B. TECH. SYLLABUS

CHEMICAL ENGINEERING

EFFECTIVE FROM 2025-2026

DHARMSINH DESAI UNIVERSITY

NADIAD, GUJARAT, 387001

PROGRAM OUTCOMES (POs)

PO-1 **Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

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

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

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

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

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

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

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

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

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

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

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO-1 Apply technical knowledge to solve industrial problems, ensuring efficiency and safety with emphasis on integrating social values in decision-making.

PSO-2 Prepared for higher education, ethical research and entrepreneurship

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1 Create employability in process industries cutting across various sectors through creating industry ready graduates by providing industrial training as part of curriculum

PEO2 To develop technical skill for solving real life industrial problems. (Strong theoretical/fundamental practical knowledge required for Consultancy and technical services)

PEO3 Value added services and skill development as networking between university and industry

PEO4 Graduates qualified for higher studies nationally and internationally

PEO5 Produce creative graduates for innovative research

PROGRAM EDUCATIONAL OUTCOMES (PEOs)

PEO1 Employability in process industries cutting across various sectors

PEO2 Technically skilled engineers for solving real life industrial problems upholding social and ethical values

PEO3 Graduates qualified for higher studies nationally and internationally

PEO4 Creative graduates for innovative research who networks between industry and societal needs

CURRICULUM

Total minimum credits needed for completing the B.Tech. program in **Chemical Engineering is 173.**

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES

The structure of B.Tech. program shall have University Requirement, Program Core, Elective Courses, and Essential Program Laboratory Requirements (ELR) are as follows:

S. N.	Course category	Number of Courses	Number of Credits
1.	Basic Science Courses	7	27
2.	Engineering Science Courses	6	19
3.	Program Core and Elective Courses	23	88
4.	Open Elective Courses	3	09
5.	Internship and Project Work	3	23
6.	Humanities Courses	3	07
	Total	**45**	**173**
*	Minor Course (Optional, Extra Credits)	6	18
**	Honors Course (Optional, Extra Credits)	6	18

HONORS COURSE

Honors in Chemical Engineering is offered to the students of Chemical Engineering Department after **earning 18 extra credits**, provided the student maintains a minimum of 7.5 CG/CPI overall at the time of opting for the honors course as well as at the time of exit.

Honors may be awarded to the students who choose one of the following streams. Students will have to choose 6 courses of 3 credits each, offered by DDU/NPTEL after due consent from the department. A minimum of 3 courses must be chosen from DDU.

	Process System Engg.	**Course Offerred**	**Credits**
1	Process Intensification	DDU	3
2	Advanced Process control	DDU	3
3	Advanced Optimization Techniques	DDU	3
4	Non-linear Control theory and applications	MOOC (noc25-ch14) / DDU	3
5	Applied Time-Series Analysis	MOOC (noc25-ch05)	3
6	Modeling Stochastic phenomena for Engineering applications	MOOC (noc25-ch32)	3

	Environmental management system	**Course Offerred**	**Credits**
1	Environmental Modeling	DDU	3
2	Solid waste management	DDU	3
3	Pollution control Equipment design	DDU	3
4	Physico-chemical processes for wastewater treatment	MOOC (noc25-ch37)	3
5	Environmental Quality Monitoring & Analysis	MOOC (noc25-ch24)	3
6	Electrochemical Technology in Pollution Control	MOOC (noc25-ch21)	3
7	Pollution Prevention in Process Industries	DDU	3

MINOR COURSE

Department offers **Minor in Chemical Engineering** to the students of other Departments. They can earn Minor only after earning 18 extra credits. Following are the details -

Compulsory Courses (Total – 14 Credits)

1. Introduction to Chemical Engineering (4 Credits – L-T-P = 3-0-2)
2. Basics of Reaction Engineering (4 Credits – L-T-P = 3-0-2)
3. Unit Operations (4 Credits – L-T-P = 3-0-2)
4. Seminar (2 Credits)

Any **one** course from the following (4 Credits – L-T-P = 3-0-2)

1. Transport Processes
2. Chemical Engineering Thermodynamics
3. Instrumentation and Process Control
4. Safety and Environment

OR any Equivalent courses from NPTEL after due consent from the department.

ABBREVIATIONS

L	**Lecture**	**Ext.**	**External Exam**	**P**	**Practical**
T	**Tutorial**	**S**	**Sessional Exam**	**C**	**Credit**
P	**Practical**	**TW**	**Term Work**		

Semester – I

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
BS102	Mathematics -I	3	1	0	4	4	60	40	0	0	100
ES	Structural Mechanics	3	1	0	4	4	60	40	0	0	100
BS	Applied Chemistry - I	3	0	2	5	4	60	40	25	25	150
BS	Computer Programming in chemical engineering	2	0	3	5	3.5	60	40	25	25	150
BS	Physics	2	0	2	4	3	60	40	25	25	150
SM101	Environmental Studies	4	0	0	4	4	60	40	0	0	100
	Total	**17**	**2**	**7**	**26**	**22.5**	**360**	**240**	**75**	**75**	**750**

Semester – II

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
PC	Introduction to Chemical Engineering	2	0	2	4	3.0	60	40	25	25	150
BS203	Mathematics-II	3	1	0	4	4.0	60	40	0	0	100
ES203	Engineering Graphics	2	1	2	5	4.0	60	40	50	0	150
BS	Applied Chemistry - II	3	0	3	6	4.5	60	40	25	25	150
ES	Electrical and Electronics Engineering	3	0	2	5	4.0	60	40	50	0	150
ES	Workshop Practices	0	1	2	3	2.0	0	0	50	0	50
	Total	**13**	**3**	**11**	**27**	**21.5**	**300**	**200**	**200**	**50**	**750**

Semester – III

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
PC	Chemical Engineering Thermodynamics-I	3	0	0	3	3.0	60	40	0	0	100
CH309	General Chemical Technology	3	1	2	6	5.0	60	40	25	25	150
CH310	Material & Energy Balance Computations	3	1	0	4	4.0	60	40	0	0	100
ES	Material Science	2	0	0	2	2.0	60	40	0	0	100
HM	IKS and Yoga	1	0	2	3	2.0	60	40	25	25	150
HM	Effective Technical Communication	3	0	0	3	3.0	60	40	0	0	100
	Total	**15**	**2**	**4**	**21**	**19.0**	**360**	**240**	**50**	**50**	**700**

Semester – IV

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
CH419	Fluid Mechanics	3	0	3	6	4.5	60	40	25	25	150
CH420	Heat Transfer	3	0	3	6	4.5	60	40	25	25	150
CH421	Mass Transfer - I	3	1	0	4	4.0	60	40	0	0	100
CH422	Particles and Fluid Particle Processing	3	0	3	6	4.5	60	40	25	25	150
CH423	Chemical Engineering Thermodynamics-II	3	0	0	3	3.0	60	40	0	0	100
	Total	**15**	**1**	**9**	**25**	**20.5**	**300**	**200**	**75**	**75**	**650**

Semester – V

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
CH508	Chemical Reaction Engineering- I	3	0	3	6	4.5	60	40	25	25	150
CH509	Mass Transfer - II	3	1	3	7	5.5	60	40	25	25	150
CH414	Numerical Techniques in Chemical Eng.	2	0	3	5	3.5	60	40	25	25	150
PCE	Core Elective - I	3	0	0	3	3.0	60	40	0	0	100
OE	Open Elective - I	3	0	0	3	3.0	60	40	0	0	100
CH515	Universal Human Values	2	0	0	2	2.0	60	40	0	0	100
	Total	**16**	**1**	**9**	**26**	**21.5**	**360**	**240**	**75**	**75**	**750**

Semester – VI

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
CH613	Chemical Reaction Engineering-II	3	0	3	6	4.5	60	40	25	25	150
CH616	Instrumentation and Process Control	3	1	3	7	5.5	60	40	25	25	150
CH615	Process Equipment Design & Drawing	3	0	3	6	4.5	60	40	25	25	150
CH617	Chemical Process Safety	3	0	0	3	3.0	60	40	0	0	100
PCE	Core Elective - II	3	0	0	3	3.0	60	40	0	0	100
OE	Open Elective - II	3	0	0	3	3.0	60	40	0	0	100
	Total	**18**	**1**	**9**	**28**	**23.5**	**360**	**240**	**75**	**75**	**750**

Semester – VII

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
CH716	Transport Phenomena	3	0	3	6	4.5	60	40	25	25	150
CH617	Design and Simulation	2	0	4	6	4.0	60	40	25	25	150
PC	Chemical Engineering Plant Design and Economics	3	0	0	3	3.0	60	40	0	0	100
PCE	Core Elective-III	3	0	0	3	3.0	60	40	0	0	100
OE	Open Elective-III	3	0	0	3	3.0	60	40	0	0	100
CH723	Summer Training	0	0	0	0	6.0	0	0	100	0	100
	Total	**14**	**0**	**7**	**21**	**23.5**	**300**	**200**	**150**	**50**	**700**

Semester – VIII

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
PCE	Core Elective-IV	3	0	0	3	3.0	60	40	0	0	100
PC	CAD Lab	0	0	2	2	1.0	0	0	25	25	50
INT	Industrial Internship	0	0	0	0	14.0	0	0	100	250	350
INT	Seminar	1	0	4	5	3.0	0	0	100	0	100
	Total	**4**	**0**	**6**	**10**	**21.0**	**60**	**40**	**225**	**275**	**600**

ELECTIVES OFFERED

Core Elective-1 SEM-V

1. Environmental Engineering
2. Statistical Thermodynamics
3. Plant Utilities
4. Heat Exchanger Design and Analysis
5. Polymer Science and Engineering
6. Fluidization

Open Elective-1 SEM-V

1. Data Analysis and Statistics
2. Green Tech. and Sus. Devp.
3. Corrosion Engineering
4. Industrial Management

Core Elective-2 SEM-VI

1. Energy Technology
2. Petrochemical Technology
3. Chemical System Modeling
4. Multicomponent Distillation

Open Elective-2 SEM-VI

1. Introduction to Machine Learning
2. Nanotechnology and Applications
3. Operation Research

Core Elective-3 SEM-VII

1. Chemical Process Optimization
2. New Separation Techniques
3. Fuel Cell Technology
4. Chemical Engineering Practices

Open Elective-3 SEM-VII

1. Advanced Process Control
2. Environment Impact Assessment
3. Research Methodology
4. Banking and Taxation
5. Industrial Safety Engg. and Management

Core Elective-4 SEM-VIII

1. CAD in Chemical Engineering
2. Process Synthesis
3. Heat Exchanger Network

Semester – I

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
BS	Mathematics -I	3	1	0	4	4	60	40	0	0	100
ES	Structural Mechanics	3	1	0	4	4	60	40	0	0	100
BS	Applied Chemistry - I	3	0	2	5	4	60	40	25	25	150
BS	Computer Programming in chemical engineering	2	0	3	5	3.5	60	40	25	25	150
BS	Physics	2	0	2	4	3	60	40	25	25	150
BS	Environmental Studies	4	0	0	4	4	60	40	0	0	100
	Total	**17**	**2**	**7**	**26**	**22.5**	**360**	**240**	**75**	**75**	**750**

B.TECH. – SEMESTER-I
MATHEMATICS-I (25BS102)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	0	4	4.0	60	40	0	0	100

A. COURSE OVERVIEW

Develop a strong foundational understanding of mathematical analysis for engineering applications, particularly through integral calculus and vector analysis. Equip students with the ability to model and solve real-world problems using the principles of linear algebra, including vector spaces and linear transformations. Introduce students to periodic function representation and prepare them to apply orthogonal expansions to signals and systems. Enhance the students' capability to analyse and interpret functions of several variables and use differential techniques for optimization. Foster analytical thinking through the application of vector calculus to physical systems, especially in fluid dynamics and electromagnetics. Introduce fundamental concepts of probability to enable quantitative reasoning in uncertain environments relevant to engineering.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (48)
1.	**Calculus: Integral Calculus** Evolutes and involutes, Applications of definite integrals to evaluate surface areas and volumes of revolutions. Rolle's Theorem, Langrage Mean value theorems, Cauchy's Mean value theorem	CO1	8
2.	**Linear algebra matrices, Vectors, Determinants, Linear systems** Matrices: Addition and Scalar Multiplication, Matrix Multiplication, Symmetric and Skew- symmetric matrix, Rank of a matrix, Consistency of a Linear System of equations: Existence and Uniqueness of solution, Inverse of a matrix by Gauss-Jordan method, Eigen values and eigen vectors, Linear Independence of vectors, Diagonalization of a matrix.	CO2	10
3.	**Fourier series** Introduction, Euler's Formulae, Functions having points of discontinuity, Change of interval, Expansion of even and odd functions, Half range sine and cosine series, Parseval's theorem.	CO3	7
4.	**Multivariable calculus (differentiation)** Partial derivatives: Functions of two or more variables, Chain Rule, Total derivative: Differentiation of Implicit and composite functions **Applications of partial differentiation** Jacobians, Taylor and Maclaurin's series expansion for function of two variables, Maxima and minima of function of two variables, Lagrange's method of undetermined multipliers.	CO4	11
5.	**Vector differential calculus** Scalar and vector point functions – Vector operator del, Del operator applied to scalar point functions – Gradient, Physical interpretation of gradient (normal to the surface), Directional derivatives, Del operator applied to vector point functions – divergence and curl, Physical interpretation of div $F\rightarrow$ and Curl $F\rightarrow$,	CO5	6
6.	**Probability** Probability, Independent and dependent events, Permutations and Combination, Conditional probability, Baye's theorem	CO6	6

C. TEXT / REFERENCE BOOKS

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 40^{th} Edition, 2007.
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Ed. Pearson, 2002.Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
5. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 2010.
6. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publica- tions, Reprint, 2010.
7. V. Krishnamurthy, V.P. Mainra and J.L. Arora, An introduction to Linear Algebra, Affiliated East–West press, Reprint 2005.

D. COURSE OUTCOMES

Cos	STATEMENT
CO1	Demonstrate the ability to model and solve problems involving the computation of geometrical quantities such as area and volume using definite integrals in a variety of coordinate systems.
CO2	Apply fundamental concepts of linear algebra to analyze the structure of vector spaces, determine the solvability of linear systems, and perform transformations using eigenstructure methods.
CO3	Represent periodic and piecewise-defined functions in terms of orthogonal series and utilize these representations to analyze convergence and energy content.
CO4	Analyze functions of multiple variables through differentiation, including computation of total derivatives, and apply expansion techniques for local approximations.
CO5	Investigate the behavior of multivariable functions to determine optimal points under constraints using advanced analytical techniques involving auxiliary functions.
CO6	Evaluate vector-valued functions and interpret physical phenomena by computing directional rates of change and characterizing field behavior using vector operators; also solve problems involving discrete and conditional probability.

E. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	3	2	2	2	2	**2.2**
PO 3	-	1	-	-	2	-	**1.5**
PO 4	2	-	-	2	2	1	**1.8**
PO 5	-	-	-	-	-	-	**-**
PO 6	-	-	-	-	-	-	**-**
PO 7	-	-	-	-	-	-	**-**
PO 8	-	-	-	-	-	-	**-**
PO 9	-	-	-	-	-	-	**-**
PO 10	-	-	-	-	-	-	**-**
PSO1	3	3	3	3	3	3	**3.0**
PSO2	-	-	-	-	2	2	**2.0**

B.TECH. – SEMESTER-I
STRUCTURAL MECHANICS (25ESxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	0	4	4.0	60	40	0	0	100

A. COURSE OVERVIEW

The primary purpose of the study of mechanics is to develop the capacity to predict the effects of force and motion while carrying out the creative design functions of engineering. The present course is aimed to offer a broad aspect of those areas of Strength Mechanics which are specifically required as an essential background to all engineering students for their studies in higher semesters.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	Concepts of forces, their types, Resolution of forces, Composition of forces	CO1 CO2	4
2.	Equilibrium of rigid bodies - Conditions of equilibrium. Equilibrium of beams	CO1 CO2	4
3.	Concept of moment of Inertia (Second moment of area) its use, Parallel axis theorem. Problems of finding centroid and moment of Inertia different section, Perpendicular axis theorem	CO1 CO2	4
4.	Shear Force and Bending Moment - Basic concept, S.F. and B.M. diagram for cantilever, simply supported beams. Problems with concentrated and U.D. loads.	CO1 CO2	6
5.	Stresses and Strains - Tensile and compressive stresses, strains, modulus of elasticity, Lateral strain, Poisson's ratio. Thermal stresses and strains.	CO1 CO3	6
6.	Theory of Bending - Assumptions in derivation of basic equation, Basic equation, section modulus, bending stress distribution diagram	CO1 CO4	4
7.	Problems on shear stress - Concept, Derivation of basic formula. Shear stress distribution for standard shapes. Problems of Shear stress distribution.	CO1 CO4	4
8.	Torsion, Pure torsion Theory, Example based on the torsion theory	CO1 CO5	4

C. TEXT BOOKS

1. Vector Mechanics for Engineers-Statics -Vol-1-Dynamics Vol-2- F. P. Beer and E. R. Johnston-Mc Graw Hill Education-(New Delhi)-10th SI Edition 2017
2. Strength of Materials-Part– I and II-Stephen Timoshenko-CBS Publisher (USA)-3rd Edition – 2002

D. REFERENECE BOOKS

1. Engineering Mechanics-Statics-Vol-1-Dynamics-Vol-2-J. L. Meriam and L. G. Kraige-Wiley (New Jersey)-5th Edition-2017
2. Strength of Materials-Sadhu Singh-Khanna Book Publishing Company (New Delhi)-11th Edition-2016
3. Advanced Mechanics of Solid-L. S. Srinath-McGraw Hill Publication (New Delhi)-3rd Edition-2017

E. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the use of basic concepts of structural Mechanics
CO2	Analysis of the beams and applying conditions of equilibrium.
CO3	Understand the different stresses and strains occurring in components of structure various standard loadings
CO4	Determination of shear stress, bending stresses in the beams
CO5	Understand the concept of torsion & Analysis of the beams

F. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	Average
PO 1	3	3	3	3	3	**3.0**
PO 2	3	3	2	3	3	**2.8**
PO 3	2	3	3	2	3	**2.6**
PO 4	2	3	3	3	2	**2.6**
PO 5	2	1	1	2	1	**1.4**
PO 6	1	2	1	2	1	**1.4**
PO 7	2	1	2	1	2	**1.6**
PO 8	2	1	2	1	2	**1.6**
PO 9	3	3	3	3	3	**3.0**
PO 10	1	1	1	1	1	**1.0**
PO 11	2	3	2	3	3	**2.6**
PSO 1	3	3	3	3	3	**3.0**
PSO 2	3	3	3	3	3	**3.0**

B.TECH. – SEMESTER-I
APPLIED CHEMISTRY-I (25BSxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	2	5	4.0	60	40	25	25	150

A. COURSE OVERVIEW

This course provides a fundamental understanding of chemical bonding, molecular interactions, and molecular geometry. It explores thermodynamic principles, chemical equilibrium, electrochemistry, and corrosion prevention. Emphasis is placed on applications in engineering, including electrolysis, industrial processes, and material stability. This course covers fundamental concepts of organic chemistry, including key reactions. It explores engineering materials such as glass, ceramics, composites, and polymers, emphasizing their properties and uses. Additionally, it examines water chemistry, treatment methods, and industrial water-related challenges.

B. PREREQUISITES

High school chemistry foundation covering atomic structure, periodic table, chemical formulas, equations, and basic concepts of matter, solutions, and acids/bases is essential.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (39)
1.	**Chemical Bonding and Molecular Interactions** Valence bond Theory, Types of chemical bonds, Electrovalent bond, & its characteristics, Covalent bond & its characteristics, Co- ordinate bond & its characteristics, Hydrogen bond, its types and Significance, Metallic bond, Explanation of Metallic properties, Intermolecular force of attraction, Molecular Geometry and Shape of Molecules.	CO1	7
2.	**Thermodynamics and Chemical Equilibrium** Introduction, First and second laws of thermodynamics, Entropy, enthalpy, Hess's Law, Gibbs free energy & Vont Hoff equation derivation, Feasibility and spontaneity of reaction, Acid base and solubility equilibria, Numerical.	CO2	7
3.	**Electrochemistry and Corrosion** Conductance and electrochemical cells, Nernst equation, Electrolysis and Industrial Applications, Corrosion types and prevention, Numerical.	CO3	6
4.	**Analytical & Water Chemistry** Molar Mass, Concentration, and stoichiometric relationship. Sources, conservation of water, impurities in water and their effects. WHO guideline and BIS guideline for drinking water. Chemistry and unit processes of water purification (Softening and hardness removal, sedimentation, coagulation-flocculation, filtration, chlorination).	CO4	6
5.	**Fundamentals of Organic Reactions and their Applications** Organic Reactions, Substitution [Electrophilic (electrophilic aromatic and aliphatic substitution) and Nucleophilic Substitution (SN1 and SN2 reactions), Free Radical Substitution], Addition, Elimination, Oxidation and Reduction.	CO5	7
6.	**Industrially Important Reactions-1** Petroleum & Petrochemicals (Formation of Petroleum, classification of Petroleum products and important reactions), Polymers (monomers, oligomers, classification of polymers, examples of polymerization processes), Dyes (Chromophore, Auxochrome, classification of dyes and synthesis of some important dyes) Drugs (Major types of drugs and their examples, synthesis of some important drugs).	CO6	6

D. PRACTICAL AND TERM WORK

1. Preparation of solution of specific stoichiometry.
2. Find out the concentration of unknown acid by standardised base solution.
3. Determine the total hardness of water by EDTA method.
4. Determine the Chloride content in the given water sample by Mohr's method. (Argentometric method).
5. Calculation of solubility Product.
6. Solubility and Lassaigne test of unknown organic compound (2 experiments).
7. Identification of Functional group in Organic compound.
8. Separation of solids with solubility difference by Separating funnel.
9. Preparation of Azo dye.

E. TEXT BOOKS

1. Atkins' Physical Chemistry by Peter Atkins and Julio de Paula, 11th Edition, Oxford University Press Publication Year: 2017
2. Engineering Chemistry by P.C. Jain and Monika Jain, 16th Edition, Dhanpat Rai Publishing CompanyPublication Year: 2015
3. Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition
4. University Chemistry by Mahan, Bruce H, 4th Edition, Pearson Education India, Year: 2009

F. REFERENECE BOOKS

1. Fundamentals of Analytical Chemistry by D. A. Skoog, D. M. West, F. James Holler and S. R. Crouch, Cengage Learning, 2014
2. Organic Chemistry, L.G. Wade Jr, Pearson Education
3. Antropov, L., Theoretical Electrochemistry; 2nd ed.; Mir Publishers: Moscow, 1977
4. Fundamentals of Engineering Thermodynamics" by Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, and Margaret B. Bailey. Edition: 9th Edition, Wiley. ISBN: 9781118412930

G. ONLINE RESOURSES

1. Chemistry - Atomic Structure and Chemical Bonding
   https://onlinecourses.nptel.ac.in/noc22_cy36/preview
2. NPTEL: Engineering Chemistry I - https://archive.nptel.ac.in/courses/122/101/122101001/
3. Advances in Corrosion Engineering - https://archive.nptel.ac.in/courses/113/108/113108051/
4. Introductory Organic Chemistry I - https://onlinecourses.nptel.ac.in/noc25_cy36/preview
5. Industrial Inorganic Chemistry - https://archive.nptel.ac.in/courses/104/105/104105103/
6. Thermodynamics and Kinetics of Materials
   https://www.classcentral.com/course/swayam-thermodynamics-and-kinetics-of-materials-119559
7. Analytical Techniques (UGC MOOCs) -
   https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/141

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Demonstrate knowledge of diverse chemical bond types, their characteristics, and molecular geometry.
CO2	Apply thermodynamic principles to analyze energy transformations, predict reaction feasibility, understand equilibrium concepts, and solve related numerical problems in chemistry.
CO3	Explain the fundamentals of conductance and electrochemical cells, apply the Nernst equation, and analyze industrial electrolysis, corrosion, and prevention methods.
CO4	Apply water chemistry principles to analyze impurities, relate to National/International standards, and describe purification techniques for safe water management.
CO5	Explore fundamental Organic Chemistry reactions and apply this understanding to the synthesis of new molecules.
CO6	Explain the fundamentals of the Petroleum, Polymer, Dyes, and Drugs industries and apply synthesis knowledge in the preparation of important chemicals.

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	1	3	3	2	1	3	**2.2**
PO 2	1	3	3	2	1	2	**2.0**
PO 3	-	1	2	3	1	2	**1.5**
PO 4	-	2	2	2	1	2	**1.5**
PO 5	-	1	2	1	-	2	**1.0**
PO 6	-	2	2	3	1	3	**1.8**
PO 7	-	1	1	3	2	3	**1.7**
PO 8	-	1	1	2	1	2	**1.3**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	2	2	2	1	2	**1.7**
PO 11	2	2	2	2	2	2	**2.0**
PSO 1	2	3	3	3	2	3	**2.7**
PSO 2	3	2	2	1	3	3	**2.3**

B.TECH. – SEMESTER-I
COMPUTER PROGRAMMING IN CHEMICAL ENGINEERING (25BSxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	0	3	5	3.5	60	40	25	25	150

A. COURSE OVERVIEW

This overview covers the fundamental components of a computer system, introducing algorithms and the C programming language, including constants, variables, data types, and operators. It delves into control structures for decision-making and looping, as well as arrays, user-defined functions, and the concept of pointers. Finally, it addresses file handling techniques, including reading, writing, and appending data in C.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (24)
1.	**Introduction:** Introduction to components of computer system, Idea of algorithm, Introduction to C, Constants, Variables & Data types in C, Managing input and Output operators	**CO1**	**2**
2.	**Operators and expressions** C Operators: Arithmetic, relational, logical, increment & decrement, assignment and conditional, Arithmetic Expressions & Precedence Rule, Type conversion in C, Mathematical	**CO2**	**3**
3.	**Decision Making and Branching** Decision making with If & If...else statements, switch statements, goto-continue statements	**CO3**	**3**
4.	**Decision Making and Looping** The while statement, the break statement & the do... while loop, the for loop, Jump within loops - Programs.	**CO3**	**3**
5.	**Arrays** Array 1D, 2D, Character Array as String	**CO3, CO6**	**4**
6.	**User Defined Functions** Categories of Functions (Including using built in library), Call by Value, Parameter passingto function, Recursion	**CO3, CO6**	**4**
7.	**Structure** Defining structure, Assigning value to the structure members, Array of structure	**CO3, CO6**	**2**
8.	**Pointer:** Idea of pointer, declaration and Initialization of pointer, passing address as function argument, passing array to function using pointer	**CO4, CO6**	**2**
9.	**Basics of file handling syntaxes:** File reading, writing and appending.	**CO5**	**1**

C. PRACTICAL AND TERM WORK

1. (A) Simple C Program (B) Standard Input /Output Functions
2. Operators And Expression
3. Formatted Input /Output
4. (A) Decision making & Branching- I (If … Else)
   (B) Decision making & Branching-II(Switch… Case)
5. (A) Decision making & Looping-I(While, Do…While)
   (B) Decision making & Looping-I (For)
6. Arrays
7. User Defined Functions
8. Structures
9. Introduction to Pointers
10. File Handling

D. TEXT BOOKS

1. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
2. Yashvant Kanetkar, Let Us C, 12th Edition, BPB Publication

E. REFERENECE BOOKS

1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/106/104/106104128/
2. https://archive.nptel.ac.in/courses/106/105/106105171/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the fundamental concepts of computer systems, algorithms, and C programming syntax.
CO2	Apply decision-making, branching, and looping constructs to develop structured programs.
CO3	Analyze and implement arrays, strings, and structures for effective data management.
CO4	Evaluate functions, recursion, and pointer operations to optimize program performance.
CO5	Develop applications using file handling techniques to store and retrieve data efficiently.
CO6	Integrate programming logic with engineering applications to solve real-world problems.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	2	3	2	3	**2.7**
PO 2	2	3	3	3	3	3	**2.8**
PO 3	1	2	3	3	3	3	**2.5**
PO 4	1	2	3	3	3	3	**2.5**
PO 5	2	3	3	3	3	3	**2.8**
PO 6	1	1	2	2	2	2	**1.7**
PO 7	1	1	2	2	2	2	**1.7**
PO 8	1	1	2	2	2	2	**1.7**
PO 9	1	2	2	3	3	3	**2.3**
PO 10	1	2	2	3	3	3	**2.3**
PO 11	1	1	2	3	2	3	**2.0**
PSO 1	2	3	3	3	3	3	**2.8**
PSO 2	2	2	2	3	2	3	**2.3**

B.TECH. – SEMESTER-I
PHYSICS (25BSxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	0	2	4	3.0	60	40	25	25	150

A. COURSE OVERVIEW

Physics provides a foundational understanding of optics, lasers, fiber optics, electromagnetism, and quantum mechanics, emphasizing their engineering applications. It bridges the gap between school-level physics and advanced engineering concepts, ensuring a smooth transition for students. Topics include wave optics (interference, diffraction, and polarization), laser principles, fiber optic technologies, electromagnetism, and quantum mechanics. Through theoretical and applied learning, students develop critical thinking and problem-solving skills essential for modern engineering challenges.

B. PREREQUISITES

Basic mathematics and physics

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (24)
1.	**Optics** **Interference:** Introduction to optics, Principles of superposition, Constructive & Destructive Interference, Types of Interference, Conditions for observing interference, interference due to thin films, wedge shaped films, Newton's rings, applications of interference. **Diffraction:** Concept of diffraction, Types of diffraction (Fraunhofer and Fresnel diffraction), difference between interference and diffraction, Fraunhofer diffraction at single slit, double slit, and multiple slits; Diffraction grating and its applications. **Polarisation:** Introduction, polarisation by reflection, polarisation by double refraction, scattering of light, circular and elliptical polarisation, optical activity, Polarization of light waves, Polaroid, Optical activity.	**CO1** **CO2**	8
2.	**Laser and Fibre Optics** **Lasers:** Introduction to interaction of radiation with matter, principles and working of laser, Characteristics of laser, Properties of lasers, laser types: solid state Laser, Ruby laser, He-Ne laser, semiconductor laser, applications of laser, Industrial applications, and Medical applications. **Fibre Optics:** Introduction, Principle and propagation of light in optical fibres, Fermat's principle and Snell's law, structure of optical fibres, numerical aperture, acceptance angle, types of optical fibres (material, refractive index, mode), losses in fibres, Fabrication: Double Crucible Technique, Vapour phase Oxidation Process, applications of optical fibres	**CO3**	4
3.	**Electromagnetism and Magnetic Properties of Materials** **Electrostatics & Electrodynamics:** Introduction to electrostatics, Coulomb's law for distribution of charges, polarization and Gauss's law electric current and equation of continuity. **Magnetostatics & Magnetism:** Introduction to magnetostatics, Lorentz force, Steady current and equation of continuity, Biot Savart Law-Ampere's law, magnetization and magnetic intensity, Magnetization: Faraday's laws of electromagnetic induction, Electromagnetic waves: wave equation, Electromagnetic energy density, Poynting theorem, Maxwell's equations, Physical significance of Maxwell's equations, propagation of EM waves in free space, Lenz's law.	**CO4** **CO5**	8

4.	**Quantum Mechanics** **Introduction to Quantum Mechanics:** Plank's Quantum Theory, Properties of Photon, Photoelectric effect, Inadequacy of classical mechanics (black body radiation, photoelectric effect). Classical mechanics and its limitations, Planck's radiation law, Wien's law, and Rayleigh Jean's law, wave and particle duality of radiation, de Broglie concept of matter waves, Davisson-Germer experiment, Heisenberg's uncertainty principle, Consequences of uncertainty principle. Equation of motion of matter waves, Schrodinger time independent wave equation.	**CO6**	**4**

D. PRACTICAL AND TERM WORK

1. Determination of radius of curvature of a plano-convex lens using Newton's rings setup.
2. Determination of wavelength of a source (sodium vapor lamp) using a diffraction grating.
3. Evaluation of numerical aperture and bending losses of an optical fiber.
4. Verification of Faraday's laws of Electromagnetic induction.
5. Determination of the size of a particle using a Laser.
6. Determination of Planck's constant.
7. Determination of wavelength of laser using a diffraction grating.

