sparger, agitator-type, size and motor power, heat transfer calculations for coil and jacket, sterilization system, scale-up, scale down, bioinstrumentation and control.

UNIT V NOVEL BIOREACTORS DESIGN 9

Design of Immobilized enzyme packed bed Reactor. Fluidized bed reactors, Slurry Reactors, Airlift & Loop reactors, Packed bed and Hollow fiber membrane bioreactors, Bioreactors for waste treatment processes; SSF bioreactors.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the students will be able to

CO1: Compare kinetics and reaction rates for various bioreactor designs, based on operational mode and type of substrate.

CO2: Differentiate and estimate productivity in commercial bioreactors- packed bed, fed batch reactors

CO3:Helps to understand various requirements such as material of construction, valves, agitator, sensors etc

CO4:Understanding the mechanical design and heat transfer calculations for various type of bioreactor

CO5: Analyze immobilization techniques in reactors and use it for various applications

TEXT BOOKS:

1. Bioprocess Engineering -Kinetics, Mass Transport, Reactors and Gene Expression Wolf R. Vieth A Wiley-Interscience Publication 1994
2. Chemical Kinetic Methods: Principles of relaxation techniques Kalidas C New Age International 1996
3. Chemical Reactor Analysis and Design Forment G F and Bischoff K B John Wiley 1990

REFERENCE:

1. Bioprocess Engineering -Kinetics, Biosystems, sustainability and reactor Design, Shijie Liu, Elsevier Publication 2013.

O mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	2	2	2	3	3	2	2	2	2	2	2	2	2	3	2
CO 3	2	2	2	3	3	2	2	2	2	2	2	2	2	3	2
CO 4	2	2	3	3	3	2	2	2	3	2	2	2	2	3	2
CO 5	2	2	3	3	3	2	2	2	3	2	2	3	2	3	2

PROFESSIONAL ELECTIVE COURSES

VERTICAL IV: ENVIRONMENTAL AND SAFETY ENGINEERING

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1	CH23D11	Air Pollution and Control	3	0	0	3	3
2	CH23D12	Waste Water Treatment	3	0	0	3	3
3	CH23D13	Solid waste Management	3	0	0	3	3
4	CH23D14	Environmental Impact Assessment and Management	3	0	0	3	3
5	CH23D15	Process Safety Management	3	0	0	3	3
6	CH23D16	Risk and HAZOP Analysis	3	0	0	3	3

CH23D11 AIR POLLUTION AND CONTROL L T P C
3 0 0 3

OBJECTIVES:

- To introduce students to basic concepts of pollution.
- The contents involved the knowledge of causes of air pollution and dispersion of pollutants.
- The equipment students to control air pollution levels by designing.
- To develop conventional and hybrid equipment to control air pollution.
- To learn about air pollution cost models.

UNIT I INTRODUCTION 9

Air Pollution Regulatory Framework History – Air Pollution Regulatory Framework - Regulatory System Laws and Regulations – Clean air Act – Provisions for Recent Developments.

UNIT II AIR POLLUTION GASES 9

Measurement fundamentals – Flue dispersion behavior - chemicals and physical properties – Phase Equilibrium - consecution laws Incinerators – Design and Performance – Operation and Maintenance - Absorbers – Design operationand improving performances Absorbers.

UNIT III PARTICULATE AIR POLLUTION 9

Particle Collection mechanisms– Fluid particle - Dynamics – Particle size Distribution – Efficiency – Gravity Settling chambers Cyclones- Electrostatic precipitators

UNIT IV HYBRID SYSTEM 9

Heat electrostatic precipitation – Genizing Heat Scrubbers – Dry Scrubbers – ElectrostaticallyAugmented Fabric Filtration

UNIT V AIR POLLUTION CONTROL EQUIPMENT 9

Introduction – Installation and Cost of biofilters – Catalytic reactor- Ceramic Filters.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students will have

- Ability to understand basic concepts of pollution.
- Ability to understand the dispersion of pollutants
- Ability to identify engineering problems that occur during the control of air pollution
- Ability to develop conventional and hybrid equipment

- An understanding of the cost of air pollution control equipment

TEXTBOOKS:

1. Louis Theodore "Air Pollution Control Equipment Calculations" ,Wiley Interscience, 1st edition,2008.
2. C. David Cooper and F.C. Alley "Air Pollution Control: A Design Approach "Waveland Press ,3rd Edition ,2002.
3. Noel De Nevers, "Air pollution control Engineering", McGraw Hill International Edition, McGraw Hill Inc, New Delhi, 2000.

REFERENCES

1. M. N. Rao, H. V. N. Rao, Air pollution, Tata McGraw Hill Pvt Ltd, New Delhi, 2017
2. Dr. Y. Anjaneyulu, "Air Pollution and Control Technologies", Allied publishers Pvt. Ltd., 2019.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	3	1	2	2	1	1	1	1	1	3	2	1
CO 2	3	2	2	3	1	2	2	1	1	1	1	1	3	2	1
CO 3	3	2	2	3	1	2	2	1	1	1	1	1	3	2	1
CO 4	3	2	2	3	1	2	2	1	1	1	1	1	3	2	1
CO 5	3	2	2	3	1	2	2	1	1	1	1	1	3	2	1

CH23D12 WASTEWATER TREATMENT L T P C
3 0 0 3

OBJECTIVES:

- To focus on the wastewater transport system and the theory and design technique for the wastewater treatment process.
- To enable students to understand about the principles behind separation systems.
- To gain knowledge on Chemical unit processes and their application.
- To be exposed to the various biological treatments includes aerobic and anaerobic processes.
- To study the advanced wastewater treatment methods for minimization of contaminants.

UNIT I WASTE WATER TREATMENT AN OVERVIEW 9

Terminology – Regulations – Health and Environment Concerns in waste water management – Constituents in waste water inorganic – Zero Liquid Discharge (ZLD)- Organic and metallic constituents.

UNIT II PROCESS ANALYSIS AND SELECTION 9

Components of waste water flows – Analysis of Data – Reactors used in waste water treatment – Mass Balance Analysis – Modeling of ideal and non-ideal flow in Reactors – Process Selection.

UNIT III CHEMICAL UNIT PROCESSES 9

Role of unit processes in waste water treatment chemical coagulation – Chemical precipitation for improved plant performance chemical oxidation –Neutralization – Chemical Storage.

UNIT IV BIOLOGICAL TREATMENT 9

Overview of biological Treatment – Microbial metabolism – Bacterial growth and growth curve – Aerobic biological oxidation – Anaerobic fermentation and oxidation – Trickling filters – Rotating biological contractors – Combined aerobic processes – Activated sludge film packing.

UNIT V ADVANCED WASTE WATER TREATMENT 9

Technologies used in advanced treatment – Classification of technologies Removal of Colloids and suspended particles – Depth Filtration – Surface Filtration – Membrane Filtration Absorption – Ion Exchange – Advanced oxidation process, Electrocoagulation, Microbial Fuel Cell (MFC), and Nano-based treatment.

TOTAL: 45 PERIODS

OUTCOMES:

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

- Evaluate the various regulations related to wastewater treatment.
- Identify the reactors used in wastewater treatment.
- Compare unit processes in wastewater treatment.
- Discuss biological treatment methods for wastewater.
- Determine the advanced technologies in wastewater treatment.

TEXTBOOKS:

1. Waste water Engineering Treatment and Reuse: Mc Graw Hill, G. Tchobanoglous, FI Biston, 2002.
2. Industrial Waste Water Management Treatment and Disposal by Waste Water Mc Graw Hill III Edition 2008.