E. TEXT BOOKS

1. Gaur R. K. and Gupta S. L. Engineering Physics, Dhanpat Rai Publications (P) Ltd., 8th edn., New Delhi, 2001.
2. M.N. Avadhanulu and P.G. Kshirsagar, A text book of Engineering Physics, S. Chand and Company, New Delhi, 2009.

F. REFERENECE BOOKS

1. William, T. S. Laser Fundamentals, 2nd edn; Cambridge University press, New York, 2004
2. Halliday, D. Resnick, R and Walker J. Fundamentals of Physics, 6th Edition, John Wiley and Sons, New York, 2001.

G. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/122/103/122103011/
2. https://archive.nptel.ac.in/courses/115/102/115102124/
3. https://archive.nptel.ac.in/courses/115/107/115107095/
4. https://archive.nptel.ac.in/courses/115/104/115104088/

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Remember the fundamental principles of interference, diffraction, and polarization, and understand their physical significance in optical phenomena.
CO2	Apply the concepts of interference, diffraction, and polarization to real-world engineering applications.
CO3	Understand and analyze the principles, working mechanisms, and applications of lasers and optical fibers, including their role in industrial, medical, and communication technologies.
CO4	Remember the fundamental principles of electrostatics, electrodynamics, and magneto statics, and understand their significance in electric and magnetic fields.
CO5	Analyze and apply Maxwell's equations, electromagnetic wave propagation, and Faraday's laws of induction to solve problems in electromagnetism and related engineering applications.
CO6	Understand and apply quantum mechanics principles, including wave-particle duality, uncertainty principle, and Schrödinger's equation, to analyse microscopic systems.

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	3	**2.2**
PO 3	2	2	3	2	3	3	**2.5**
PO 4	1	1	2	1	2	2	**1.5**
PO 5	1	1	2	1	1	3	**1.5**
PO 6	1	2	3	1	1	2	**1.7**
PO 7	-	1	2	-	-	-	**1.5**
PO 8	-	-	2	1	2	2	**1.8**
PO 9	2	2	2	2	2	2	**2.0**
PO 10	2	2	3	2	2	2	**2.2**
PO 11	2	2	3	3	2	3	**2.5**
PSO 1	1	1	2	1	1	2	**1.3**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-I
ENVIRONMENTAL STUDIES (25SM101)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
4	0	0	4	4.0	60	40	-	-	100

A. COURSE OVERVIEW

This course introduces engineering students to the principles of environmental science and the impact of industrial activities on ecosystems. It emphasizes pollution control, sustainable engineering practices, environmental laws, and resource management. The course aims to develop environmentally responsible engineers equipped to design solutions that support sustainable development.

B. PREREQUISITES Basic Science Knowledge and General Awareness of Environmental Issues

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (45)
1.	**The Multidisciplinary Nature of Environmental Studies:** Definition, scope and importance & need for public awareness	CO1	2
2.	**Natural Resources** Renewable and non-renewable resource: Natural resources and associated problems, Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams, and their effects on forests and tribal people, Water resources: Use and over- utilization of surface and ground water, floods, drought, conflicts over water, dams benefit and problems, Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies, Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies, Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources, case studies, Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification, Role of an individual in conservation of natural resources. Equitable use of resources of sustainable lifestyles	CO2	8
3.	**Ecosystems** Concept of an ecosystem, Structure and function of an ecosystem, producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystem: Forest ecosystem, Grassland ecosystem, Desert ecosystem and Aquatic ecosystem (ponds, streams, lakes, rivers, oceans, estuaries)	CO3	6
4.	**Biodiversity and Its Conservation** Introduction definition: Genetic, species and ecosystem diversity, Bio-geographical classification of India, Value of biodiversity: Consumptive use, productive use, social, ethical, aesthetic and option values. Biodiversity at global, national and local levels, India as a mega diversity nation, Hot-spots of biodiversity, Threats to biodiversity, habitat loss, poaching of wildlife, man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity: In-situ and ex-situ conservation of biodiversity	CO4	8
5.	**Environmental Pollution** Definition, Causes, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, nuclear hazards, Solid waste management, causes, effects and	CO5	8

	control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides		
6.	**Social Issues and The Environment** From unsustainable to sustainable development, Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rehabilitation of people: its problems and concerns. Case studies, Environmental ethics: Issues and possible solutions, Climate change: Global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, Case studies, Wasteland reclamation, Consumerism and waste products, Environment Protection Act: Air (Prevention and Control of Pollution) Act, Water (Prevention &Control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation, public awareness	**CO6**	**7**
7.	**Human Population and The Environment** Population growth, variation among nations, population explosion, Family Welfare Program, environment and human health, human rights, Value education, HIV/AIDS, Women and Child Welfare, Role of Information Technology in Environmental and human health, Case studies	**CO6**	**6**
8.	**Field Work** Visit to local area to document environmental assets, polluted sites. Study common plants, insect's bird. Study simple ecosystems		

D. TEXT BOOKS

1. Erach Bharucha Textbook of Environmental Studies; Second Edition, Universities Press: Hyderabad, 2013
2. Rajagopalan, R. Environmental Studies; Oxford University Press: India, 2015

E. REFERENECE BOOKS

1. Varandani, N. S. Basics of Environmental studies; Lambert Academic Publishing: Germany, 2013
2. Rao, C. S. Environmental Pollution Control Engineering; Wiley publishers: New Delhi, 2006
3. Clark, R. S. Marine Pollution; Clanderson Press Oxford: Bath, 2001
4. Cunningham, W.P.; Cooper; Gorhani, T. H. E.; Hepworth, M.T., Environmental Encyclopedia; Jaico Publ. House: Mumbai, 2001
5. De, A. K. Environmental Chemistry; Wiley Eastern: New Delhi, 2006

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the scope, multidisciplinary nature, and importance of environmental studies.
CO2	Identify and evaluate the use and impact of natural resources on the environment.
CO3	Describe the structure and function of ecosystems and their role in sustaining life.
CO4	Analyze biodiversity and its conservation strategies at local, national, and global levels.
CO5	Explain the causes, effects, and control measures of different types of environmental pollution.
CO6	Discuss key social, legal, and ethical issues related to environmental protection and sustainable development.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	2	1	1	1	1	**1.3**
PO 2	2	3	2	1	3	1	**2.0**
PO 3	2	3	3	3	3	1	**2.5**
PO 4	2	3	2	2	3	1	**2.2**
PO 5	1	1	1	1	3	2	**1.5**
PO 6	2	2	3	3	3	3	**2.6**
PO 7	3	3	3	3	3	3	**3.0**
PO 8	2	3	3	3	3	2	**2.6**
PO 9	3	3	2	2	3	3	**2.6**
PO 10	2	2	2	2	2	2	**2.0**
PO 11	3	3	3	3	3	3	**3.0**
PSO 1	2	3	3	3	3	3	**2.8**
PSO 2	2	2	2	2	2	2	**2.0**

Semester – II

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
PC	Introduction to Chemical Engineering	2	0	2	4	3.0	60	40	25	25	150
BS	Mathematics-II	3	1	0	4	4.0	60	40	0	0	100
ES	Engineering Graphics	2	1	2	5	4.0	60	40	50	0	150
BS	Applied Chemistry - II	3	0	3	6	4.5	60	40	25	25	150
ES	Electrical and Electronics Engineering	3	0	2	5	4.0	60	40	50	0	150
ES	Workshop Practices	0	1	2	3	2.0	0	0	50	0	50
	Total	**13**	**3**	**11**	**27**	**21.5**	**300**	**200**	**200**	**50**	**750**

B.TECH. – SEMESTER-II
INTRODUCTION TO CHEMICAL ENGINEERING (25CHxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	0	2	4	3.0	60	40	25	25	150

A. COURSE OVERVIEW

This course introduces the fundamentals of chemical engineering, covering unit operations, unit processes, and modes of operation. It provides insight into the structure and functioning of Chemical Process Industries, including raw materials and products. Students learn to interpret standard industrial diagrams (PBD and PFD) and apply basic mathematical and scientific principles to process calculations. The course also highlights the roles of chemical engineers in industry and research, laying the groundwork for advanced studies and professional practice.

B. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (24)
1.	**Introduction and fundamentals** About the discipline of chemical engineering, concept of unit operations and unit processes, operations in batch, semi-batch and continuous mode, flow pattern as co- current, counter-current and cross-current, concept of fluid solid contacting using fixed, moving and fluidized beds.	CO1	3
2.	**Overview of Chemical Process Industries (CPI)** Definition of CPI/GCT, important chemical process industries, its typical raw materials, products and end usages.	CO2	4
3.	**Role of Chemical Engineer** Role of chemical engineer in various aspects such as research, process development, process design & evaluation, plant design, construction (EPC firms), process supervision, plant technical service, product sales, general aspects of chemical engineering such as communication, human relations, professional activities & technical reading. Environmental, safety and ethical aspects associated with chemical engineering profession.	CO3	5
4.	**Flowsheet Drawing** Symbols as per Indian Standards 3232, basics of PBD and PFD systematic analysis of chemical processes by flowsheet reading and drawing.	CO4	4
5.	**Useful Mathematical Methods** Presentation of data as table and chart, basics of regression and correlation, linear and polynomial curve fitting using graphical and numerical method, determining goodness of fit (R2 calculation), graphical and numerical methods for interpolation, integration and to find the root of an equation, graphical addition & subtraction of mass (inverse lever arm rule).	CO5	4
6.	**Physical and Chemical Principles** Process variables like temperature, pressure, density, viscosity, composition and flow rate. Ideal and real gas calculations and associated laws like Dalton and Amagat. Concept of vapor-liquid equilibria, laws like Raoult’s law, Henry’s law. Dew and Bubble calculations.	CO6	4

C. PRACTICAL AND TERM WORK

1. Graphical Curve Fitting
2. Numerical Curve Fitting
3. Integration (Graphical and Numerical)
4. Finding Root (Graphical and Numerical)
5. Graphical Addition (Mixture Rule)
6. Interpolation
7. Vapour-Liquid Equilibrium
8. R^2 Calculations

D. TEXT BOOKS

1. Andersen, L. B.; Wenzel, L. A. *Introduction to chemical engineering*; McGraw Hill Book Company, New York, 1961.

E. REFERENECE BOOKS

1. Ghosal, S. K.; Sanyal S. K.; Datta, S. Introduction to Chemical Engineering; McGraw Hill Education, 1st Ed, 2007
2. Himmelblau, D. M.; Riggs, J. B. Basic Principles and Calculations in Chemical Engineering; PHI Learning Pvt Ltd, 7th Ed, 2013

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Fundamental concepts of chemical engineering, including unit operations, unit processes, and different modes of operation.
CO2	Structure and significance of Chemical Process Industries, focusing on raw materials, products, and end uses.
CO3	Roles and responsibilities of chemical engineers in research, process development, plant design, operations, and safety.
CO4	Process representation through Process Block Diagrams (PBD) and Process Flow Diagrams (PFD) with standard notation.
CO5	Mathematical techniques relevant to chemical engineering analysis, such as regression, curve fitting, interpolation, and numerical integration.
CO6	Application of physical and chemical principles in solving process calculations involving gas laws, vapor-liquid equilibrium, and mass balances.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	2	2	3	3	**2.7**
PO 2	2	2	2	3	3	3	**2.5**
PO 3	2	2	3	3	2	2	**2.3**
PO 4	1	1	2	2	3	3	**2.0**
PO 5	1	1	2	3	3	2	**2.0**
PO 6	-	-	3	-	-	2	**0.8**
PO 7	-	-	2	-	-	3	**0.8**
PO 8	-	-	3	-	-	-	**0.5**
PO 9	-	-	2	-	-	-	**0.3**
PO 10	1	1	2	2	1	1	**1.3**
PO 11	1	1	2	2	2	1	**1.5**
PSO 1	3	3	3	3	2	3	**2.8**
PSO 2	2	1	2	1	3	2	**1.8**

B.TECH. – SEMESTER-II
MATHEMATICS-II (25BS203)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	0	4	4.0	60	40	0	0	100

A. COURSE OVERVIEW

Provide students with the knowledge and techniques to model dynamic systems through ordinary and partial differential equations. Enable students to understand and apply analytical methods for solving equations that describe spatial and temporal variations in physical processes. Strengthen problem-solving abilities involving multiple integrals and coordinate transformations used in engineering design and analysis. Introduce the concepts of vector integration and its application to physical laws governing conservation and field behavior. Familiarize students with transform techniques to simplify complex differential models, particularly in linear time-invariant systems. Train students to use inverse transformation methods to interpret system responses and analyze the behavior of engineering systems in the time domain.

B. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (48)
1.	**First Order Ordinary Differential Equations And Introduction To Higher Order Differential Equations** Exact, linear and Bernoulli's equations, Introduction to second order linear differential equations with variable coefficients, Method of variation of parameters, Cauchy-Euler equation.	CO1	10
2.	**Partial Differential Equations** Introduction, Solutions of partial differential equations: Equations solvable by direct integration, Lagrange's linear equation of first order, Non-linear equations of first order, Charpit's method, Homogenous linear equations with constant coefficients, Rules to find the complementary functions and the particular integral, Working procedure to solve homogeneous linear equations of any order, Non-homogenous linear equations with constant coefficients **Applications of partial differential equations** Method of separation of variables.	CO2	12
3.	**Multivariable Calculus (Integration)** Multiple Integration: Double integrals (Cartesian), Change of order of integration in double integrals, Change of variables (Cartesian to polar).	CO3	8
4.	**Vector Integral Calculus** Vector line integrals – Circulation – Work, Surface integrals, Green's theorem in a plane, Gauss-Divergence theorem, and Stoke's theorem.	CO4	6
5.	**Laplace Transform** Introduction, Definition, transform of elementary functions, Properties of Laplace transform: Linearity property, First shifting property, change of scale property, transforms of derivatives, Transforms of integrals, Multiplication by t^n, Division by t, Evaluation of integrals by Laplace transform. Finding inverse Laplace transform by partial fraction, Convolution theorem **Application of Laplace Transforms** Solving ordinary differential equations using Laplace transform.	CO5 CO6	12

C. RECOMMENDED TEXT / REFERENCE BOOKS

1. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 40th Edition, 2007.
2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Ed. Pearson, 2002.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

4. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.

D. COURSE OUTCOMES

Cos	STATEMENT
CO1	Develop and apply methods to find analytical solutions of scalar-valued functions defined through relations involving derivatives, including linear and nonlinear forms.
CO2	Formulate equations representing physical processes in multiple independent variables and solve them using direct, systematic, and characteristic-based approaches.
CO3	Evaluate integrals over regions in two or more dimensions using transformations and change of order, and apply them to solve engineering problems involving mass, charge, or fluid distribution.
CO4	Analyze and compute integrals over curves and surfaces in vector fields, and verify the validity of integral theorems by converting between differential and integral forms.
CO5	Transform time-domain mathematical models into an alternate domain to simplify the solution of initial value problems and apply operational techniques for system analysis.
CO6	Reverse transform expressions in the transformed domain back to the original domain using algebraic and integral methods, and interpret the results in the context of system dynamics.

E. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	2	**2.0**
PO 3	-	2	-	-	-	-	**2.0**
PO 4	-	1	2	2	-	1	**1.5**
PO 5	-	-	-	-	-	-	**-**
PO 6	-	-	-	-	-	-	**-**
PO 7	-	-	-	-	-	-	**-**
PO 8	-	-	-	-	-	-	**-**
PO 9	-	-	-	-	-	-	**-**
PO 10	-	-	-	-	-	-	**-**
PO 11	-	-	-	-	-	-	**-**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	2	2	-	2	-	2	**2.0**

B.TECH. – SEMESTER-II
ENGINEERING GRAPHICS (25ES203)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	1	2	5	4.0	60	40	50	0	150

A. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (30)
1.	**Engineering Curves** Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic section curves (Ellipse, Parabola, Hyperbola), Cycloidal Curves (Cycloid, Epicycloid, Hypocycloid), Involutes; Archimedean Spiral	CO1	9
2.	**Solid Geometry** Projection of points, projection of lines and their applications, projection of regular planes such as square, rectangle, triangle, circle, pentagon, hexagon, rhombus, projection of right and regular solids inclined to both the planes (prisms, pyramids, cylinder and cone)	CO2	8
3.	**Orthographic Projections** Concept of orthographic projections, first angle and third angle projection methods, conversion of pictorial views into orthographic projections with dimensioning, computer aided drawing of orthographic projection views	CO3	4
4.	**Sectional Orthographic Projections** Concept of sectional orthographic projections, special sections, computer aided drawing of sectional orthographic projection views	CO4	3
5.	**Isometric Projections** Principles of isometric projection, isometric scale, isometric projection and view, conversion of orthographic views to isometric projections and views	CO5	3
6.	**Development of Surfaces** Introduction, engineering applications of development of surfaces, methods of development, development of surfaces of right regular solids prismpyramid, cylinder and cone	CO6	3

B. PRACTICAL AND TERM WORK

Sheet No.	Title of the sheet	Exercises for sketchbook	Exercises for Sheet	Lab. Turns Allotted
0	Zero Sheet	As per given sheet	---	01
1	Engineering curves (Conics)	6	3	03
	Orthographic projection	2	1	
2	Projections of straight lines	3	2	03
	Projections of planes	4	2	
	Sectional orthographic projection	2	1	
3	Cycloidal curves	3	2	02
	Involutes	2	1	
	Projection of solids	2	1	
4	Isometric drawing / projection	2	1	03
	Archimedean spiral	2	1	
	Development of surfaces	4	2	
5	Introduction to Computer Aided Drawing, drawing of orthographic and sectional orthographic views	---	---	03

C. RECOMMENDED TEXT / REFERENCE BOOKS

1. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
2. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
3. Shah P. J., (2014) Engineering Graphics, S. Chand Publishing
4. Luzadder W., Duff J., (1992), Fundamentals of Engineering Drawing, Peachpit Press
5. Gill P. S., (2009), Engineering Drawing, S. K. Kataria & Sons
6. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication

D. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand primary concepts of Engineering Drawing, geometrical construction and various engineering curves
CO2	Illustrate correct usage of methods, concepts, and theories to solve problems of solid geometry
CO3	Select an appropriate standard projection system, break down complex 3D problem into various orthographic views, understand and apply computer aided drawing software to solve orthographic projection problems
CO4	Break down complex 3D problems into sectional orthographic views, understand apply computer aided drawing software to solve the problems of sectional orthographic projections
CO5	Generate isometric projection from two-dimensional drawings
CO6	Create development of surfaces for various parts / components in real life situations

E. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	3	3	3	3	3	**3.0**
PO 2	-	1	2	2	2	2	**2.0**
PO 3	-	1	1	1	1	1	**1.0**
PO 4	-	1	1	1	1	1	**1.0**
PO 5	-	-	-	2	2	-	**2.0**
PO 6	-	-	-	-	-	-	**-**
PO 7	-	-	-	-	-	-	**-**
PO 8	-	-	-	-	-	-	**-**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	1	1	1	2	2	**1.0**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	1	2	2	2	2	2	**2.0**
PSO 2	1	2	1	2	2	2	**2.0**

B.TECH. – SEMESTER-II
APPLIED CHEMISTRY-II (25BSxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	4.5	60	40	25	25	150

A. COURSE OVERVIEW

This course explores key concepts in chemistry with industrial relevance. It begins with surface chemistry and catalysis, covering adsorption, Langmuir isotherm, and various catalysts, followed by Chemical kinetics, where, reaction rates, activation energy and collision theory are introduced. Spectroscopy and analytical techniques comprising UV-Vis, IR, chromatography, and electrochemical methods are covered to impart analytical skills. Organic chemistry portion covers the study of heterocyclic compounds, their synthesis and reactions, natural products like carbohydrates, lipids, and proteins, along with their industrial applications, are highlighted. The chemistry behind industrially important materials like glass, ceramics, cement, metals, and composites is also discussed. Finally, green chemistry and sustainable practices are introduced. The course provides a strong foundation in applied chemistry for industrial and research applications.

B. PREREQUISITES

A solid foundation in general chemistry, including concepts of chemical reactions, kinetics, and basic organic chemistry, is necessary. Familiarity with solution chemistry and basic analytical techniques would also be beneficial.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (39)
1.	**Chemistry of Surfaces and catalysis** Adsorption at surfaces, Langmuir adsorption isotherm, reactions at interfaces, colloids, Surfactants (classification and types of surfactants, micelles) Catalysis (classification, acid-base catalysis, organometallic catalysts in industrial processes).	CO1	7
2.	**Chemical Kinetics** Introduction, Reaction Mechanism, Rates of Chemical reactions: Elementary rate laws, temperature dependence of rate. Homogeneous-heterogeneous reactions, Theories of chemical kinetics: Collision theory, activated complex theory, Arrhenius theory, Numerical.	CO2	7
3.	**Spectroscopy and Analytical Techniques** Basics of UV, IR, and applications of spectroscopy in material analysis. Chromatography techniques and applications, Theory, instrumentation and applications of Conductometry, pH Metry and Potentiometry.	CO3	6
4.	**Heterocyclic compounds** Heterocyclic compounds, synthesis and reactions of Furan, Thiophene, Pyrrole, Pyridine and Furfural.	CO4	5
5.	**Natural Products** Carbohydrates, Lipids (Vegetable Oils), Proteins, and Enzymes, their Industrial applicability.	CO5	5
6.	**Industrially Important Reactions-2** Fundamentals of Glass, ceramics, cement, metals and refractory, and composites and important chemical reactions involved therein.	CO6	6
7.	**Green Chemistry and Sustainable Practices** SDGs, Importance of Green Chemistry and Sustainable Industrial processes.	CO5	3

D. PRACTICAL AND TERM WORK

1. Adsorption Isotherm on Charcoal.
2. Potentiometric Redox titration.
3. Dissociation constant by Conductometer.
4. Chemical Kinetics.
5. Chromatography (Paper Chromatography).
6. Separation of unknown binary organic mixture and spotting (2
7. Experiments).
8. Organic Spotting (2 Experiments).

E. TEXT BOOKS

1. "Physical Chemistry" by Peter Atkins and Julio de Paula.
2. "Analytical Chemistry" by Gary D. Christian.
3. "Organic Chemistry" by Clayden, Greeves, Warren, and Wothers.
4. "Shreve's Chemical Process Industries" by George T. Austin.

F. REFERENECE BOOKS

1. "Surface Chemistry" by G.A. Somorjai.
2. "Chemical Kinetics and Reaction Dynamics" by Paul L. Houston.
3. "Chromatography: Concepts and Contrasts" by James M. Miller.
4. "Natural Products: A Synthesis Perspective" by K.C. Nicolaou and E.J. Sorensen.
5. "Ullmann's Encyclopaedia of Industrial Chemistry"
6. Green Chemistry: Theory and Practice" by Paul T. Anastas and John C. Warner.

G. ONLINE RESOURSES (NPTEL COURSES)

1. Catalyst Science and Technology
2. Introduction to Chemical Thermodynamics and Kinetics
3. Introduction to the Modern Instrumental Methods of Analysis
4. Heterocyclic Chemistry

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Comprehend surface phenomena such as adsorption, interfacial interactions, colloids, surfactants, and catalysis, with relevance to industrial and chemical processes.
CO2	Examine and evaluate reaction rates, comprehend the determinants affecting reaction processes, and use diverse kinetic theories to elucidate and simulate chemical reactions.
CO3	Apply UV, IR, chromatography, conductometry, pH metry, and potentiometry techniques for qualitative and quantitative analysis of materials.
CO4	Synthesize and predict the reactivity of common heterocyclic compounds (furan, thiophene, pyrrole, pyridine, and furfural).
CO5	Relate the chemical properties of carbohydrates, lipids, proteins, and enzymes to their industrial applications and analyze industrial processes through the lens of green chemistry and sustainable development goals.
CO6	Explain the chemical principles and reactions underlying the production and properties of glass, ceramics, cement, metals, refractories, and composites.

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	2	3	**2.8**
PO 3	1	2	1	2	2	1	**1.5**
PO 4	1	3	1	2	1	2	**1.7**
PO 5	-	-	3	-	-	-	**3.0**
PO 6	3	1	-	1	3	2	**2.0**
PO 7	-	-	-	1	3	-	**2.0**
PO 8	1	2	3	1	1	-	**1.6**
PO 9	-	1	-	1	-	-	**1.0**
PO 10	1	-	1	1	2	1	**1.2**
PO 11	1	1	-	-	2	2	**1.5**
PSO 1	3	3	3	2	3	3	**2.8**
PSO 2	2	3	3	3	3	2	**2.7**

B.TECH. – SEMESTER-II
ELECTRICAL ENGINEERING AND ELECTRONICS (25ESxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	2	5	4	60	40	50	-	150

A. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Fundamentals of DC Circuits** Voltage and Current Sources, Basic Laws, Network Theorems, Superposition Theorem and Thevenin's Theorem,		6
2.	**AC Fundamentals:** A.C. through resistance, inductance and capacitance, simple RL, RC and RLC circuits. Power, power factor		4
3.	**Three Phase Systems:** Three phase system of emfs and currents, Star and Delta connections, Three phase power		3
4.	**Single phase transformers**: Principle of working, Efficiency, regulation.		3
5.	**Electrical drives:** Basic concepts of different types of Electrical motors as drives, Their suitability for various applications.		2
6.	**Regulated power supplies**: Diodes as rectifiers, Half wave and Full wave rectifier, Filters and Regulators		4
7.	**Bipolar junction transistors:** Different configurations, Characteristics, Concept of basic amplifier circuits, Amplifier gain, Transistor as switch		4
8.	**Introduction to Integrated circuits:** Basic concepts of ICs		2
9.	**Introduction to data acquisition and signal conditioning:** Basic concept and Block diagram, Concept of conversion of physical quantity to electrical signal, signal conditioning, Introduction to A/D and D/A converters		3
10.	**Introduction to instrumentation amplifiers and their applications:** Operational Amplifier – Notation, Pin diagram, Differential and common mode gain, CMRR, Applications as non-inverting, inverting, summing, differential amplifiers, integrator, differentiator		5

B. TEXT/REFERENECE BOOKS

1. Basic Electrical, Electronics and Computer Engineering, R. Muthu Subramanian, S. Salivahanan, K. A. Muraleedharan, 2nd Edition, Tata McGraw Hill
2. Electronics Principles, Albert Paul Malvino, 6th Edition, Tata McGraw Hill
3. Electrical Engineering Fundamentals by Vincent Deltoro
4. Electronic devices and circuits by Boylstead, Nashelsky
5. Electrical Machines by Nagrath, Kothari
6. Electrical Technology by B.L.Theraja, A.K.Theraja vol I,II,IV

C. COURSE OUTCOMES

Cos	STATEMENT
CO1	To find DC Circuit parameters using KVL, KCL, Ohm's Laws in DC circuits and apply various Network Theorems to solve DC networks.
CO2	Compute various parameters of AC circuits consists of R, Land C.
CO3	Discriminate half wave / full wave rectifier circuit and analyze load line and operating point

	for different biasing circuits of NPN and PNP transistor.
CO4	Understand the operation of Transformer and three phase systems.
CO5	Understand the principles, types, and characteristics of various electrical motors and their suitability for selecting appropriate drives in various industrial and commercial applications.
CO6	To explore signal conditioning, A/D and D/A converters, and gain an understanding of the principles and applications of operational amplifiers, including their different configurations and functions.

D. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	3	2	2	3	3	**2.5**
PO 2	2	3	2	2	3	3	**2.5**
PO 3	1	1	1	1	2	2	**1**
PO 4	1	1	1	1	1	2	**1**
PO 5	2	2	2	2	2	2	**2**
PO 6	2	2	2	2	2	2	**2**
PO 7	1	1	1	1	1	1	**1**
PO 8	1	1	1	1	1	1	**1**
PO 9	1	1	1	1	1	1	**1**
PO 10	-	-	-	-	-	-	**-**
PO 11	-	-	-	-	-	-	**-**
PSO 1	3	2	3	2	2	3	**2.5**
PSO 2	2	2	3	2	2	3	**2**

B.TECH. – SEMESTER-II
WORKSHOP PRACTICES (25ESxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
0	1	2	3	2.0	-	-	50	-	50

A. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (45)
1.	**FITTING SHOP** Introduction to Fitting tools: files, vice, chisels, punch, scriber, hammers, surface plate, angle plate, try square, calipers etc., Demonstration of fitting operations such as marking, punching, sawing, filling, grinding, drilling, tapping, Making job of fitting shop.	CO1	9
2.	**SMITHY SHOP** Introduction to Smithy tools like hammer, anvil, swage block, flatteners etc. Demonstration of Smithy operations such as upsetting, drawing down, bending, setting down, fork cutting, punching and fullering etc., Making job of cold smithy shop. Safety rules.	CO2	9
3.	**FABRICATION SHOP** Introduction to Welding process, classification of welding, Basic electric arc welding process, arc welding machine and its accessories, welding electrodes, types of weld joints, safety requirement during working with fabrication shop, etc. Demonstration of arc welding process. Making job of fabrication shop.	CO3	9
4.	**MACHINE SHOP** Introduction and demonstration of machine tools: Lathe, Milling, Drilling, Grinding, etc.	CO4	9
5.	**ELECTRONIC WORKSHOP** Introduction and application of basic electronics components. To understand use of digital multimeter in electronics. Basic exercise related to series and parallel connection with the use of breadboard.	CO5	9

B. REFERENECE BOOKS

1. Work shop technology, A. K. Hajrachaudhari & S. K. Hajrachaudhari
2. ITB Hand book, Engineering industry training board
3. Work shop Technology Vol. I & II, Gupta & Kaushik
4. Basic electrical, electronics and computer engineering, R. Muthusubramanian, S. Salivahanan, K. A. Muraleedharan, Second Edition, Tata McGraw Hill

C. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand and apply basic workshop tools for fitting
CO2	Understand and apply basic workshop tools for smithy shop
CO3	Understand and apply basic workshop tools and accessories used for fabrication/welding shop
CO4	Understand working of various machine tools like lathe, milling, drilling, grinding etc…
CO5	Understand and apply basic electronics tools with breadboard

D. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	Average
PO 1	2	2	2	2	2	**2.0**
PO 2	1	1	1	1	1	**1.0**
PO 3	2	2	2	2	2	**2.0**
PO 4	-	-	-	-	-	-
PO 5	-	-	-	-	-	-
PO 6	2	2	2	2	2	**2.0**
PO 7	1	1	1	1	1	**1.0**
PO 8	1	1	1	1	1	**1.0**
PO 9	2	2	2	2	2	**2.0**
PO 10	-	-	-	-	-	-
PO 11	-	-	-	-	-	-
PSO 1	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	**2.0**

Semester – III

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
ES	Chemical Engineering Thermodynamics-I	3	0	0	3	3.0	60	40	0	0	100
PC	General Chemial Technology	3	1	2	6	5.0	60	40	25	25	150
PC	Material & Energy Balance Computations	3	1	0	4	4.0	60	40	0	0	100
ES	Material Science	2	0	0	2	2.0	60	40	0	0	100
HM	IKS and Yoga	1	0	2	3	2.0	60	40	25	25	150
HM	Effective Technical Communication	3	0	0	3	3.0	60	40	0	0	100
	Total	**15**	**2**	**4**	**21**	**19.0**	**360**	**240**	**50**	**50**	**700**

B.TECH. – SEMESTER-III
CHEMICAL ENGINEERING THERMODYNAMICS-I (SUB. CODE)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

This course provides an in-depth understanding of the principles and applications of thermodynamics in chemical engineering. It covers the foundational laws of thermodynamics, focusing on energy conservation, equilibrium states, and phase transitions. Students will explore the behaviour of pure substances (ideal and real gases) and learn how to apply equations of state and understand the concept of entropy and its impact on system irreversibility. The course also covers thermodynamics in flow processes, such as pipe flow, throttling, compressors, and nozzles, with an emphasis on maximizing efficiency and understanding energy transfer. Students will examine various power and refrigeration cycles, including steam power plants, internal combustion engines, and vapor compression refrigeration for energy production and cooling.

B. PREREQUISITES: Basic physics and Engineering Mathematics

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Fundamentals of Thermodynamics** Concept of system and surrounding, First Law of Thermodynamics, application to steady-state flow processes, enthalpy, internal energy, equilibrium state, phase rule, Irreversible & reversible processes, heat capacity & specific heat.	CO1	3
2.	**Properties of Pure Substances & Real Gases** PVT behaviour of pure substances, Ideal & non-ideal gases, Equations of state for real gases (Viral equation, Van der Waals equation, Redlich–Kwong equation, etc.), Corresponding states theory & Pitzer's modification.	CO2	7
3.	**Second and Third Laws of Thermodynamics** Second Law of Thermodynamics, Thermodynamic temperature scale & ideal gas temperature scale, Concept of entropy, entropy change, and irreversibility, Introduction to the Third Law of Thermodynamics.	CO3	6
4.	**Heat Effects and Thermodynamic Relations** Heat capacity of gases, liquids, and solids, Heat of vaporization, fusion, sublimation, formation, and combustion, Calculation of heat effects from formation and combustion data, Fundamental thermodynamic relations and Maxwell's equations, thermodynamic properties of single phase & two-phase systems, types of thermodynamic diagrams.	CO4	5
5.	**Thermodynamics of Flow Processes** Fundamental equations & relationships for flow in pipes, Maximum velocity in pipe flow, throttling process, Flow through nozzles, single-stage & multi-stage compressors.	CO5	6
6.	**Heat Power Cycles, Refrigeration & Liquefaction** Steam power plant, internal combustion engines, gas turbines, jet engines, rocket engines, Carnot refrigeration cycle, air refrigeration cycle, vapor compression cycle, absorption refrigeration, Choice of refrigerants, heat pumps, liquefaction processes. Pressure and Temperature relation and subsequent safety aspects, Evaporation rate of chemical after leak using Clausius-Clapeyron equation, Safe operating temperature ranges based on the state.	CO6	6

D. TEXT BOOKS

1. Introduction to Chemical Engineering Thermodynamics 4th Ed. by J. M. Smith & H. C. Van Ness McGraw Hill Book Company
2. Chemical Engineering Thermodynamics" by Y.V.C. Rao, Universities Press

E. REFERENECE BOOKS

1. Chemical Engineering Thermodynamics by B. F. Dodge McGraw Hill Book Company
2. A Textbook of Chemical Engineering Thermodynamics by K. V. Narayanan, PHI Learning Private Limited

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/103/103103144/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Basic concepts of thermodynamics including the First Law and the behavior of reversible and irreversible processes.
CO2	PVT behavior of pure substances and apply equations of state for real gases.
CO3	the Second Law of Thermodynamics to analyze entropy changes, irreversibility and the Third Law.
CO4	Heat effects such as heats of formation, combustion; and apply thermodynamic relations including Maxwell's equations.
CO5	Steady-flow thermodynamic processes such as flow through pipes, nozzles, throttling devices, and compressors.
CO6	Various heat power cycles and refrigeration systems.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	3	3	2	3	1	**2.3**
PO 3	1	2	2	2	2	2	**1.8**
PO 4	1	3	2	2	2	2	**2.0**
PO 5	1	1	1	2	3	2	**1.7**
PO 6	1	1	2	3	2	3	**2.0**
PO 7	-	-	-	-	2	2	**0.7**
PO 8	1	-	2	-	1	-	**0.7**
PO 9	-	1	-	2	-	1	**0.7**
PO 10	1	-	2	2	2	2	**1.5**
PO 11	1	2	2	1	1	3	**1.7**
PSO 1	2	2	3	3	3	3	**2.7**
PSO 2	2	2	2	1	1	3	**1.8**

B.TECH. – SEMESTER-III
GENERAL CHEMICAL TECHNOLOGY (25CH309)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	2	6	5.0	60	40	25	25	150

A. COURSE OVERVIEW

General Chemical Technology (GCT) introduces students to key industrial chemical processes across sectors like petroleum, petrochemicals, polymers, fertilizers, natural products, Inorganic chemicals, fine chemicals, and dyes. The course emphasizes raw materials, process flow sheets, and process analysis, integrating fundamental science and engineering principles. It covers concepts of unit operations and unit processes in the production of essential industrial products. Additionally, students gain insights into environmental sustainability and engineering solutions for industrial challenges.

B. PREREQUISITES: Basic Chemistry, Introduction to Chemical Engineering (IChE)

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (46)
1.	**Petroleum, Petrochemicals, and Polymer Industries** **Petroleum Refining**: Origin, formation, and composition of petroleum, Petroleum reservoirs (India and worldwide)**,** Evaluation of petroleum, thermal properties, and testing methods**,** Dehydration and desalting of crude oil**,** Fractional distillation of petroleum and treatment of products**,** Thermal and catalytic cracking, catalytic reforming**,** Coking, alkylation, and hydrogen processes. **Petrochemical Industry**: Overview of petrochemical products from petroleum feedstocks. **Polymer and Synthetic Fiber Industry**: Manufacturing of phenol-formaldehyde and urea-formaldehyde resins**,** Production of PVC, polyethylene, nylon, polyester, acrylic, and rayon.	**CO1**	**20**
2.	**Industrial Water and Fuels** **Water and Water Treatment**: Industrial use of water, Demineralization, deionization, RO system, Water treatment and water resource management **Fuels & Energy**: Classification of fuels (solid, liquid, and gas), Water gas, Producer Gas, Coke oven gas, Coal & coal chemicals, coking of coal, Various types of coal gasifiers	**CO2**	**4**
3.	**Oils, Fats, Soaps, and Detergents:** **Oils & Fats Processing:** Extraction methods (Mechanical and Solvent extraction), Hydrogenation of oils **Soaps & Detergents**: Cleaning mechanism of soaps and detergents, Manufacturing of soaps, glycerine, and detergents, Surfactants and their industrial applications	**CO3**	**4**
4.	**Pulp, Paper, Sugar, and Starch Industries** **Pulp & Paper Manufacturing**: Kraft process and sulfite process, Chemical recovery system, Types of paper and paper manufacturing **Sugar & Starch Industry**: Manufacturing of sugar, starch, and dextrin, By-products of sugar industry and their applications	**CO4**	**4**
5.	**Inorganic Chemical Process Industries** **Cement & Glass Manufacturing**: Limestone beneficiation, Types and manufacturing of cement, Types and manufacturing of glass **Sulfur and Electrolytic Processes**: Elemental sulfur production (Frasch process), Hydrogen sulfide conversion and sulfur recovery, Sulfur extraction from iron pyrites, Electrolytic manufacturing of	**CO5**	**10**

	aluminum and magnesium **Fertilizer Industry:** Types of fertilizers, Manufacturing of urea, single super phosphate (SSP), di-ammonium phosphate (DAP), Triple Super Phosphate (TSP) **Chlor-Alkali Industry:** Preparation and purification of brine, mercury cell, diaphragm cell, and membrane cell technologies, Manufacturing processes of chlorine, caustic soda (NaOH), and hydrogen gas		
6.	**Fine Chemicals, Pharmaceuticals, and Dyes** **Fine Chemicals & Pharmaceuticals**: Classification of pharmaceuticals**,** Manufacturing of important drugs – salicylic acid, methyl salicylate, aspirin, antibiotics, vitamins **Dyes & Intermediates**: Industrial production and applications of dyes, Application of dyes in textiles, polymers, and coatings, Sustainable dyeing technologies	**CO6**	**4**

D. TEXT BOOKS

1. Shreve's Chemical Process Industries, 5th Ed. By, George F. Austin McGraw Hill International Edition NY
2. Dryden's Outlines of Chemical Technology, 2nd Ed. By M. Gopala Rao & Marshall Sitting, East West Press Pvt. Ltd., New Delhi
3. Bhaskara Rao, B.K., Modern Petroleum Refining Processes, 6th Ed. Oxford & Ibh, New Delhi, 2017
4. Bhaskara Rao, B.K., A Text On Petro Chemicals, 5th Ed, Khanna Publisher, New Delhi, 2010

E. REFERENECE BOOKS

1. Chemical Process Industries, 4th Ed. by R. Norris Shreve & J. A. Brink, Jr. International Student's Edition.
2. Pollution Control in Chemical Process Industries, 1st Ed. By S. P. Mahajan Tata McGraw Hill Publications, New Delhi

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/103/103103217/
2. https://archive.nptel.ac.in/courses/103/103/103103218/
3. https://archive.nptel.ac.in/courses/103/107/103107082/
4. https://archive.nptel.ac.in/courses/103/102/103102022/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the fundamental processes involved in petroleum refining, petrochemicals, and polymer production, and analyze their industrial significance.
CO2	Develop an understanding of industrial water and fuel systems and apply this knowledge to chemical process operations.
CO3	Explain the extraction and processing of oils and fats, and analyze the manufacturing processes of soaps, detergents, and surfactants.
CO4	Analyze the process flow and key engineering problems in pulp, paper, sugar, and starch industries.
CO5	Understand and apply the production processes of cement, glass, fertilizers, and chlor-alkali products using process flow diagrams and basic chemical principles.
CO6	Understand the environmental and sustainability concerns in fine chemical and pharmaceutical manufacturing, and analyze industrial dyeing practices.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	2	3	3	2.8
PO 2	3	3	2	3	3	3	2.8
PO 3	3	2	2	3	3	2	2.5
PO 4	-	2	3	3	-	3	1.8
PO 5	3	3	-	3	3	2	2.3
PO 6	3	3	-	3	3	3	2.5
PO 7	-	-	2	-	-	3	0.8
PO 8	2	2	2	2	2	3	2.7
PO 9	3	3	2	3	2	3	2.7
PO 10	3	3	-	3	3	3	2.5
PO 11	3	3	2	3	3	3	2.8
PSO 1	3	3	3	3	3	3	3.0
PSO 2	3	3	2	3	3	3	2.8

B.TECH. – SEMESTER-III
MATERIAL AND ENERGY BALANCE COMPUTATIONS (25CHxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	0	4	4.0	60	40	0	0	100

A. COURSE OVERVIEW
Fundamentals of unit conversion, stoichiometry and engineering computations related to unit operations and unit processes. Analysis of chemical processes in steady-state and unsteady-state domain along with mass and energy balances involving recycle, bypass and purge.

B. PREREQUISITES:
Basic Mathematics, Physics and Chemistry.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (48)
1.	**Units, Dimensions and Dimensional Analysis** Unit conversion of process variables like temperature, pressure, flow, density and concentration. Unit conversion focussing safety aspects like conversion from mg/m3 to ppm for TLV, conversion of flammability limits from percentage to ppm and vice versa. Temperature scale (absolute and relative) conversion, different ways of expressing units of physical constants. Concept of gc in absolute and gravitational unit systems. Conversion of empirical formula from one-unit system to another. Dimensional analysis using Rayleigh and Buckingham methods.	**CO1**	**5**
2.	**Physical and Chemical Computations** Computations involving Van-der-Waals Equation of State, Antoine equation, Raoult's law and Henry's law. Concept of saturation, mass, molal, percentage and relative humidity. Stoichiometric computations focused towards fertilizers, pharmaceuticals, chlor-alkali, acidity and hardness analysis calculations. Concentration representation of solutions as normality, molarity and molality.	**CO1**	**5**
3.	**Material Balance without Chemical Reaction** Schematic representation of process, selection of key component and degree of freedom analysis. Material balance over unit operations like distillation, mixing unit, evaporator, absorber, stripper, extractors, crystallizers, dryer, humidifier and dehumidifier. Complex mass balance involving recycle, bypass and purge stream. In addition, mass balance in unsteady state domain over simple unit operation.	**CO2**	**10**
4.	**Material Balance with Chemical Reaction** Concept of limiting & excess reactants, conversion, yield and selectivity, material balance involving single as well as multiple parallel reactions with special emphasis on fertilizers, chlor-alkali, petrochemicals, pharma and dyestuff industries.	**CO3**	**8**
5.	**Energy Balance** Concept of energy balance over flow process and non-flow process. Heat capacity of gas and gaseous mixtures, heat capacity of liquids and solids, sensible heat change in liquids and gases, enthalpy changes during phase change transformation, enthalpy changes accompanied by chemical reactions (exothermic and endothermic reactions), thermo-chemistry of mixing process, dissolution of liquids and solids, Energy balance at plant elevated conditions. Case study of energy balance – MIC and Non MIC route for carbaryl production, Latent heat of vaporisation and BLEVE. Adiabatic	**CO4**	**10**

	temperature rise calculations and discussion of safety aspects associated with energy balance.		
6.	**Overall Mass and Energy Balance over the Flowsheet** Mass and energy balance over connected equipment and complete mass and energy balance over at least one process flow sheet from Dryden. Safety aspects, ethics and decision making while performing mass and energy balance over flowsheet.	**CO5**	**5**
7.	**Fuels & Combustion** Types of fuels, proximate and ultimate analysis of fuel, calorific value of fuels as gross and net, problems on combustion of coal, liquid fuels and gaseous fuels. Limiting oxygen concentration and associated safety issues.	**CO6**	**5**

D. TEXT BOOKS

1. Himmelblau, D. M., Riggs, J. B.; Basic Principles & Calculations in Chemical Engineering; 7th Ed.; Prentice Hall India Learning Pvt. Ltd., 2013.
2. Bhatt, B. I., Thakore, S. B.; Stoichiometry; 5th Ed.; Tata McGraw Hill Education Pvt. Ltd., 2010.

E. REFEREENECE BOOKS

1. Felder, R.M., Rousseau R.W.; *Elementary Principles of Chemical Processes*; 3rd Ed.; John Wiley & Sons Inc., 2005.
2. **Watson, K.M., Hougen, O.A., Ragatz, R.A.;** *Chemical Process Principles Part-I Material and Energy balances*; 2nd Ed.; CBS Publishers & Distributors Pvt. Ltd., 2004.
3. Narayan, K. V., B. Lakshmikutty; *Stoichiometry and Process Calculations;* Second Edition, PHI Learning Private Limited: Delhi-110092, 2013.