REFERENCES

1. Rangwala.S.C, “Fundamentals of water supply and sewerage Engineering”, Charotar Publishing,2000.
2. Birde.G.SandBirde.J.S,“Water supply and sanitary Engineering”,DhanpatRai Publications Pvt.Ltd New Delhi,2001.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	1	1	1	1	1	1	3	3	2	2
CO 2	3	2	3	2	3	2	2	1	1	1	1	2	2	2	2
CO 3	3	2	2	2	2	1	1	1	1	1	1	1	3	1	2
CO 4	3	3	2	1	3	2	1	2	2	3	1	2	3	2	2
CO 5	3	2	2	2	3	1	2	1	2	3	2	1	3	3	2

CH23D13 ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT

L T P C

3 0 0 3

OBJECTIVES:

- To provide a comprehensive understanding of Environmental Impact Assessment (EIA) and its process
- To identify and predict environmental impacts using various tools and methods, such as matrices, networks, checklists, and cost-benefit analysis.
- To teach students the essentials of documenting EIA findings, including effective planning, organizing information, creating visual displays, and preparing comprehensive reports
- To provide students with the knowledge and skills to prepare, implement, and review an Environmental Management Plan (EMP).
- To equip students with the ability to assess and manage environmental risks by introducing them to key frameworks and methodologies like HAZOP, FMEA.

UNIT I INTRODUCTION 8

Historical development of Environmental Impact Assessment (EIA). EIA in Project Cycle. Legal and Regulatory aspects in India. – Types and limitations of EIA –.EIA process- screening – scoping - setting – analysis – mitigation. Cross sectoral issues and terms of reference in EIA – Public Participation in EIA

UNIT II IMPACT INDENTIFICATION AND PREDICTION 10

Matrices – Networks – Checklists –Cost benefit analysis – Analysis of alternatives – Software packages for EIA – Expert systems in EIA. Prediction tools for EIA – Mathematical modeling for

impact prediction – Assessment of impacts – air – water – soil – noise – biological — Cumulative Impact Assessment

UNIT III SOCIAL IMPACT ASSESSMENT AND EIA DOCUMENTATION 8

Social impact assessment - Relationship between social impacts and change in community and institutional arrangements. Individual and family level impacts. Communities in transition Documentation of EIA findings – planning – organization of information and visual display materials – Report preparation.

UNIT IV ENVIRONMENTAL MANAGEMENT PLAN 7

Environmental Management Plan - preparation, implementation and review – Mitigation and Rehabilitation Plans – Policy and guidelines for planning and monitoring programmes – Post project audit – Ethical and Quality aspects of Environmental Impact Assessment- Case Studies

UNIT V ENVIRONMENTAL RISK ASSESSMENT AND MANAGEMENT 12

Environmental risk assessment framework-Hazard identification -Dose Response Evaluation – Exposure Assessment – Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree and fault tree analysis – Multimedia and multipath way exposure modelling of contaminant- Risk Characterization Risk communication - Emergency Preparedness Plans –Design of risk management programs-

TOTAL: 45 PERIODS

OUTCOMES:

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

- Understand the historical development and significance of Environmental Impact Assessment (EIA) within project cycles.
- Identify and predict environmental impacts using various tools such as matrices, networks, and checklists.
- Develop skills in planning, organizing information, creating effective visual displays, and preparing comprehensive EIA reports.
- Prepare, implement, and review Environmental Management Plans (EMP) effectively. They will be skilled in developing mitigation and rehabilitation plans, applying relevant policies and guidelines for planning and monitoring environmental programs.
- **A**pply comprehensive environmental risk assessment frameworks, including hazard identification, dose-response evaluation, and exposure assessment. They will be proficient in using tools such as HAZOP and FEMA methods, event tree and fault tree analysis

TEXTBOOKS

1. Canter, L.W., "Environmental Impact Assessment", McGraw Hill, New York. 1996

2. Lawrence, D.P., "Environmental Impact Assessment – Practical solutions to recurrent problems", Wiley-Interscience, New Jersey. 2003

3. World Bank –Source book on EIA

4. Cutter, S.L., "Environmental Risk and Hazards", Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.

REFERENCES

1. Kolluru Rao, Bartell Steven, Pitblado R and Stricoff "Risk Assessment and Management Handbook", McGraw Hill Inc., New York,1996.
2. K. V. Raghavan and A A. Khan, "Methodologies in Hazard Identification and Risk Assessment", Manual by CLRI, 1990.
3. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification, Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 2	3	2	3	2	3	2	2	1	1	1	1	2	2	2	2
CO 3	3	2	2	2	2	1	1	1	1	1	1	1	3	1	2
CO 4	3	3	2	1	3	2	1	2	2	3	1	2	3	2	2
CO 5	3	2	2	2	3	1	2	1	2	3	2	1	3	3	2

CH23D14 SOLID WASTE MANAGEMENT

L T P C
3 0 0 3

OBJECTIVES:

- To provide students with a comprehensive understanding of the various types and sources of solid and hazardous wastes and the necessity of effective waste management.
- To enable students to understand solid and hazardous wastes' characteristics and generation patterns, including their physical, chemical, and biological properties.
- To provide students with the knowledge and skills necessary for effectively handling, segregating, storing, and collecting municipal solid and hazardous wastes.
- To introduce students to the various technologies used in waste processing, including material separation, biological and chemical conversion, composting, and thermal conversion with energy recovery
- To provide students with a comprehensive understanding of various waste disposal options, with a focus on landfill disposal methods.

UNIT I SOURCES, CLASSIFICATION AND REGULATORY FRAMEWORK 9

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management –- Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, nuclear wastes - lead acid batteries, electronic

wastes , plastics and fly ash – Elements of integrated waste management and roles of stakeholders - Financing and Public Private Participation for waste management.

UNIT II WASTE CHARACTERIZATION AND SOURCE REDUCTION 8

Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse

UNIT III STORAGE, COLLECTION AND TRANSPORT OF WASTES 9

Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes – hazardous waste manifests and transport- Circular Economy - Waste disposal options – Challenges.

UNIT IV WASTE PROCESSING TECHNOLOGIES 10

Objectives of waste processing – material separation and processing technologies – biological and chemical conversion technologies – methods and controls of Composting - thermal conversion technologies and energy recovery – incineration – solidification and stabilization of hazardous wastes - treatment of biomedical wastes - Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment

UNIT V WASTE DISPOSAL 9

Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – Rehabilitation of open dumps – landfill remediation

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student is expected to be able to

- Identify and classify different types of solid and hazardous wastes, understand the legal and regulatory frameworks in India for waste management.
- Analyze waste generation rates, and accurately characterize solid and hazardous wastes based on their properties and hazardous characteristics.
- Design and evaluate waste handling, segregation, and collection systems for municipal solid wastes, and understand the operational needs of transfer stations.
- Understand and apply different waste processing technologies for material separation, biological and chemical conversions, and thermal treatments.
- Evaluate and select appropriate waste disposal methods, particularly focusing on landfill design and operation.

TEXTBOOKS:

1. William A. Worrell, P. AarneVesilind (2012) Solid Waste Engineering, Cengage Learning,

2012.
2. John Pitchel (2014), Waste Management Practices-Municipal, Hazardous and industrial — CRC Press, Taylor and Francis, New York.
3. Tchobanoglous, G., Theisen, H. M., and Eliassen, R. "Solid. Wastes: Engineering Principles and Management Issues". McGraw Hill, New York, 1993.
4. Vesilind, P.A. and Rimer, A.E., "Unit Operations in Resource Recovery Engineering", Prentice Hall, Inc., 1981

REFERENCE BOOKS:

1. Government of India, "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of UrbanDevelopment, New Delhi, 2000.
2. Manser A.G.R. and Keeling A.A.," Practical Handbook of Processing and Recycling of Municipal solid Wastes", Lewis Publishers, CRC Press, 1996.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	1	1	1	1	1	1	3	3	2	2
CO 2	3	2	3	2	3	2	2	1	1	1	1	2	2	2	2
CO 3	3	2	2	2	2	1	1	1	1	1	1	1	3	1	2
CO 4	3	3	2	1	3	2	1	2	2	3	1	2	3	2	2
CO 5	3	2	2	2	3	1	2	1	2	3	2	1	3	3	2

CH23D15 PROCESS SAFETY MANAGEMENT

L T P C
3 0 0 3

OBJECTIVES:

- To achieve an understanding of the principles of safety management.
- To enable the students to learn about various functions and activities of the safety department.
- To enable students to conduct safety audit and write audit reports effectively in auditing situations.
- To have knowledge about sources of information for safety promotion and training.
- To familiarize students with evaluation of safety performance.