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/105/103105209/
2. https://archive.nptel.ac.in/courses/102/106/102106069/
3. https://archive.nptel.ac.in/courses/113/104/113104010/

G. COURSE OUTCOMES

Cos	**STATEMENT**
CO1	Students will be able to perform unit conversion and computations involving physical and chemical principles.
CO2	Determine mass balance without chemical reactions in steady state and unsteady domain.
CO3	Foster the ability to evaluate mass balance involving chemical reactions in steady state domain.
CO4	Capability to perform detailed energy balance computations.
CO5	Improvisation of skill to execute complete mass and energy balance computations over the entire process flowsheet.
CO6	Calculations involving gross and net calorific values of fuels along with fuels requirement for various combustion operations.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3**
PO 2	2	2	2	3	3	3	**2.5**
PO 3	1	1	1	2	2	2	**1.5**
PO 4	-	-	1	1	1	1	**0.66**
PO 5	-	-	1	1	1	1	**0.66**
PO 6	1	1	2	2	2	2	**1.67**
PO 7	-	-	1	1	1	1	**0.66**
PO 8	1	1	2	2	3	2	**1.83**
PO 9	1	1	1	1	2	1	**1.17**
PO 10	1	1	1	1	2	1	**1.17**
PO 11	1	1	1	1	2	1	**1.17**
PSO 1	2	2	2	3	3	3	**2.5**
PSO 2	2	2	2	2	3	2	**2.17**

B.TECH. – SEMESTER-III
MATERIAL SCIENCE (25ESxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	0	0	2	2	60	40	0	0	100

A. COURSE OVERVIEW

The objective of this course is to teach different classes of materials relevant to Chemical Process Industries. The engineering applications of materials will be discussed with special emphasis on ferrous, non-ferrous metals, organic, inorganic and speciality materials for specific applications. The performance characteristics of materials and its testing is also covered in the course. The in-depth understanding of corrosion types, its mechanism and control strategies will also be addressed. This course is the pre-requisite for equipment designing as well as plant economics and design.

B. PREREQUISITES:

Basic knowledge of Physics and Chemistry.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (24)
1.	**Basic concepts of materials and material science** Introduction to materials and material science ages, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, Van der Waals bond. Relationship between structures, property, processing and its performance. Isotropic and anisotropic materials, logarithmic scale of materials and criteria for material selection.	CO1	2
2.	**Fundamental Mechanical Properties and its Testing** Stress and strain relation, Hooke's law, Modulus of material, Poisson's ratio. Fundamental mechanical properties and its testing as per ASTM standards. Plastic deformation, necking, creep and fatigue failure related to safety aspect. The Miller indices of directions and planes, packing of atoms inside solids, close packed structures, structure of ceramics, ionic solids, glass and polymers.	CO2	5
3.	**Ferrous Metals** Pig iron, cast iron and wrought iron. Steel and stainless steel production and its grades. Alloy steels and its classification, advantages and limitations of Alloy Steel. Purpose of Alloying, effect of alloying elements on mechanical properties of steel, their safety and health impacts. Suitable heat treatment methods for ferrous materials.	CO3	5
4.	**Non-Ferrous Materials** Non-ferrous metals like Tin, Lead, Titanium, Nickel, Copper, Aluminium, Zinc and their alloys. Semi-crystalline materials, their classification, structure and configuration of ceramics, polymers, copolymers and liquid crystals. Non- crystalline/amorphous materials: Silicates, glass transition temperature, viscoelasticity. Composite and polymer nano-composite materials and their applications.	CO4	5
5.	**Corrosion, Degradation and Recycling** Mechanism of corrosion, dry & wet corrosion, other forms of corrosion, Passivity, factors influencing corrosion, specific types of corrosion with respect to chemical engineering systems. Corrosion Prevention and Control – cathodic & anodic control, inhibitors & other protective measures. Protective coatings, metallic coating & metal cladding, physico-chemical principles involved, chemical conversion coating, organic coating, enamels, ceramic protective materials. Discussion on safety aspects pertaining to corrosion in various chemical equipment.	CO5	5

6.	**Material Characterisation Techniques** Introduction to experimental characterisation techniques: UV-VIS, FTIR, TGA, XRD, NMR and BET surface area.	**CO6**	**2**

D. TEXT BOOKS

1. Jastrzebski, Z.D. The Nature and Properties of Engineering Materials; (ed 2), Wiley & Sons: New York, 1976
2. Hajra Chaudhary, S.K. Material science and Processes; Indian Book Distributing Co., 2009

E. REFERENECE BOOKS

1. Van Vlack, L.H. Elements of Material Science and Engineering; Thomas Press: India, 1998
2. Raghavan, V. Materials Science and Engineering, fifth edition, Prentice Hall of India Private Limited: New Delhi, 2011
3. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007
4. Vijaya, M.S.; Rangarajan, G. Materials Science; Tata McGraw-Hill Education, 2004
5. William, D.; Callister, Jr. Materials Science and Engineering – An introduction; sixth edition, John Wiley & Sons, Inc., 2004

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/112/106/112106293/
2. https://archive.nptel.ac.in/courses/113/104/113104082/
3. https://archive.nptel.ac.in/courses/112/108/112108150/
4. https://archive.nptel.ac.in/courses/113/102/113102080/
5. https://archive.nptel.ac.in/courses/113/106/113106032/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Students will have a conceptual understanding of material science
CO2	Clarity on various mechanical properties and its testing as per ASTM standards
CO3	Ability to select cost-effective ferrous metal based on service and performance requirements.
CO4	Clarity on various non-ferrous metals and advanced materials, their applications and limitations
CO5	In-depth knowledge of possible types of corrosion, its mechanism and control strategies
CO6	Clarity on sophisticated analytical characterization techniques

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	1	1	1	1	1	1	**1**
PO 2	1	1	1	1	1	2	**1.17**
PO 3	1	1	2	2	2	2	**1.67**
PO 4	1	1	1	1	1	2	**1.17**
PO 5	1	1	1	1	1	2	**1.17**
PO 6	1	2	2	2	2	2	**1.83**
PO 7	1	2	2	2	2	2	**1.83**
PO 8	1	1	2	2	2	2	**1.67**
PO 9	1	1	1	1	1	2	**1.17**
PO 10	1	1	2	2	2	2	**1.67**
PO 11	1	1	1	1	2	2	**1.33**
PSO 1	2	2	2	2	2	2	**2**
PSO 2	1	2	2	2	2	2	**1.83**

B.TECH. – SEMESTER-III
INDIAN KNOWLEDGE SYSTEM (IKS) AND YOGA (SUB. CODE)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
1	0	2	3	2.0	60	40	25	25	150

A. COURSE OVERVIEW
An introductory course to aware the engineering students about India's rich legacy and valuable contributions in the fields of Science, Engineering, Mathematics, Astronomy, Medicine, Surgery, Pharma, Cosmetics, Art, Music, Culture, Yoga and Meditation.

B. PREREQUISITES:
Basic understanding of Mathematics and Science, Enthusiasm for learning new things.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (12)
1.	Introduction of IKS, its Need and significance	CO1	1
2.	Overview of Shruti and Smriti based classification of Indian Traditional Knowledge; Overview of Vedic and Non-Vedic Darsanas.	CO1	1
3.	IKS and Mathematics: Indian Numeral System, Units and Measurements, Geometry, Trigonometry and Calculus.	CO2	1
4.	IKS and Basic Sciences: Physics, Chemistry, Biology and Astronomy.	CO2	1
5.	IKS and Humanity Sciences: Arts, Culture, Economics and Language (Grammar).	CO3	1
6.	IKS and Pharma, Medicine, Surgery, Yoga, Health and Wellness	CO4	1
7.	Bhagavat Geeta and Lessons on Life Management & Stress Management.	CO4	1
8.	IKS and Basic Engineering: Overview of Civil Construction, Sanitation, Town Planning and 3D illusing sculptures.	CO5	1
9.	IKS and Material Science Engineering: Overview of Paints, Metals and Metalworking.	CO5	1
10.	IKS and Chemical Engineering Unit Operations – 1 (Heat Transfer and Thermodynamic Operations)	CO6	1
11.	IKS and Chemical Engineering Unit Operations – 2 (Fluid Flow Operations, Mechanical Operations and Mass Transfer Operations)	CO6	1
12.	IKS, Unit Processes and Chemical Reaction Engineering	CO6	1

D. PRACTICAL AND TERM WORK:
Practice of Yogasan by Certified Yoga Teacher.

E. TEXT BOOKS
1. B. Mahadevan; V. R. Bhat and Nagendra Pavna, Introduction to Indian Knowledge System (Concepts and Applications), Prentice Hall India, New Delhi, 2024.

F. REFERENCE BOOKS
1. A. C. Bhaktivedanta Swami Prabhupada, Bhagavad Geeta (As It Is), Bhaktivedanta Book Trust, BHARAT, 2019.
2. Swami Vivekananda, Patanjali's Yoga Sutras, Fingerprint Publishing, New Delhi, 2019.

G. ADDITIONAL SUGGESTED READING
1. P. C. Ray, A History of Hindu Chemistry, Kurukshethra Prakasan Pvt Ltd, BHARAT, 2022.
2. B. Datta and A. N. Singh, History of Hindu Mathematics: Part I and II, Asia Publishing House, Mumbai, 1962.

3. Kautilya, Arthashastra, Indian Penguin Classics, INDIA, 2000.
4. M. Danino, The Lost River – On the Trail of Saraswati, Penguin Books, New Delhi, 2010.
5. S. Sanyal, Land of the Seven Rivers (A Brief History of India's Geography), Penguin INDIA, 2013.

H. ONLINE RESOURCES

1. https://onlinecourses.swayam2.ac.in/imb23_mg53/preview
2. https://onlinecourses.swayam2.ac.in/ntr25_ed18/preview
3. https://elearn.nptel.ac.in/shop/iit-workshops/completed/mapping-neuroscience-to-indian-knowledge-systems/?v=c86ee0d9d7ed
4. https://www.youtube.com/playlist?list=PLRfu94TCePTtVPR-kC4RpIGIwo7-ViCGP

I. COURSE OUTCOMES

Cos	STATEMENT
CO1	Basic understanding of Indian Knowledge System (IKS)
CO2	IKS and Basic Sciences (Science and Maths)
CO3	IKS and Humanity Sciences
CO4	IKS, Yoga, Health and Wellness
CO5	IKS and Basic Engineering
CO6	Relevance of IKS with Core Chemical Engineering Fundamentals

J. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	2	2	2	2	2	**2.0**
PO 2	1	1	1	1	1	1	**1.0**
PO 3	2	2	2	2	2	2	**2.0**
PO 4	1	1	1	1	1	1	**1.0**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	2	2	2	2	2	2	**2.0**
PO 7	2	2	2	2	2	2	**2.0**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	3	3	3	3	3	3	**3.0**
PO 10	2	2	2	2	2	2	**2.0**
PO 11	3	3	3	3	3	3	**3.0**
PSO 1	1	1	1	1	1	1	**1.0**
PSO 2	1	1	1	1	1	1	**1.0**

B.TECH. – SEMESTER-III
EFFECTIVE TECHNICAL COMMUNICATION (SUB. CODE)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	0	0	100

A. COURSE OVERVIEW

This course will help students of engineering develop their Linguistic skills. Students will learn the effective ways of writing technically. Errorless writing and presenting will be developed. Understanding ways of self-development will make students competent to enhance their professional and Personal growth. Learning and understanding Professional ethics will help them be a better professional. Overall, the course is going to help student be competent and efficient professional.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Module 1: Information Design and Development-** Different kinds of technical documents, Information development life cycle, Organization structures, factors affecting information and document design, Strategies for organization, Information design and writing for print and for online media.	**CO1**	**6**
2.	**Module 2: Technical Writing, Grammar and Editing-** Technical writing process, forms of discourse, writing drafts and revising, Collaborative writing, creating indexes, technical writing style and language. Basics of grammar, study of advanced grammar, editing strategies to achieve appropriate technical style. Introduction to advanced technical communication, Usability, Hunan factors, Managing technical communication projects, time estimation, Single sourcing, Localization.	**CO1** **CO2**	**7**
3.	**Module 3: Self Development and Assessment-** Self assessment, Awareness, Perception and Attitudes, Values and belief, Personal goal setting, career planning, Self-esteem. Managing Time; Personal memory, Rapid reading, taking notes; Complex problem solving; Creativity.	**CO3** **CO5**	**6**
4.	**Module 4: Communication and Technical Writing-** Public speaking, Group discussion, Oral; presentation, Interviews, Graphic presentation, Presentation aids, Personality Development. Writing reports, project proposals, brochures, newsletters, technical articles, manuals, official notes, business letters, memos, progress reports, minutes of meetings, event report.	**CO1** **CO4** **CO6**	**12**
5.	**Module 5: Ethics-** Business ethics, Etiquettes in social and office settings, Email etiquettes, Telephone Etiquettes, engineering ethics, Managing time, Role and responsibility of engineer, Work culture in jobs, Personal memory, Rapid reading, Taking notes, Complex problem solving, Creativity.	**CO3**	**5**

C. TEXT BOOKS & REFERENECE BOOKS

1. David F. Beer and David McMurrey, *Guide to writing as an Engineer*, John Willey. New York, 2004
2. Diane Hacker, *Pocket Style Manual*, Bedford Publication, New York, 2003. (ISBN 0312406843)
3. Shiv Khera, *You Can Win*, Macmillan Books, New York, 2003.

D. COURSE OUTCOMES

Cos	STATEMENT
CO1	Enhance Professional way of Speaking and Writing,
CO2	Understand basics of Grammar in Professional writing
CO3	Understand the Business Ethics, Etiquettes and Values.
CO4	Present himself/herself in the effective way at Public, Group Discussion and Interview.
CO5	Improve Self-awareness and Perception.
CO6	Enhance their soft skills required for their professional development.

E. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	1	1	2	1	1	1	**1.1**
PO 2	2	2	2	2	2	2	**2**
PO 3	-	-	-	-	-	-	**-**
PO 4	-	-	-	-	-	-	**-**
PO 5	-	-	-	-	-	-	**-**
PO 6	-	-	-	-	-	-	**-**
PO 7	-	-	3	-	-	-	**0.5**
PO 8	2	-	2	3	2	3	**2.4**
PO 9	3	3	3	3	3	3	**3**
PO 10	3	3	1	3	2	3	**2.1**
PO 11	2	2	3	2	1	2	**2**
PSO 1	2	2	2	2	2	2	**2**
PSO 2	2	2	3	3	2	2	**2.3**

Semester – IV

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
25CH419	Fluid Mechanics	3	0	3	6	4.5	60	40	25	25	150
25CH420	Heat Transfer	3	0	3	6	4.5	60	40	25	25	150
25CH421	Mass Transfer - I	3	1	0	4	4.0	60	40	0	0	100
25CH422	Particles and Fluid Particle Proceesing	3	0	3	6	4.5	60	40	25	25	150
25CH423	Chemical Engineering Thermodynamics-II	3	0	0	3	3.0	60	40	0	0	100
	Total	**15**	**1**	**9**	**25**	**20.5**	**300**	**200**	**75**	**75**	**650**

B.TECH. – SEMESTER-IV
FLUID MECHANICS (25CH419)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	4.5	60	40	25	25	150

A. COURSE OVERVIEW

This course provides the foundation for understanding the fluid behavior in chemical engineering processes. It emphasizes the fundamental underlying fluid mechanical principles and application of those principles to solve real life problems. It will be imparting knowledge to enable **efficient design, optimization,** and **sustainability** of systems involving fluid flows.

B. PREREQUISITES:

Mathematics, Physics, Engineering Mechanics

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Introduction to Fluid mechanics and Basic concepts of Fluid Properties**: Definition and importance of Fluid mechanics, Definition of fluid, Types of fluids, Fluid Properties: Mass Density, Specific Weight, Specific Gravity, Newton's Law of Viscosity, Dynamic Viscosity, Surface Tension, Capillarity, Bulk modulus of elasticity, Compressibility, Vapor pressure. Dimensionless number used in fluid mechanics	CO1	3
2.	**Fluid Statics and Kinematics Fluid Statics:** Laws of fluid statics: Pascal's law, Hydrostatic law, Barometric equation, Hydrostatic equilibrium equation in a centrifugal field, Pressure and types of pressure, Measurement of pressure using manometers and pressure gauges, Selection criteria for pressure measuring devices. **Fluid Kinematics:** Methods of describing fluid motion, Types of Flow- steady, unsteady, uniform, non-uniform, laminar, turbulent, one, two and three dimensional, compressible, incompressible, rotational, irrotational, Types of flow patterns **-** stream lines, path lines, streak lines, Boundary layer and boundary layer thickness concept.	CO2	9
3.	**Fluid Dynamics:** Concept of Control Volume, Newton's Laws of Motion Applied to Fluids. **Governing Equations for flow analysis**: Mass, linear momentum, and Bernoulli's equation, Kinetic and momentum correction factor , Total Energy Line (T.E.L.), Hydraulic gradient Line (H.G.L), Definition of Flowmeter and its classification, Application of Bernoulli's equation - Venturi- meter, Orifice meter, Rotameter, Pitot-tube, Detailed leak flow rate calculations (integrating time derivative, liquids & gases also).	CO3	6
4.	**Fluid flow in pipes and ducts:** Introduction to pipe and pipe fittings, Pipe joints, Selection criteria for pipe, Process design of piping, Optimal pipe size, Recommended fluid velocity, Piping systems- series and parallel connections, Equivalent pipe, Laminar flow through circular pipe and between two parallel plates: average and maximum velocities, shear stress distribution, pressure drop, Major and minor energy losses in pipes, Types of friction, Moody's chart, Overview about flow through non circular cross-section.	CO4	6
5.	**Introduction to Valves and Fluid machines:** **Valves:** Definition of valve, Classification of valves, Basic components of a valve, Valve materials, Valve maintenance, Details about various types of valves: Gate valve, Globe Valve, Ball Valve, Check valve (Key features, Types, Advantages, Disadvantages, and Application etc.)	CO5	8

Fluid Machines: Definition of pump, Classification of pumps, Selection criteria for a pump, Terminologies, Details about Centrifugal pump and Positive displacement pump, Characteristics curves for pump, Introduction to cavitation, NPSH, Priming of pump, Pump in series and parallel, Overview on fluid machines for compressible fluids. Safety issues of pumping volatile substances and erosion issues.

6.	**Flow around Immersed Bodies:** Concept of Drag and lift, Types of drag, Drag coefficient, Flow through bed of solids, Fluidization- Conditions, Types and Applications.	**CO6**	**4**

D. PRACTICAL AND TERM WORK:

1. To determines the different regimes of flow using Reynold's apparatus.
2. To verify Bernoulli's theorem.
3. To determine discharge co-efficient for the flow through Venturimeter.
4. To determine discharge co-efficient for the flow through orifice meter.
5. To calibrate the given Rotameter.
6. To determine the point velocity of fluid using pitot tube.
7. To determine discharge co-efficient for the flow through an open channel.
8. To determine major and minor energy losses through pipes.
9. To determine pressure-drop for the flow through packed bed.
10. Centrifugal pump test rig

E. TEXT BOOKS

1. L. W. McCabe, J. C. Smith, and P. Harriott, "Unit Operations of Chemical Engineering", Tata McGraw-Hill publication
2. R. W. Fox, A. T. McDonald, P. J. Pritchard, and J. C. Leylegian, Fox and McDonald's Introduction to Fluid Mechanics, John Wiley & Sons publication.
3. Dr. R. K. Bansal, Fluid Mechanics and Hydraulic Machines, 9th Ed., Laxmi Publications.

F. REFERENECE BOOKS

1. C. J. Geankoplis, Transport Processes and Separation Process Principles, Prentice Hall publication
2. Dr. A. K. Jain, Fluid Mechanics Including Hydraulic Machines, Khanna Publishers.
3. B. R. Bird, E. W. Stewart, and N. E. Lightfoot, Transport Phenomena, John Wiley & Sons publication.
4. J. M. Coulson and J. F. Richardson, Chemical Engineering, Vol-1: Fluid Flow, Heat Transfer and Mass Transfer, Pergamon Press.

G. ONLINE RESOURCES

1. Fluid mechanics and its application https://nptel.ac.in/courses/103102211
2. Fluid flow operation https://nptel.ac.in/courses/103103147
3. Fluid mechanics https://nptel.ac.in/courses/103104044

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Solve practical problems involving fluid properties.
CO2	Analyze the concepts of fluid statics and its application to pressure measurement through problem solving. Evaluate fluid kinematic properties to classify types of fluid flow using flow visualization techniques
CO3	Apply the governing equations for mass, momentum and energy based on Reynolds Transport Theorem and utilize them in practical problems to evaluate the performance of flow metering devices
CO4	Develop and solve mathematical models for laminar and turbulent fluid flow using shell balance and empirical relations.

CO5 Understand the theoretical knowledge and develop practical skills necessary to effectively design, operate, and maintain pump and valve systems in various engineering applications.

CO6 Analyze and interpret flow behavior in fluidized and packed beds to optimize industrial.

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	3	3	**3.0**
PO 3	1	2	2	2	1	2	**1.6**
PO 4	-	-	2	2	-	2	**1.0**
PO 5	-	-	2	2	-	2	**1.0**
PO 6	-	-	-	-	-	-	**-**
PO 7	-	-	-	-	-	-	**-**
PO 8	-	2	2	2	-	2	**1.3**
PO 9	-	-	-	-	-	-	**-**
PO 10	-	-	-	-	-	-	**-**
PO 11	1	2	2	2	2	2	**1.8**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-IV
HEAT TRANSFER (25CH420)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	4.5	60	40	25	25	150

A. COURSE OVERVIEW

The course will introduce the fundamental concepts of various modes of heat transfer. It will further elaborate these concepts with theories and applications to the solutions of practically relevant chemical engineering problems. Some aspects of process design principles of various heat transfer equipment will be taken up in the later part of this course.

B. PREREQUISITES

Engineering Mathematics, CET-I, Material and Energy Balances

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Basics of Heat Transfer Operations** Modes of heat transfer: Conduction, Convection, and Radiation. Material properties of importance in heat transfer: Thermal conductivity, Specific heat capacity. Application of heat transfer in industrial fire & explosion phenomenon.	CO1	2
2.	**Conduction** Steady state conduction in one dimension. Basic law of heat conduction- Fourier's law, Steady state heat conduction through composite wall, Steady state heat conduction through a variable area: cylinder, sphere. Heat conduction in bodies with heat source: plane wall, cylinder, sphere.	CO2	5
3.	**Convection** Newton's law of cooling. Dimensionless numbers and their physical significance, empirical correlations for free and forced convection. Thermal and hydrodynamic boundary layer, heat and momentum analogy.	CO3	4
4.	**Extended Surfaces** Types of fins, heat flow through rectangular fin, infinitely long fin, fin insulated at the tip and fin losing heat at the tip, efficiency and effectiveness of fin. Concept of critical thickness of insulation for fire protection to prevent the fire propagation.	CO3	4
5.	**Boiling and Condensation** Definition, phenomena of boiling, boiling curve, regimes of boiling. Heat transfer to boiling liquids, the mechanism of nucleate boiling, correlation for pool boiling heat transfer: Nucleate boiling, critical heat flux, stable film boiling. Force convection boiling. Definition, phenomena of condensation, film type & drop wise condensation. Film condensation on vertical surface, condensation on horizontal tube or tube bank.	CO4	5
6.	**Heat Exchangers** Classification of heat exchanger, LMTD for parallel and counter flow exchanger. Overall heat transfer coefficient, fouling factor, correction factors for multi-pass heat exchanger. Effectiveness and number of transfer unit for parallel and counter flow heat exchanger. Design of Double pipe heat exchanger and shell and tube heat exchanger using Kern's method of Heat Exchanger design. Introduction to compact heat exchanger. Importance of Safety and Ethics in design of heat exchanger and its importance in process industry.	CO5	10
7.	**Evaporators** Boiling point elevation, heat transfer coefficient, enthalpy balance	CO5	4

	calculation for Evaporators. Capacity and economy, single and multiple effect evaporators, Method of feeding: forward & backward feed systems, Types of evaporators: natural circulation evaporator, forced circulation evaporator. Introduction to evaporators safety procedures.		
8.	**Radiation** Basic definition radiation: Absorptivity, reflectivity, and transmissivity. Blackbody radiation, laws of radiation: Planck's law, Wien's law, The Stefan-Boltzmann law for blackbody, Kirchhoff's law. Introduction to radiation hazards & safety.	**CO6**	**2**

D. PRACTICAL & TERM WORK

1. To determine the overall thermal conductivity of composite wall apparatus.
2. To determine the effectiveness of the pin Fin in natural and forced convection.
3. To determine the emissivity of a test plate in an emissivity measurement apparatus.
4. To determine the heat transfer rate and heat transfer coefficient in a forced convection apparatus.
5. To determine the heat transfer rate, heat transfer coefficient, L.M.T.D. and effectiveness of a concentric tube heat exchanger for both parallel and counter flow.
6. To determine the heat transfer rate, heat transfer coefficient, L.M.T.D. and effectiveness of a plate & frame type heat exchanger for counter flow.
7. To determine the inside and outside heat transfer coefficient of Film wise and Dropwise condenser and also to study the Dropwise and Film wise condensation phenomena.
8. To determine the evaporator capacity on an open pan evaporator.

E. TEXT BOOKS

1. Dutta, B. K., *Heat Transfer – Principles and Applications*, PHI, 2004.
2. Kern, D. Q., *Process Heat Transfer*, McGraw Hill, 1997

F. REFERENECE BOOKS

1. Holman, J. P., *Heat Transfer*, 9 ed., McGraw Hill, 2008.
2. Sinnott, R. K., Coulson & Richardson's *Chemical Engineering Design*, Vol. 6, Elsevier Butterworth Heinemann,1996.
3. Incropera Frank P., Dewitt David P., Bergman T. L., Lavine A. S., Seetharaman K.N.,Seetharaman T. R., *Fundamentals of Heat and Mass Transfer*, Wiley, 2014.

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand basic heat transfer modes and related material properties.
CO2	Analyze steady-state heat conduction in various geometries.
CO3	Apply convection principles and correlations, including fin analysis.
CO4	Explain boiling and condensation mechanisms and correlations.
CO5	Evaluate performance and design of heat exchangers and evaporators.
CO6	Understand fundamentals and laws of thermal radiation.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	3	3	2	3	2	**2.5**
PO 3	–	2	2	2	3	2	**1.8**
PO 4	–	2	2	2	2	2	**1.7**
PO 5	–	1	2	1	3	1	**1.8**
PO 6	–	–	–	–	2	–	**1.7**
PO 7	–	–	–	–	2	–	**1.8**
PO 8	–	–	–	–	1	–	**1.7**
PO 9	–	–	–	–	1	–	**1.8**
PO 10	–	–	–	–	1	–	**1.7**
PO 11	–	–	–	–	2	–	**1.8**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	2	2	2	2	3	2	**2.2**

B.TECH. – SEMESTER-IV
MASS TRANSFER-I (SUB. CODE)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	0	4	4.0	60	40	-	-	100

A. COURSE OVERVIEW
This course provides a fundamental introduction to mass transfer principles, equipping students with the ability to identify, formulate, and solve mass transfer problems. It also covers the essential concepts of mass transfer equipment and their application in design. The objective is to develop a strong theoretical and analytical foundation, enabling students to understand mass transfer operations, apply them effectively, and address complex engineering challenges.

B. PREREQUISITES
Mathematics, Chemistry, Thermodynamics

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (42)
1.	**Introduction to Mass Transfer Operations (MTO)**: Classification, methods of conducting MTO	CO1	5
2.	**Molecular Diffusion in Fluids:** Steady state molecular diffusion in fluids (both liquids & gases). Diffusivity of liquids & gases. Diffusion in Solids: Fick's law. Unsteady state diffusion. Types of solid diffusion	CO2	7
3.	**Mass Transfer Coefficients:** MT coefficients in laminar flow & turbulent flow. Theories of MT, heat, mass & momentum transfer in laminar & turbulent flow & their analogies. Simultaneous heat & mass transfer. Effect of chemical reaction on mass transfer.	CO3	6
4.	**Interphase Mass Transfer:** Equilibrium, diffusion between phases. Local & overall diffusion. Various processes & material balance for each of them	CO4	5
5.	**Equipment for Gas – Liquid Operations:** Gas dispersion. Liquid dispersion equipment	CO5	5
6.	**Distillation:** VLE data, flash distillation, simple distillation and continuous rectification. McCabe Thiele & Ponchon-Savarit methods. Distillation in packed columns & vacuum distillation. Azeotropic distillation. Use of steam. Tray hydraulic study. Safety aspects related to distillation of heat sensistive and flammable liquids. Introduction to multicomponent distillation. Moral issues and ethics	CO6	14

D. TEXT BOOKS

1. Treybal, R.E. Mass Transfer Operations,3rd Ed.; Tata McGraw Hill: New Delhi, 2012.
2. McCabe, W.L.; Smith. J.C.; Harriot, P. Unit Operations in Chemical Engineering, 4th Ed.; McGraw Hill Publications: NY, 1985.

E. REFERENECE BOOKS

1. Dutta, B. K. *Principles of Mass Transfer and Separation Processes*, 2nd ed.; Prentice Hall of India: New Delhi, 2007
2. Foust, S. *Principles of Unit Operations*, 2nd Ed.; Wiley: New York, 1980.

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Learn the basic fundamentals and mechanism of mass transfer operation involved in molecular diffusion and convective diffusion.
CO2	Analyze steady state molecular diffusion in fluids (both liquids & gases) and unsteady state diffusion in solids
CO3	Explore the mass transfer coefficient and evaluate the problems related to interphase mass transfer
CO4	Study the interphase mass transfer with understanding of equilibrium concept and calculation of efficiency related to stage and cascade.
CO5	Describe the different equipments for gas-liquid operations with their relevant application and solve related problems
CO6	Study the distillation and associated parameters, using VLE data estimate the process parameters related to design calculation of distillation and stripping column

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	3	3	**3.0**
PO 3	2	2	2	2	2	3	**2.2**
PO 4	2	2	2	2	2	2	**2.0**
PO 5	1	2	2	2	2	2	**1.9**
PO 6	1	1	2	2	2	2	**1.7**
PO 7	1	1	2	2	2	2	**1.7**
PO 8	2	2	2	2	3	2	**2.2**
PO 9	2	2	2	3	3	2	**2.2**
PO 10	1	2	2	2	2	2	**1.9**
PO 11	2	2	2	2	2	2	**2.0**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	3	3	3	3	3	3	**3.0**

B.TECH. – SEMESTER-IV
PARTICLES AND FLUID PARTICLE PROCESSING (25CH422)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	4.5	60	40	25	25	150

A. COURSE OVERVIEW

This course provides a comprehensive understanding of mechanical unit operations essential to chemical process industries. It focuses on the principles and applications of solid characterization, size reduction, and handling operations. Students will gain insight into solid-fluid interactions, including filtration, mixing, agitation, and transportation. Emphasis is placed on solid-liquid separation techniques and troubleshooting of industrial equipment to promote sustainable development. The course aims to develop a strong foundation in particulate technology, enabling students to analyze and apply operations such as screening, sedimentation, and solid-liquid separations with practical exposure to related equipment and calculations.