UNIT I CONCEPTS AND TECHNIQUES 9

History of Safety movement –Evolution of modern safety concept- general concepts of management – planning for safety for optimization of productivity -productivity, quality and safety-line and staff functions for safety-budgeting for safety-safety policy. Incident Recall Technique (IRT), disaster control, job safety analysis, safety survey, safety inspection, safety sampling, evaluation of performance of supervisors on safety.

UNIT II SAFETY AUDIT **9**

Components of safety audit, types of audit, audit methodology, non-conformity reporting (NCR), audit checklist and report – review of inspection, remarks by government agencies, consultants, experts – perusal of accident and safety records, formats – implementation of audit indication - liaison with departments to ensure co-ordination – check list – identification of unsafe acts of workers and unsafe conditions in the shop floor.

UNIT III ACCIDENT INVESTIGATION AND REPORTING **9**

Concept of an accident, reportable and non-reportable accidents, reporting to statutory authorities – principles of accident prevention – accident investigation and analysis – records for accidents, departmental accident reports, documentation of accidents – unsafe act and condition – domino sequence – supervisory role – role of safety committee –cost of accident.

UNIT IV SAFETY PERFORMANCE MONITORING **9**

ANSI (Z16.1) Recommended practices for compiling and measuring work injury experience – permanent total disabilities, permanent partial disabilities, temporary total disabilities - Calculation of accident indices, frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, safety "t" score, safety activity rate – problems.

UNIT V SAFETY EDUCATION AND TRAINING **9**

Importance of training-identification of training needs-training methods – programmes, seminars, conferences, competitions – method of promoting safe practice - motivation – communication - role of government agencies and private consulting agencies in safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign – Domestic Safety and Training.

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to

- To understand the functions and activities of the safety engineering department.
- To carry out a safety audit and prepare a report for the audit.
- To prepare an accident investigation report.
- To estimate the accident cost using the supervisor's report and data.
- To evaluate the safety performance of an organization from accident records.
- To identify various agencies, support institutions, and government organizations involved in safety training and promotion

TEXTBOOKS

1. "Accident Prevention Manual for Industrial Operations", N.S.C.Chicago, 13th Edition 2009.
2. Blake R.B., "Industrial Safety" Prentice Hall, Inc., New Jersey,. 3rd Edition 2000.
3. Dan Petersen, "Techniques of Safety Management", McGraw-Hill Company, Tokyo, 1981.
4. Heinrich H.W. "Industrial Accident Prevention" McGraw-Hill Company, New York, 1980

REFERENCES

1. John Ridley, “Safety at Work”, Butterworth and Co., London, 1983
2. Lees, F.P., “Loss Prevention in Process Industries” Butterworth publications, London, 2nd edition, 1990.
3. Relevant Indian Standards and Specifications, BIS, New Delhi.
4. “Safety and Good House Keeping”, N.P.C., New Delhi, 1985.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	1	1	1	1	1	1	3	3	2	2
CO 2	3	2	3	2	3	2	2	1	1	1	1	2	2	2	2
CO 3	3	2	2	2	2	1	1	1	1	1	1	1	3	1	2
CO 4	3	3	2	1	3	2	1	2	2	3	1	2	3	2	2
CO 5	3	2	2	2	3	1	2	1	2	3	2	1	3	3	2

CH23D16 RISK AND HAZOP ANALYSIS

L T P C

3 0 0 3

OBJECTIVES:

- To introduce the fundamental concepts and methodologies of consequence analysis within the context of risk assessment.
- To provide students with a detailed understanding of the models used to analyze fire and explosion scenarios, including the calculation of radiation intensity, flame length, and the effects on plants, people, and property.
- To equip students with the knowledge and skills required to conduct comprehensive risk analysis and develop effective risk management strategies.
- To develop students' ability to identify hazards and conduct thorough safety audits using various tools such as checklists, "what if" analysis, vulnerability models, and event and fault tree analysis.
- To familiarize students with the Hazard and Operability Study (HAZOP) methodology, including the use of guide words, parameters, deviations, causes, and consequences to systematically identify and mitigate risks in industrial processes.

UNIT I INTRODUCTION TO CONSEQUENCE ANALYSIS 9

Risk analysis introduction – quantitative risk assessment – rapid risk analysis – comprehensive risk analysis – emission and dispersion – leak rate calculation – single and two phase flow – dispersion model for dense gas – flash fire – plume dispersion – jet dispersion – toxic dispersion model – evaluation of risk.

UNIT II FIRE AND EXPLOSION MODELS 9

Radiation – tank on fire – flame length – radiation intensity calculation and its effect on plant, people & property radiation VCVCE – explosion due to – over pressure – effects of explosion, risk contour –effects, explosion – BLEVE – jet fire – fire ball.

UNIT III RISK MANAGEMENT AND ISO 14000 9

Overall risk analysis – generation of metrological data – ignition data – population data consequences analysis and total risk analysis – overall risk contours for different failure sceneries – disaster management plan – emergency planning – on site & off site emergency planning, risk management ISO 14000, EMS models, case studies – marketing terminal, gas processing complex, refinery.

UNIT IV PAST ACCIDENT ANALYSIS 9

Hazard identification – safety audits – checklists – what if analysis – vulnerability models event tree and fault tree analysis. HAZAN, past accident analysis fix borough– Mexico – Bhopal – Madras – Vizag accident analysis.

UNIT V PRINCIPLES OF HAZOP 9

HAZOP – guide word – parameter – deviation – causes – consequences – recommendation - coarse HAZOP study – case studies – pumping system – reactor system – mass transfer system.

TOTAL : 45 PERIODS

OUTCOMES

Upon completion of the course, the Students will be able,

- To evaluate and interpret the risks associated with various dispersion scenarios, contributing to more effective risk management and safety planning.
- To apply fire and explosion models to assess potential hazards in industrial settings
- To perform overall risk analysis using various data inputs and create detailed risk contours for different failure scenarios.
- To effectively identify potential hazards and conduct comprehensive safety audits using structured methods.

- To conduct HAZOP studies to identify potential hazards and operability issues in industrial processes

TEXTBOOKS

1. K.V. Raghavan and A.A. Khan: "Methodologies in Hazard identification and assessment manual", by CLRI December 1990.
2. V.C. Marshal: "Major Chemical Hazards", Ellis Harwood Ltd., Chichester, U.K. 1987

REFERENCES

1. Frank P. Lees: "Loss prevention in process industries", Vol I: Butter worth –London1980.
2. A Guide to Hazard Operability Studies – Chemical Industry Safety and Health Council 1977.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	1	1	1	1	1	1	3	3	2	2
CO 2	3	2	3	2	3	2	2	1	1	1	1	2	2	2	2
CO 3	3	2	2	2	2	1	1	1	1	1	1	1	3	1	2
CO 4	3	3	2	1	3	2	1	2	2	3	1	2	3	2	2
CO 5	3	2	2	2	3	1	2	1	2	3	2	1	3	3	2

PROFESSIONAL ELECTIVE COURSES

VERTICAL V: COMPUTATIONAL CHEMICAL ENGINEERING

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1	CH23E11	Computational Techniques	3	0	0	3	3
2	CH23E12	Optimization of Chemical Processes	3	0	0	3	3
3	CH23E13	Process Modeling and Simulation	3	0	0	3	3
4	CH23E14	Pinch Analysis and Heat Exchange Network Design	3	0	0	3	3
5	CH23E15	Chemical Process Flow sheeting	3	0	0	3	3
6	CH23E16	Computational Fluid Dynamics for Chemical Engineers	3	0	0	3	3

CH23E11 COMPUTATIONAL TECHNIQUES

L T P C

3 0 0 3

OBJECTIVES:

The main learning objective of this course is to prepare the students for:

- Applying Solve chemical engineering problems form core courses using Excel, Matlab, Polymath and process simulation packages.
- To learn various numerical computational techniques and apply to engineering problems
- To provide the basic concepts of numerical methods in view of solving linear systems and nonlinear equations
- To introduce several methods for the interpolation of data from chemical engineering problems
- To train students with mathematical aspects so as to comprehend, analyze, design and create novel products and solution for the real-life problems

UNIT I INTRODUCTION TO COMPUTATIONAL TECHNIQUES 9

Introduction: Motivation and applications; Computation and error analysis: Accuracy and precision; Truncation and round-off errors; Binary Number System; Error propagation; Functional analysis

UNIT II NUMERICAL COMPUTATIONAL TECHNIQUES 9

Linear Systems and Equations: Roots of algebraic equation; Matrix representation; Cramer's rule; Gauss Elimination; Matrix Inversion; LU Decomposition; Iterative Methods; Relaxation Methods; Eigen Values.

UNIT III METHODS OF SOLUTION 9

Algebraic Equations: Bracketing methods: Bisection, Reguli Falsi; Open methods: Secant, Fixed point iteration, Newton-Raphson; Multivariate Newton’s method.

UNIT IV DATA FITTING AND INTERPOLATIONS 9

Regression and Curve fitting: Linear regression; Least squares; Total Least Squares; Interpolation; Newton’s Difference Formulae; Cubic Splines, mathematical modeling, parameter identification;

Numerical differentiation: Numerical differentiation; higher order formulae.

UNIT V MATHEMATICAL EQUATIONS & SOLUTIONS 9

Integration and Integral Equations: Trapezoidal rules; Simpson's rules; Quadrature; ODEs & PDEs: Initial Value problems. Boundary value problems, Introduction to Partial Differential Equations.

TEXT BOOKS

1. Gupta Santosh Kumar (2015) Numerical Methods for Engineers, New Age International.

2. Chapra S.C. and Canale R.P.(2014) Numerical Methods for Engineers, 7th Ed; McGraw Hill.

REFERENCES:

1. Ramirez, W., Computational Methods in Process Simulation, 2nd Edn., Butterworths Publishers, New York, 2000.

2. Chemical Process Modeling and computer simulation, Amiya K Jana, PHI, 3rd Edn, 2018

OUTCOMES

Upon completing the course, the student can

- Learn how to apply error analysis and data analysis methods to experimental data and real life problems
- Apply computational and numerical methods to solve single and simultaneous equations
- Apply computational techniques to solve practical engineering problems with algebraic equations
- Apply the knowledge about ordinary and partial differential equations (ODEs & PDEs) and how they serve as mathematical models for physical processes and learn their solution techniques
- Apply the methodologies to solve the system of integral equations numerically for exact/approximate solutions of chemical engineering and real life problems involving initial and boundary value problems

Mapping of Course Outcomes with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	-	-	-	1	2	-	2	2	3	
CO2	3	3	1	3	2	-	-	-	1	2	-	3	3	3	2
CO3	3	3	1	3	3	-	-	-	1	2	-	3	3	3	2
CO4	3	3	3	3	3	-	-	-	1	2	-	3	3	3	3
CO5	3	3	3	3	3	-	-	-	1	2	-	3	3	3	3

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

CH23E12 OPTIMIZATION OF CHEMICAL PROCESSES

L T P C

3 0 0 3

OBJECTIVES:

The course is aimed to

- Develop objective functions for optimization problems.
- Ue linear programming, geometric, dynamic and integer programming and genetic algorithms for solution.
- To develop the concept of optimization in engineering systems & real-life problems.
- To provide optimal solutions to chemical engineering problems.

UNIT I : INTRODUCTION TO OPTIMIZATION 9

Introduction to optimization; applications of optimization in chemical engineering; classification of optimization problems; Developing models for optimization

UNIT II : FUNCTIONS AND THEIR CHARACTERISTIC METHODS 9

Continuity of Functions; NLP Problem Statement Convexity and Its Applications Interpretation of the Objective Function in Terms of its Quadratic Approximation Necessary and Sufficient Conditions for an Extremum of an Unconstrained Function; region elimination methods; interpolation methods; direct root methods.

UNIT III: GENERAL ALGORITHMS TO SOLVE OPTIMIZATION PROBLEMS 9

Methods Using Function Values Only -Random Search -Grid Search – Univariate Search - Simplex Search Method - Conjugate Search Directions; Methods That Use First Derivatives - Steepest Descent - Conjugate gradient Methods; Newton's Method and Quasi Newton's Method.

UNIT IV : HIGHER ORDER TECHNIQUES TO SOLVE OPTIMIZATION PROBLEMS 9

Introduction to geometric, dynamic and integer programming and genetic algorithms. Linear Programming – Solution of Problems using Excel SOLVER.

UNIT V : OBJECTIVE FUNCTIONS APPLIED TO CHEMICAL ENGINEERING 9

Formulation of objective functions; fitting models to data; applications in fluid mechanics, heat transfer, mass transfer, reaction engineering, equipment design, reaction engineering, resource allocation and inventory control.

Total: 45 Periods

OUTCOMES:

On the completion of the course students are expected to

CO1: Frame mathematical models and formulate optimization models for chemical processes / equipment.

CO2: Understand the concept of optimum and extremum and the necessary and sufficient conditions for extremum and solve single and multivariable optimization problems through various techniques.

CO3: Apply various search methods to solve unconstrained single variable optimization and unconstrained multi variable optimization

CO4: Apply higher order techniques like geometric programming, dynamic and integer programming and genetic algorithms

CO5: Able to use the principles of engineering and in particular chemical engineering to develop equality and inequality constraints for an optimization problem and apply solutions

TEXT BOOKS:

1. Rao, S. S., Engineering Optimization - Theory and Practice, Third Edition, John Wiley & Sons, New York, 2013.

2. Edgar, T.F., Himmelblau, D.M., Optimisation of Chemical Processes, McGraw-Hill Book Co., New York, 2003.

3. Weiguo Xie, Sam Toan, Richard Davis "Chemical Engineering Analysis & Optimization using Matlab", John Wiley, New York, 2024.

REFERENCES:

1. Venkataraman, P. (2009). Applied optimization with MATLAB programming. John Wiley & Sons.

2. Ferris, M. C., Mangasarian, O. L., & Wright, S. J. (2007). Linear programming with MATLAB (Vol. 7). SIAM.

3. J Nocedal and S J Wright (2006). Numerical Optimization. Springer Verlag.

4. Suman Dutta (2016). Optimization in Chemical Engineering, Cambridge University Press.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	-	-	-	3	2	3	2	2	3	-
CO 2	3	3	3	1	2	-	-	-	3	2	1		3	3	-
CO 3	3	3	3	3	3	-	1	-	3	3	3	3	3	3	-
CO 4	3	3	3	3	3	-	1	-	3	3	3	2	3	-	-
CO 5	3	3	3	3	3	-	-	-	3	3	-	-	1	1	-

CH23E13 PROCESS MODELING AND SIMULATION

L T P C

3 0 0 3

OBJECTIVES:

The course is aimed to

- Develop steady state and transient models for processes and unit operations.
- To understand lumped and distributed parameter models.
- To seek solution of models using analytic and numerical techniques.
- To construct data driven models and estimate the parameters.

UNIT I : PRELIMINARIES TO MATHEMATICAL MODELING 9

Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

UNIT II : MATHEMATICAL MODELING AND SOLUTIONS 9

Degree of freedom analysis, single and network of process units, systems yielding linear and nonlinear algebraic equations, flow sheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations using Matrices and Numerical techniques. Error estimates.

UNIT III : CHEMICAL ENGINEERING MODELS AND SOLUTIONS 9

Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems – Solution of ODE using Eigen values – Jordan Canonical Form – Stiff equations – Gear's algorithm -Perturbation Methods.

UNIT IV : COMPLEX MODELS AND SOLUTIONS 9

Analysis of compressible flow, heat exchanger, packed columns, Monolith Reactor Modeling – Pseudo-homogeneous and Heterogeneous models for catalytic reactors – plug flow reactor, solution of ODE boundary value problems – shooting Method.

UNIT V : APPLICATIONS & SOLUTIONS TO DIFFERENT TYPES OF MATH MODELS 9

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, - hierarchy in model development, classification and solution of partial differential equations – Characteristic

curves for parabolic, Elliptic and Hyperbolic equations - Empirical modeling, parameter estimation, population balance and stochastic modelling - Principal Component Analysis.

TOTAL: 45 PERIODS

OUTCOMES:

On the completion of the course students are expected to

CO1: Understand the fundamentals of modeling and their applications to transport/energy equations, chemical and phase equilibria kinetics.

CO2: Associate the model with constitutive relations such as phenomenological laws, rate equations, equations of state, property estimation methods.

CO3: Create the mathematical models for different unit operations equipments such as stirred tank heaters, Heat exchangers, Evaporators, Reactors, distillation columns

CO4: Analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems

CO5: Apply relevant solution methods for different types of mathematical models and data driven models

TEXT BOOKS

1. Nayef Ghasem, "Modeling and simulation of chemical process systems," CRC Press (2015)

2. An Introduction to Process Modelling Identification and Control for Engineers, Rames Chandra Panda, T. Thyagarajan, Narosa Publishing House, Alpha Science, 2017

3. Varma A. and Morbidelli M., Mathematical Methods in Chemical Engineering, Oxford University Press, 1997.

REFERENCES:

1. Upreti Simant R, Process Modeling and Simulation for Chemical Engineers, John Wiley & Sons Inc. 2017

3. Chapra S.C. and Canale R.P. Numerical Methods for Engineers, McGraw Hill, 2010

4. Press W.H., Teukolsky S.A., Vetterling W.T. and Flannery B.P., Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007

5. Luyben, W.L., " Process Modelling Simulation and Control ",2nd Edn, McGraw-Hill Book Co., 1990

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	1	-	-	-	-	3	3	3	3	3	3	-
CO 2	3	3	3	3	3	-	-	-	3	3		3	3	3	1
CO 3	3	3	3	3	3	-	3	3	3	3	3	3	3	3	-
CO 4	3	3	3	3	3	-	-	-	3	3	1	3	3	3	1
CO 5	3	3	3	3	3	-	-	-	3	3	2	3	3	3	-

CH23E14 PINCH ANALYSIS AND HEAT EXCHANGE NETWORK DESIGN LT P C

3 0 0 3

OBJECTIVES

- To study the basic governing equations and concepts.
- To understand Heat exchanger networks.
- To understand temperature enthalpy diagram, Temperature interval diagram.
- To inculcate the knowledge required to Pinch Design and Optimization.
- To understand the simulation tools and Energy and Resource Analysis of various processes.

UNIT I BASICS 9

Thermo dynamical review of the process, Pinch concept, significance of pinch, pinch in grid representation, Threshold problems, capital cost implication of the pinch.

UNIT II TARGETING 9

Heat exchanger networks, energy targeting, area targeting, unit targeting, shell targeting, cost targeting, super targeting, and continuous targeting.

UNIT III PINCH METHODOLOGY 9

Problem representation, temperature enthalpy diagram, simple match matrix. Heat content diagram, Temperature interval diagram.

UNIT IV PINCH DESIGN AND OPTIMIZATION 9

Networks for maximum energy recovery, Pinch design method, Flexibility criteria of the pinch, CP table, the tick of heuristic, case studies, optimization of heat exchanger network optimality for a minimum area network, Sensitivity analysis.

UNIT V ENERGY AND RESOURCE ANALYSIS OF VARIOUS PROCESSES 9

Batch process, flexible process, distillation process, evaporation process, reaction process, process using mass separating agent. Heat pipes and Heat pumps.

TOTAL: 45 PERIODS

OUTCOMES

On the completion of the course students are expected to

- Understand the basic governing equations and concepts.
- Gain knowledge on Heat exchanger networks.
- Know about temperature enthalpy diagram , Temperature interval diagram.
- Understand the Pinch Design and Optimization.
- Analyse the simulation tools and Energy and Resource Analysis of various processes.

TEXT BOOKS:

1. Robin Smith, Chemical Process Design and Integration, John Wiley & Sons Ltd., New Delhi, 2014.
2. B. K. Hodge and Robert Taylor, Analysis and Design of Energy Systems, Pearson. 3rd Edition, 1999
3. Seider, W. D., Seader, J. D., & Lewin, D. R. Product & Process Design Principles: Synthesis, Analysis And Evaluation, John Wiley & Sons, 2009.

REFERENCE BOOKS:

1. Ian C. Kemp, “Pinch Analysis and Process Integration: A User Guide on Process Integration”, Elsevier Publications, 2008
2. Alexandre C. Dimian, Costin S. Bildea, Anton A. Kiss, “ Integrated Design and Simulation of Chemical Processes”, Elsevier Publications, 2014.
3. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, Debangsu Bhattacharyya, “Analysis, Synthesis and Design of Chemical Processes”, Prentice Hall, 2012
4. V. UdayShenoy" Heat Exchanger network synthesis" Gulf Publishing Co, USA, 1995
5. D.W. Linnhoff et al., "User Guide on Process Integration for the efficient use of Energy", Institution of Chemical Engineers, U.K., 1994
6. Batch Chemical Process Integration - Analysis, Synthesis and Optimization, ThokozaniMajozi, Spinger, 2010.

CO mapping to PO/PSOs

CO / PO & PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO2	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO3	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO4	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO5	3	3	3	3	3	1	1	-	2	-	2	3	3	3	2

CH23E15 CHEMICAL PROCESS FLOW SHEETING L T P C

3 0 0 3

OBJECTIVES:

- To Emphasize the basic concepts of steady state process plant simulation.
- To acquaint with process flow sheeting, methods of flow sheeting.
- To Impart the knowledge and awareness to understand the validity and physicochemical interpretation of thermodynamic models and their limitations.
- To Develop the skills for plant simulation and optimization.
- To solve chemical engineering problems encountered in chemical industries using professional software.

UNIT I FLOWSHEETING 6

Introduction, symbols, flowsheet presentation with examples, manual flowsheet calculation, flowsheeting approaches.

UNIT II DECOMPOSITION OF NETWORKS 11

Partitioning and tearing a flowsheet, tearing algorithms based on signal flow graph, algorithms based on reduced graph, comparing various tearing algorithms

UNIT III SEQUENTIAL MODULAR APPROACH TO FLOWSHEETING 11

Principle of method, convergence of flowsheet using different methods - Newton's method, direct substitution, Wegstein's method, dominant Eigenvalue method, quasi-Newton method, criteria for acceleration

UNIT IV FLOWSHEETING BY EQUATION SOLVING METHODS 9

Precedence ordering, disjoining, tearing a system of equations, SWS algorithm, maintaining sparsity, solution of system of equations using Newton's method.

UNIT V CASE STUDIES 8

Simulation of process flowsheets involving mass recycle, energy recycle, tear stream and design specification, demonstration of open-source flow sheeting software.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Robin S., Chemical Process Design and Integration, 2 nd ed., Wiley, USA, 2016.
2. Westerberg AW, Hutchison HP, Motard, Winter, Process Flow sheeting, 1 st ed., Cambridge University Press, India, 2011.
3. Foundations of Chemical & Biological Engineering, Jonathan Verret, R Qiao, Rana A B, by BC Campus (2020).

REFERENCE BOOKS

1. Westerberg A.W., Hutchison H.P., Motard R.L., Winter P., Process Flow sheeting, 1 st ed., Cambridge Press, UK, 2011.
2. Richard T., Analysis, Synthesis and Design of Chemical Processes, 1 st ed., Pearson Education International, USA, 2009.
3. Numerical Methods for Engineers 7th Edition, Steven C. Chapra and Raymond P. Canale.McGraw hill publishers (2016)

OUTCOMES:

CO1 – Understand the basic concept in preparation of flowsheet.

CO2 – Knowledge on preparing networks.

CO3 – Understand different approach in flow sheeting.

CO4 – To learn the flowsheet preparation by equation solving methods.

CO5 – Evaluate the case studies using flow sheeting software.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
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CO 3	2	1	2	1	2	1	1	1	1	2	2	2	2	2	2
CO 4	2	2	2	1	2	1	1	1	1	2	2	2	2	2	2
CO 5	2	2	2	2	2	1	1	1	1	2	2	2	2	2	2

CH23E16 COMPUTATIONAL FLUID DYNAMICS FOR CHEMICAL ENGINEERS L T P C

3 0 0 3

OBJECTIVES

- To study the basic governing equations and understand the basic properties of CFD.
- To understand discretization techniques.
- To understand basic solving methods for improving accuracy.

- To inculcate the knowledge required to solve real time physical problems
- To understand the simulation tools, software.

UNIT I BASICS OF MODELING METHODS 7

Conservation of mass, energy, momentum balances – Overview of numerial methods – ODE, PDE with initial and boundary conditions –Discretization - Finite difference techniques

UNIT II ADVANCED SOLUTION TECHNIQUES 11

Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; Finite element methods - Rayleigh-Ritz, Galerkin methods – Mesh generation

UNIT III CFD SOLUTION TECHNIQUES 11

. QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, Solution of Navier stokes equation- Problem setup – creation of geometry, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results report and visualization

UNIT IV FLUIDIZED BEDS 9

Minimum fluidization conditions – Correlations of Ergun, Kozneykarman -Expanded bed – Elutriation – Moving solids and dilute phase – spouted bed. Heat and mass transfer in fluidized bed systems – Industrial applications and case studies of fluidized bed systems

UNIT V CASE STUDIES 7

Benchmarking, validation, Simulation of CFD problems using general CFD software, Simulation of coupled heat, mass and momentum transfer problem.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Levenspiel, “Fluidization Engineering”, 2nd Edition, Butterworth – Heinmann, 1991.

2. Moukalled, F., Mangani, L., &Darwish, M. “The finite volume method in computational fluid dynamics. An Advanced Introduction with OpenFOAM and Matlab”, 2016

3. Aref H., Computational Fluid Dynamics, 1 st ed., Cambridge University Press, USA, 2017.

REFERENCES:

1. Rowe and Davidson, “Fluidization”, Academic Press ,1971.

2. Leva, M., “Fluidization”, McGraw Hill Book Co, 1959.

3. Wen-Ching Yang., “Handbook of Fluidization and Fluid-Particle Systems”, Marcel Dekker Inc, outcomes.

4. Versteeg, H.K., and Malalasekara, W, “An Introduction to Computational Fluid Dynamics”, The Finite Volume Method, 2007.

5. Computational Fluid Dynamics and COMSOL Multiphysics: A Step-by-Step Approach for Chemical Engineers, 1st ed., Apple Academic Press, USA, 2024

OUTCOMES

CO1: Students can classify types of PDEs and governing equations.

CO2: students can apply finite difference and finite elements to solve CFD problems.

CO3: Students can apply finite volume method to solve steady and unsteady diffusion, advection-diffusion problems

CO4: Students can generate and optimize numerical mesh.

CO5: Students can Solve engineering problems using CFD software

CO mapping to PO/PSOs

CO / PO & PSO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO3
CO1	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO2	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO3	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO4	3	3	3	3	3	1	1	-	2	-	2	3	3	3	3
CO5	3	3	3	3	3	1	1	-	2	-	2	3	3	3	2

PROFESSIONAL ELECTIVE COURSES

VERTICAL VI: TECHNOLOGY COURSES

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1	CH23F11	Polymer Technology	3	0	0	3	3
2	CH23F12	Fertilizer Technology	3	0	0	3	3
3	CH23F13	Paper and Pulp Technology	3	0	0	3	3
4	CH23F14	Electrochemical Technology	3	0	0	3	3
5	CH23F15	Food Technology	3	0	0	3	3
6	CH23F16	Drugs and Pharmaceutical Technology	3	0	0	3	3

CH23F11	POLYMER TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

To provide a fundamental knowledge on polymers and their chemical, physical and mechanical behavior, the processing techniques, along with the production of polymers.

UNIT I INTRODUCTION TO POLYMER 9

The science of large molecules. Theory of polymer solutions. Measurement of molecular weight and size. Analysis and testing of polymers.

UNIT II POLYMER STRUCTURE AND PROPERTIES 9

Deformation, flow and melt characteristics. Morphology and order in crystalline polymers. Rheology and the mechanical properties of polymers. Polymer structure and physical properties.

UNIT III POLYMER SYNTHESIS 9

Condensation polymerization. Addition polymerization. Ionic and coordination polymerization. co-polymerisation. polymerization conditions and polymer reactions.

UNIT IV INDUSTRIAL POLYMERS 9

Manufacturing processes and applications: Hydrocarbon plastics and elastomers. Other carbon chain polymers. Hetero-chain thermoplastics. Thermosetting resins.

UNIT V POLYMER PROCESSING 9

Plastics, Fibres and Elastomers: Polymers developed for synthetic plastics, fibres and elastomer applications. Plastics technology. Fiber technology. Elastomer technology.

TOTAL: 45 PERIODS

OUTCOMES:

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

- Apply the knowledge and to understand the properties and use of polymeric materials and other related environmental aspects.
- Acquire sufficient knowledge on how polymeric materials are build-up from molecular level to macroscopic level and the relationship between structure and material properties.
- Equip with knowledge on synthesis/modification, characterization, processing and applications of synthetic polymers.
- Apply the various processing and manufacturing techniques.
- Correlate structure-processing-property relationships for polymers, blends and composites.

TEXTBOOKS:

1. F. Rodriguez, Claude Cohen, Christopher K. Ober and Lynden A. Archer “Principles of Polymer Systems”, Fifth Edition., Taylor and Francis, Washington, 2003.
2. "Encyclopedia of Polymer Science and Technology", John Wiley-Inter Science.

REFERENCES:

1. Principles of Polymer Science, Bahadur and Sastry, Narosa Publishing House 2002.
2. Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.
3. Fundamentals of Polymer Processing, S. Middleman, Houghton Mifflin Company, 1997

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 2	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 3	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 4	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1
CO 5	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1

CH23F12 FERTILIZER TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

On completion of the course the students are expected,

- To learn the fertilizer manufacturing including new or modified fertilizer products and new techniques.
- To understand about the nitrogenous fertilizers and its applications.
- To understand the principles involved in phosphorous fertilizers and its uses.
- To state the importance of the potassic fertilizers and handling methods.
- To get awareness on the mixed fertilizers and complex fertilizers and its applications.

UNIT I NITROGENOUS FERTILISERS 9

Methods of production of nitrogenous fertilizer- Ammonia – Urea - ammonium sulphate, nitrate, ammonium chloride and their methods of production, characteristics andspecifications, storage, and handling.

UNIT II PHOSPHATIC FERTILISERS 9

Raw materials; phosphate rock, sulphur; pyrites etc., processes to produce sulphuric and phosphoric acids; phosphates fertilizers - ground rock phosphate; bone meal-singlesuperphosphate, triple superphosphate, thermal phosphates and their methods of production, characteristics and specifications.

UNIT III POTASSIC FERTILISERS 9

Methods of production of potassium chloride, potassium schoenite, their characteristics and specifications.

UNIT IV COMPLEX AND NPK FERTILISERS 9

Methods of production of mono ammonium phosphate, sulphate diammonium phosphate, nitrophosphates, urea ammonium phosphate, and various grades of NPK fertilizers produced in the country.

UNIT V MISCELLANEOUS FERTILISERS 9

Mixed fertilizers and granulated mixtures; biofertilizers, nutrients, secondary nutrients and micro nutrients; fluid fertilizers, controlled release fertilizers.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of this course students will,

- Gain knowledge on the production and characteristics of nitrogenous fertilizers.

- Gain knowledge on the production and characteristics of phosphatic fertilizers.
- Gain knowledge on the production and characteristics of potassic fertilizers
- Gain knowledge production of complex and NPK fertilizers.
- Gain knowledge on the production biofertilizers and fluid fertilizers.

TEXT BOOKS:

1. "Handbook of fertilizer technology", Association of India, New Delhi, 1977.
82

2. Menno,M.G.; "Fertilizer Industry - An Introductory Survey", Higginbotham's Pvt. Ltd., 1973.

REFERENCES:

- Sauchelli, V.; "The Chemistry and Technology of Fertilizers", ACS MONOGRAPH No. 148,Reinhold Publishing Cor. New York, 1980.
- Fertilizer Manual, "United Nations Industrial Development Organization", United Nations,New York, 1967.
- Slack, A.V.; Chemistry and Technology of Fertilizers, Interscience, New York, 1966.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 2	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 3	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 4	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1
CO 5	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1

CH23F13	PULP AND PAPER TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

On completion of the course the students are expected,

- To learn the importance of paper industry
- To know about preparation of raw materials for paper production
- To analyze the pulping process and its types
- To understand the manufacturing process of paper.
- To know how testing of paper can be done.

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

UNIT II RAW MATERIALS AND THEIR PREPARATION 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)

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 completion of this course, the students will be able

- To Identify the importance of paper industry with their applications.
- To explain the basic characteristics of the raw materials for paper making.
- To apply the knowledge about various pulping processes.
- To understand the processes involved in the manufacture of paper.

- To apply the various testing and evaluation procedures for different types of paper.

TEXTBOOKS:

1. Britt K W, Handbook of Pulp and Paper Technology, Reinhold Publishing Corporation, New York, 2nd edition, 2004.
2. MacDonald R G, Pulp and Paper Manufacture Vol I to III, Second Edition., McGraw Hill, New York, 1967.

REFERENCES:

1. Pulp and Paper: Chemistry and Chemical Technology Vol I to IV, Casey JP, Ed., Wiley Interscience, New York, 1984.
2. Pulp and Paper Manufacture, Kocurek, Tappi Publication. Mark, Handbook of Physical and Mechanical Testing of Paper and Board, Vol.I & II, Dekker Publication,2002.
3. Wood Chemistry: Fundamentals and Applications, Second edition by E Sjostrom, Academic Press, 1993.

CO mapping to PO/PSOs

COs/ POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1	3	2	2	2	2	1	1	1	1	1	1	3	2	2	2
CO 2	2	3	3	3	3	2	2	1	1	1	1	2	1	1	1
CO 3	2	3	3	1	2	1	1	1	1	1	1	1	2	2	1
CO 4	2	3	3	2	3	2	1	1	2	1	1	2	2	2	3
CO 5	2	2	3	2	3	2	2	1	2	1	2	1	2	2	2

CH23F14	ELECTROCHEMICAL ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

On completion of the course the students are expected,

- To learn the basic principles of electrochemistry.
- To understand the mass transfer correlations in electrochemistry.
- To gain knowledge on corrosion ant its protection.
- To know about the electroplating and fuel cells.
- To understand about electrodes and electrochemical reactors.

UNIT I ELECTROCHEMISTRY PRINCIPLES 9

Basics of electrochemistry, Electrolytic polarization, limiting current density, Electrochemical properties of colloids, Electrical Double Layer, electro kinetic phenomena, Types and methods of electrode modification

UNIT II MASS TRANSFER IN ELECTROCHEMICAL SYSTEMS 9

Diffusion controlled electrochemical reaction, mass & energy balance, and efficiency in electrochemical reactors. The estimation of mass transport coefficients at commonly occurring electrodes. The importance of convention and the concept of limiting current. Convective diffusion equation and migration effects, rotating disc electrode.

UNIT III CORROSION 9

Introduction, corrosion theories derivation of potential current relations of activities controlled and diffusion-controlled corrosion process. Forms of corrosion- definition, factors and control methods of various forms of corrosion-Electrochemical methods of corrosion rate measurements, protective coatings –Vapor phase inhibitors –cathodic protection, sacrificial anodes –Paint removers.

UNIT IV METAL FINISHING & ENERGY CONVERSION 9

Electroplating, conversion coatings, electroforming, electrochemical etching. Batteries and fuel cells- battery characteristics, battery specification, evaluation of battery performance, battery components. Fuel cells –types and technology development, Polymer electrolyte and solid oxide fuel cells, Material related challenges, Microbial fuel cells.

UNIT V ELECTRODES AND ELECTROCHEMICAL REACTORS 9

Electrodes used in different electrochemical industries: Metals-Graphite –Lead dioxide –Titanium substrate insoluble electrodes –Iron oxide –semi conducting type etc. Metal finishing-cell design. types of electrochemical reactors - Plug flows and Recycle reactors, RTD analysis, dispersed plug flow, tank in series model, multiparameter models, design equation, figures of merits of different type of electrochemical reactors – Recent Applications in Electrochemistry.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students will be able

- To describe various electrochemical principles.
- To discuss and analyze the mass transfer phenomena in electrochemical reactions.
- To illustrate mechanisms of various types of corrosion and control measures.
- To evaluate metal finishing strategies and fuel cells for various applications.
- To examine the importance and applications of electrodes and electrochemical reactors.

TEXTBOOKS:

1. A.J. Bard and L.R. Faulkner, "Electrochemical Methods – Fundamentals and applications", Third edition John Wiley & Sons Inc, 2001.
2. E.E.Stansbury, R.A.Buchanan, "Fundamentals of electrochemical corrosion", ASM International, 2000.

REFERENCES:

1. Picket, "Electrochemical Engineering ", Prentice Hall. 1977.
2. D.J. Pickett, "Electrochemical Reactor Designs", Elsevier Scientific Publishing Company, New York, 1979.
3. Zaki Ahmad, "Principles of Corrosion Engineering and Corrosion Control", Butterworth - Heinmann, London, 2006.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 2	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 3	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 4	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1
CO 5	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1

CH23F15 FOOD TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

On completion of the course the students are expected,

- To understand the general aspects of food industry.
- To gain knowledge on food constituents and derivative factors.
- To learn about food processing methods.
- To learn about food preservation methods.
- To know about the production of food products.

UNIT I INTRODUCTION 5

General aspects of food industry; world food needs and Indian situation.

UNIT II FOOD CONSTITUENTS, QUALITY AND DERIVATIVE FACTORS 10

Constituents of food; quality and nutritive aspects; food additives; standards; deteriorative factors and their control.

UNIT III GENERAL ENGINEERING ASPECTS AND PROCESSING METHODS 9

Preliminary processing methods; conversion and preservation operations.

UNIT IV FOOD PRESERVATION METHODS 12

Preservation by heat and cold; dehydration; concentration; drying irradiation; microwave heating; sterilization and pasteurization; fermentation and pickling; packing methods.

UNIT V PRODUCTION AND UTILISATION OF FOOD PRODUCTS 9

Cereal grains; pulses; vegetables; fruits; spices; fats and oils; bakery; confectionery and chocolate products; soft and alcoholic beverages; dairy products; meat; poultry and fish products.

TOTAL : 45 PERIODS

OUTCOMES:

- The students will understand the concepts of need of food in India through food industry.
- The students will gain knowledge about the basic food constituents and food additives.
- The students will be able to analyze the quality of food through food safety standards, processing and preservation methods.
- The students will be able to design heat, cold and advanced preservation techniques.
- The students will be able to create innovative vegetable and fruits products,

confectionary and dairy products, meat and fish products.

TEXT BOOKS:

1. Potter N.N., Food Science, The AVI publishing Co., Westport, 2012. 5th Edition.
2. Heid J.L. Joslyn M.A., Fundamentals of Food Processing Operation, The AVI publishing Co., West port 1967.

REFERENCES:

1. Heldman D.R., Food Process Engineering, The AVI publishing co., 1975.
2. Charm S.E., The Fundamentals of Foods Engineering, The AVI Publishing Co., Westport, 1963.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	1	1	1	1	2	1	1	2	1	2	1
CO 2	3	3	3	2	1	1	1	1	2	1	1	2	1	2	1
CO 3	3	3	3	2	1	1	1	1	2	1	1	2	1	2	1
CO 4	3	3	2	2	1	1	1	1	2	1	1	2	1	2	1
CO 5	3	3	2	2	1	1	1	-	2	1	1	2	1	2	1

CH23F16	DRUGS AND PHARMACEUTICAL TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

On completion of the course the students are expected,

- To acquire the knowledge on development of drug and pharma industry
- To understand the principles of drug metabolism.
- To gain knowledge on unit process involved in pharma industry.
- To know about packing and quality control of pharma products.
- To learn about the analysis of pharma products.

UNIT I INTRODUCTION **9**

Development of drugs and pharmaceutical industry; organic therapeutic agents use and economics

UNIT II DRUG METABOLISM AND PHARMACO KINETICS & MICROBIOLOGICAL AND ANIMAL PRODUCTS **9**

Drug metabolism; physio chemical principles; pharma kinetics-action of drugs on human bodies. Antibiotics- gram positive, gram negative and broad-spectrum antibiotics; hormones

UNIT III IMPORTANT UNIT PROCESSES AND THEIR APPLICATION **9**

Chemical conversion processes; alkylation; carboxylation; condensation and cyclisation; dehydration, etherification, halogenation, oxidation, sulfonation; complex chemical conversions

UNIT IV MANUFACTURING PRINCIPLES & PACKING AND QUALITY CONTROL **9**

Compressed tablets; wet granulation; dry granulation or slugging; advancement in granulation; direct compression, tablet presses formulation; coating pills; capsules sustained action dosage forms; parential solutions, oral liquids; injections; ointments; standard of hygiene and manufacturing practice. Packing; packing techniques; quality control.

UNIT V PHARMACEUTICAL PRODUCTS & PHARMACEUTICAL ANALYSIS **9**

Vitamins; cold remedies; laxatives; analgesics; nonsteroidal contraceptives; external antiseptics; antacids and others. Analytical methods and tests for various drugs and pharmaceuticals – spectroscopy, chromatography, fluorimetry, polarimetry, refractometry, pH metry

TOTAL: 45 PERIODS

OUTCOMES

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

- Explain the organic therapeutic agents uses and economics.
- Interpret the drug Metabolism and pharmaco kinetics & microbiological and animal products.
- Apply the process on alkylation, condensation and complex chemical conversions.
- Identify the manufacturing principles and packing on active pharmaceutical ingredients.
- Select the appropriate method of analysis and test for drugs.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 2	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 3	3	3	3	2	1	1	1	-	2	-	1	2	1	2	1
CO 4	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1
CO 5	3	3	2	2	1	1	1	-	2	-	1	2	1	2	1

Open Electives offered by Chemical Engineering

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	OCH2311	Introduction to Fertilizer Technology	OE	3	3	0	0	3
2	OCH2312	Introduction to Process Technology	OE	3	3	0	0	3

OCH2311 INTRODUCTION TO FERTILIZER TECHNOLOGY **L T P C**

3 0 0 3

OBJECTIVES:

On completion of the course the students are expected,

- To learn the fertilizer manufacturing including new or modified fertilizer products and new techniques.
- To understand about the nitrogenous fertilizers and its applications.
- To understand the principles involved in phosphorous fertilizers and its uses.
- To state the importance of the potassic fertilizers and handling methods.
- To get awareness on the mixed fertilizers and complex fertilizers and its applications.

UNIT I NITROGENOUS FERTILISERS **9**

Introduction about fertilizers and uses, Methods of production of nitrogenous fertilizer-ammonium sulphate,urea and calcium ammonium nitrate, characteristics and specifications, storage and handling.

UNIT II PHOSPHATIC FERTILISERS **9**

Raw materials and processes for the production of sulphuric and phosphoric acids; phosphates fertilizers – single superphosphate, triple superphosphate, and their methods of production, characteristics and specifications.

UNIT III POTASSIC FERTILISERS **9**

Methods of production of potassium chloride, potassium schoenite, their characteristics and specifications.

UNIT IV COMPLEX AND NPK FERTILISERS **9**

Methods of production of ammonium phosphate, mono-ammonium phosphate, diammonium phosphate, nitrophosphates, superphospates

UNIT V MISCELLANEOUS FERTILISERS **9**

Mixed fertilizers and granulated mixtures; biofertilisers, nutrients, secondary nutrients and micro nutrients; fluid fertilizers, control release fertlisers.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of this course,

1. Students will be able to understand the manufacturing techniques of fertilizers.
2. Students can do the design of equipment's involved in fertilizer industry.
3. Students would identify the possible raw materials for the manufacturing of Fertilizers.
4. Students will acquire knowledge on trouble shooting the production process of fertilizers.
5. Student can able to expand the capacity and restructure the process plant of the fertilizer unit

TEXT BOOKS:

1. Handbook of fertilizer technology‖, Association of India, New Delhi, 1977.

2. Menno, M.G.; ―Fertilizer Industry - An Introductory Survey‖, Higginbothams Pvt. Ltd., 1973.

REFERENCES:

1. Sauchelli, V.; ―The Chemistry and Technology of Fertilizers‖, ACS MONOGRAPH No. 148, Reinhold Publishing Cor. New York, 1980.

2. Fertilizer Manual, ―United Nations Industrial Development Organization, United Nations, New York,1967.

3. Slack, A.V.; Chemistry and Technology of Fertilizer's, Interscience, New York, 1966.

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	2	2	2	1	1	1	1	1	1	3	2	2	2
CO 2	2	3	3	3	3	2	2	1	1	1	1	2	1	1	1
CO 3	2	3	3	1	2	1	1	1	1	1	1	1	2	2	1
CO 4	2	3	3	2	3	2	1	1	2	1	1	2	2	2	3
CO 5	2	2	3	2	3	2	2	1	2	1	2	1	2	2	2

OCH2312 INTRODUCTION TO PROCESS TECHNOLOGY

L T P C
3 0 0 3

OBJECTIVE:

On completion of the course the students are expected,

- To learn about the production of numerous chemicals found in everyday products.
- To comprehend the numerous unit processes and unit operations, as well as the sequence involved in diverse chemical businesses.

- To outline the components, present in chemical process industries and design the chemical process plant.
- To give an exposure on aspects of safety for various chemical industries.
- To impart knowledge on fertilizer, polymers and fermentation industry

UNIT I CHLOR ALKALI INDUSTRIES, SULPHURIC ACID MANUFACTURE 9

Flow charts and standard symbols used for devices, industrial safety and pollution, Manufacture of Soda ash, chlorine and caustic soda, sulphur trioxide and sulphuric acid

UNIT II CEMENT AND NITROGEN INDUSTRIES 9

Types and manufacture of Portland cement, Manufacture of glasses, Synthetic ammonia, Nitric acid, Urea

UNIT III FERTILIZER INDUSTRIES 9

Growth elements, functions, phosphoric acid, ammonium phosphate, potassium chloride, single, triple super phosphate introduction to pesticides, herbicides and bio-fertilizers.

UNIT IV ORGANIC INDUSTRIES 9

Manufacture of paper from pulp, Manufacture of Raw and refined sugar, extraction methods of oils, hydrogenation of oils, Petroleum refining, physical and chemical conversion products

UNIT V POLYMER INDUSTRIES 9

Manufacture of Nylon 6. 6., manufacturer of Cellulosic Fibres – Viscose Rayon, Polymerization processes – different types -Natural rubber; Synthetic rubber such as SBR, manufacture of films - cellulose Acetate, PVC.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of the course the students

CO 1	Will have Ability to understand the manufacturing of various inorganic and organic chemicals.
CO 2	Will have Ability to understand the process flow diagram and various process parameters.
CO 3	Will have Ability to identify engineering problems during production.
CO 4	Will be able outline the components present in various process industries.
CO 5	Will have an idea of manufacturing fertilizers.

TEXTBOOKS:

1. Shreve's Chemical Process Industries Handbook‖, Fifth Edition, McGraw-Hill 1998.

2. Dryden, C.E., ―Outlines of Chemical Technology‖, Edited and Revised by Gopala Rao. M. and M. Sitting,Second edition, Affiliated East-West press,52, 1993.

REFERENCES

1. Shukla and G.N. Pandey ―Text book on Chemical Technology‖, Vikas publishing company 1997.

2. Srikumar Koyikkal,‖Chemical Process Technology and Simulation

CO mapping to PO/PSOs

COs/ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	1	1	2	2	1	1	1	1	2	1	2	2
CO 2	3	2	3	2	2	2	3	1	2	2	1	2	2	2	2
CO 3	2	3	1	1	1	2	2	1	2	1	2	1	1	2	2
CO 4	3	1	2	1	1	2	2	1	2	2	1	2	2	2	2
CO 5	3	3	2	1	1	2	2	1	1	1	1	2	2	2	2