B. PREREQUISITES:

Basic Understanding of Mathematics

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (31)
1.	**Solids** Introduction to solid particles, Characteristics of solid particles and Concept of Sphericity, Properties of mixture, Introduction to nanoparticles properties & characterization	CO1	4
2.	**Size Reduction & Enlargement** Principle of comminution, Types of crushers, grinders & disintegrators for coarse and intermediate & fine grinding Energy & power requirement for size reduction, laws of crushers & work index, close & open circuit grinding, feed control, mill discharge and removal & supply of heat in wet grinding, Safety issues related to high-speed rotating equipment Size enlargement– objectives, methods and equipment used in industries	CO2 CO3	6
3.	**Screening & Other Separation Methods** Screen Terminology and various screen series and Differential and cumulative method of screen analysis, Types of Industrial screen, comparison of ideal & actual screens and capacity &effectiveness of screens Principle of elutriation, floatation, jigging and electrostatic & magnetic separation processes	CO2 CO3	6
4.	**Sedimentation** Concept of sedimentation, terminal settling velocity, batch settling test and free & hindered settling, Flocculation, types of thickener & thickener area calculation, batch & continuous settling chambers and sorting of classifiers Centrifugal settling process, cyclone and principle of centrifugal sedimentation	CO4	6
5.	**Filtration** Types of filtrations, requirements of filter media and filter aids Principle of cake filtration, constant pressure filtration, batch & continuousfiltration equipments – filter press, leaf filter, cartridge filter & rotary drum filter Theories of filtration, washing of cake, principle of centrifugal filtration and suspended basket centrifuge, etc.	CO4 CO6	4
6.	**Mixing & Agitation** Fundamentals of mixing & agitation, purpose of agitation and	CO5 CO6	4

	standard agitated vessel Types of impellers, vortex formation in agitated vessel, power consumption in agitated vessels, scale of agitated vessel and power consumption, Characteristics of mixing equipment, mixing of pastes & paste masses, pony mixers, beater mixer, mixing of dry powder, ribbon blender & tumbler mixer etc		
7.	**Storage and Conveying** Storage of solid, liquid and gases and types of storage vessels, Types of flow in solid discharge and various problems, Types of Mechanical & pneumatic conveying system	**CO4**	**1**

D. PRACTICAL AND TERM WORK:

1. Sieve Analysis
2. Sieve Efficiency
3. Jaw Crusher
4. Roll Crusher
5. Ball Mill
6. Sedimentation
7. Power Calculation for Agitated Vessel
8. Terminal Settling Velocity

E. TEXT BOOKS

1. McCabe, L. W.; Smith, J.C.; Peter, H. Unit Operations of Chemical Engineering; 7th ed; TataMc-Graw Hill Publication: New Delhi, 2017
2. Narayanan, C.M.; Bhattacharyya, B.C. Mechanical Operations for Chemical Engineers; 3rd ed; Khanna Publishers: New Delhi,2014

F. REFERENCE BOOKS

1. Harker, J.H.; Backhurst, J.R. Richardson, Coulson & Richardson's Chemical EngineeringVolume 2; 5th ed; Butterworth-Heinemann: Oxford Woburn MA,2002
2. Badger, L.W.; Banchero, J. Introduction to Chemical Engineering; McGraw Hill: Singapore,1984

G. ONLINE RESOURCES

1. https://archive.nptel.ac.in/courses/103/107/103107123/#
2. https://onlinecourses.nptel.ac.in/noc23_ch27

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand basic knowledge of various mechanical operations in chemical process industry.
CO2	Classify and explain solid-solid, solid-fluid related operations
CO3	Ability to select suitable size reduction equipment and solid-solid separation method.
CO4	Describe basic concept of Solid-Liquid separation used in chemical process industries
CO5	Examine the factors affecting on solid handling related operations with respects to the sustainable development of process industries
CO6	Analyze the performance of experiment related to various solid-solid and solid-liquid separation operations

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	2	3	**2.8**
PO 3	3	3	3	2	3	2	**2.7**
PO 4	3	3	3	2	2	2	**2.5**
PO 5	2	1	2	2	3	2	**2.0**
PO 6	2	2	2	3	3	3	**2.5**
PO 7	2	2	3	3	3	3	**2.7**
PO 8	3	2	2	2	3	3	**2.5**
PO 9	2	2	2	2	3	3	**2.3**
PO 10	2	2	2	3	3	3	**2.5**
PO 11	3	3	2	3	3	3	**2.8**
PSO 1	3	2	3	3	3	3	**2.8**
PSO 2	2	3	3	3	2	3	**2.7**

B.TECH. – SEMESTER-IV
CHEMICAL ENGINEERING THERMODYNAMICS-II (25CH423)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

Many separation processes in the chemical industry are based on phase equilibrium such as vapor-liquid (VLE), liquid-liquid (LLE) and vapor-liquid-liquid (VLLE). This course provides a macroscopic study of key thermodynamic properties to analyze these equilibrium systems and address challenges arising from non-idealities in multicomponent mixtures. It covers the application of equations of state (EOS) and activity models. These fundamental concepts are essential for understanding and developing industrial applications, including the design and simulation of separation processes. In addition, this course will cover the fundamentals of statistical thermodynamics, providing a molecular-level perspective on thermodynamic properties and equilibrium.

B. PREREQUISITES:

Chemical Engineering Thermodynamics-I, Material and Energy Balances.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Systems of Variable Composition. Ideal behavior** Fundamental property relation for variable compositions, concept of chemical potential, Chemical Potential as a criterion of equilibrium, Gibbs theorem, Property changes of mixing for ideal gas mixtures and ideal solution, Derivation of Raoult's law and its applications, phase diagrams and problems solving approach.	CO1	6
2.	**Systems of Variable Composition. Non-ideal behavior** Concept of Partial properties, Gibb's – Duhem equation, concepts of fugacity and fugacity coefficient of pure species and species in solution, residual properties, generalized correlations for the fugacity coefficient, Evaluation of fugacity coefficient for mixtures using EOS, concepts of activity and activity coefficient, the excess gibbs energy, modified Raoult's law & its applications, Positive & negative deviations from Raoult's law.	CO2	8
3.	**Phase Equilibria at Low to Moderate pressures** Phase rule, Models for excess Gibb's energy (Activity models) such as Redlich-kister, Wohl's, Van Laar, Margule's, Wilson, NRTL, UNIQUAC & UNIFAC, VLE calculations such as bubble points, dew points and flash calculations, Lewis-Randall rule and Henry's law, Thermodynamic consistency tests. Ethics in design and simulation for separation processes.	CO3	6
4.	**Thermodynamic Properties of fluids from Equations of State** Properties of fluids from the virial equations of state and cubic equation of state, VLE calculations at high pressures. Understanding LLE, VLLE, pressure and temperature relation and subsequent safety aspects.	CO4	6
5.	**Chemical Reaction Equilibria** Representation of chemical reactions, Equilibrium criterion for a chemical reaction, concept of equilibrium constant (k), Evaluation of equilibrium constants at different temperatures, maximum conversion, Phase rule for reacting systems.	CO5	4
6.	**Introduction to Statistical Thermodynamics** Probability theory, Different thermodynamic distributions- Boltzmann, Bose – Einstein & Fermi-Dirac, Laws of thermodynamics & their applications, Partition functions, Behavior of Monatomic gases.	CO6	3

D. TEXT BOOKS

1. Smith, J. M.; Van Ness, H. C. Introduction to Chemical Engineering Thermodynamics; Fourth Edition, McGraw Hill Book Company: Singapore, 1987.
2. Sonntag, R. E. & Van Wylen, Gordon J. Fundamentals of Statistical Thermodynamics; First Edition, John Wiley & Sons: United States of America, 1968.

E. REFERENECE BOOKS

1. Narayan, K. V. A Textbook of Chemical Engineering Thermodynamics; Second Edition, PHI Learning Private Limited: Delhi, 2013.
2. Rao, Y.V.C. Chemical Engineering Thermodynamics; First Edition, Universities Press India Private Limited: Hyderabad, 1997.
3. S. Sandler, "Chemical, Biochemical and Engineering Thermodynamics",4th edition, Wiley, India.
4. Elliot, J.E.; Lira C.T. Introductory Chemical Engineering Thermodynamics; Second Edition, Pearson Education publishing as Prentice Hall: South Africa, 2012.

F. ONLINE RESOURCES

1. https://archive.nptel.ac.in/courses/103/103/103103144/
2. https://nptel.ac.in/courses/103103355

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Thermodynamic property relationships for the behavior of multicomponent, multiphase systems.
CO2	Phase equilibrium phenomena in systems exhibiting ideal and non-ideal behavior.
CO3	Selection of appropriate thermodynamic models for phase equilibrium.
CO4	Calculate the composition of each phase in a system at equilibrium using appropriate thermodynamic models.
CO5	Estimate equilibrium conversion in chemical reactions.
CO6	Basic understanding of statistical thermodynamics.
	Thermodynamic property relationships for the behavior of multicomponent, multiphase systems.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	3	3	3	3	3	**2.83**
PO 2	3	3	3	3	3	2	**2.83**
PO 3	2	2	3	3	2	1	**2.17**
PO 4	3	3	3	3	3	2	**2.83**
PO 5	3	3	3	3	3	2	**2.83**
PO 6	1	2	2	1	2	2	**1.67**
PO 7	-	-	-	-	1	1	**0.33**
PO 8	1	1	1	2	2	1	**1.33**
PO 9	1	1	1	2	2	1	**1.33**
PO 10	-	-	-	1	2	-	**0.50**
PO 11	2	2	2	2	2	3	**2.17**
PSO 1	3	3	3	3	3	2	**2.83**
PSO 2	2	3	3	3	2	2	**2.50**

Semester – V

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
25CH508	Chemical Reaction Engineering- I	3	0	3	6	4.5	60	40	25	25	150
25CH509	Mass Transfer - II	3	1	3	7	5.5	60	40	25	25	150
25CH514	Numerical Techniques in Chemical Eng.	2	0	3	5	3.5	60	40	25	25	150
PCE	Core Elective - I	3	0	0	3	3.0	60	40	0	0	100
OE	Open Elective - I	3	0	0	3	3.0	60	40	0	0	100
HM	Universal Human Values	2	0	0	2	2.0	60	40	0	0	100
	Total	**16**	**1**	**9**	**26**	**21.5**	**360**	**240**	**75**	**75**	**750**

ELECTIVES OFFERED

Core Elective-1 SEM-V	
1.	Environmental Engineering
2.	Statistical Thermodynamics
3.	Plant Utilities
4.	Heat Exchanger Design and Analysis
5.	Polymer Science and Engineering
6.	Fluidization

Open Elective-1 SEM-V	
1.	Data Analysis and Statistics
2.	Green Technology and Sustainable Devp.
3.	Corrosion Engineering
4.	Industrial Management

B.TECH. – SEMESTER-V
CHEMICAL REACTION ENGINEERING–I (25CH508)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	**T**	**P**	**Total**		**Ext.**	**Int.**	**TW**	**P**	**Total**
3	**0**	**3**	**6**	**4.5**	**60**	**40**	**25**	**25**	**150**

A. COURSE OVERVIEW
Selection, Design, Operation and Troubleshoot Ideal Reactors for various type of chemical reactions.

B. PREREQUISITES:
Applied Chemistry, Material & Energy Balance Calculations, Applied Mathematics I and II, Chem Engg Thermodynamics I and II

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Introduction** Introduction to chemical reaction engineering and Classification of chemical reactions, Concept of Chemical kinetics. Role of Thermodynamics in chemical reaction engineering. Definition of Rate of reaction, Rate expression for various types of reactions. Variables affecting the rate of reaction: Temperature, Pressure, concentration, catalyst, inert, surface area etc.	**CO1**	**3**
2.	**Kinetics of Homogeneous Reactions** Effect of concentration on rate of reaction. Terminology in calculation of rate of reaction: Elementary vs non elementary reactions, Molecularity of reactions, order and rate constant of reaction, Irreversible vs Reversible reactions. Effect of temperature on rate of reaction: Application of Arrhenius theory, Collision theory & Transition state theory and comparison. Kinetic of non-elementary reactions: Obtaining rate law equation from mechanism using pseudo steady state.	**CO2**	**5**
3.	**Interpretation of Batch Reactor Data of homogeneous reactions** Stoichiometric table for liquid phase and gas phase reactions Using Integral method of analysis to obtain kinetics of chemical reaction from obtained experimental data. Studying different type of reactions like Constant and variable volume reactions, irreversible, reversible, series, parallel, catalytic, autocatalytic reactions, elementary and non-elementary reactions Half Life Method, Differential method of analysis: Reactions with shifting order: Reactions with shifting of order from Higher to lower and lower to higher. and obtaining kinetics using experimental data	**CO3**	**7**
4.	**Introduction to Reactor Design** Introduction to concept of macro and micro mixing. Concept of ideal mixing in reactors. Definition and characteristics of various ideal reactors: Batch, CSTR, PFR, Selection of Batch or continuous mode of reactor operation. Batch cycle. Motivation for semi batch reactor and its applications	**CO4**	**3**
5.	**Single Ideal Reactors** Reactor terminology - space time, space velocity, steady state condition, local conversion, global conversion, Derive equation for Ideal Reactors from first principal model. Apply design equations of Ideal individual reactors for single reactions, Application to real life problems.	**CO5**	**5**
6.	**Design for Single Reactions** Comparison of various type of reactors for same order. Comparison of same type of reactors for various feed ratios for order more than one, comparison of MFR with that of PFR for same order for constant volume and variable volume reactors. Comparison of ideal reactors using graphical and analytical method.	**CO5** **CO6**	**6**

	Multiple reactor system in series and/or parallel, Equal/unequal size reactors in series, Reactors of different types in series. Introduction to recycle reactor, Design of recycle reactor, Solution using graphical and analytical method, application of recycle reactor to autocatalytic reaction		
7.	**Design for Multiple Reactions** Maximising desired product for parallel and series reactions. Mixed complex reactions. Selection of order of reactors for multiple reactions to maximize the output.	**CO5** **CO6**	**4**

D. PRACTICAL & TERM WORK

1. Integral method of analysis for equal concentration
2. Integral method of analysis for unequal concentration
3. Differential method of analysis
4. Half Life method of analysis
5. Pseudo order reaction
6. Activation energy and frequency factor
7. Non elementary reaction
8. Decomposition of H_2O_2 using homogeneous catalyst.
9. Reversible reaction

E. TEXT BOOKS

1. Levenspiel, O. Chemical Reaction Engineering; 3rd ed.; John Wiley & Sons (Asia) Pvt. Ltd: Singapore, 2014.
2. Scott, F. H. Elements of Chemical Reaction Engineering**;** 5th ed.; Prentice Hall India (p) Ltd.: New Delhi, 2016.

F. REFERENCE BOOK

1. Smith, J. M. *Chemical Engineering Kinetics*; 3rd ed.; McGraw Hill Incorporation: New York, 2000.
2. Lanny D Schimdt The engineering of chemical reactions, 2nd Edition, Oxford University press, 2005

G. ONLINE RESOURCES

1. The Swayam Course Code for Chemical Reaction Engineering-1 Is Noc23_Ch50.

H. COURSE OUTCOMES

Cos	**STATEMENT**
CO1	Understand and state the fundamentals of chemical reactions (Classification, Definitions) and chemical kinetics
CO2	Explain the concept of Rate of Reaction, Evaluate Kinetic Expression and Examine the effect of various parameters on it
CO3	Perform experiments in a judicious way to get the required data, if not available.
CO4	Define the concept of Ideal Reactor and classify the type of ideal reactors,
CO5	Select appropriate single and multiple reactor configuration for given application
CO6	Evaluate and design (process) the chemical reactors optimally as required. Understand and state the fundamentals of chemical reactions (Classification, Definitions) and chemical kinetics

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	2	3	3	**2.8**
PO 3	2	3	3	2	3	3	**2.7**
PO 4	2	2	2	2	3	3	**2.3**
PO 5	1	2	2	2	3	3	**2.2**
PO 6	1	2	2	2	3	2	**2.0**
PO 7	2	2	3	2	3	2	**2.3**
PO 8	1	1	2	2	2	2	**1.7**
PO 9	1	2	2	2	2	2	**1.8**
PO 10	1	1	2	2	1	2	**1.5**
PO 11	2	2	2	2	3	3	**2.3**
PSO 1	3	3	2	3	2	3	**2.7**
PSO 2	3	3	3	2	2	3	**2.7**

B.TECH. – SEMESTER-V
MASS TRANSFER-II (25CH509)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	3	7	5.5	60	40	25	25	150

A. COURSE OVERVIEW

This course provides the use of mass transfer fundamentals to design, analyze and optimize the different mass transfer operation and related equipments like scrubber, dryers, extractors, adsorbers, crystallizers, humidifiers with consideration of safety and ethical standards.

B. PREREQUISITES:

Mathematics, Mass Transfer-I, Chemical Engineering Thermodynamics, Heat Transfer and Equipment Safety

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (47)
1.	**Gas-Liquid Operations:** **Absorption and stripping:** Concept of ideal and non-ideal solution, Material balance for single component transfer, Minimum liquid-gas ratio and its significance, Counter current multi stage operation, Absorption and stripping factors and their significance, Solvent selection criteria for absorption, Concept of HETP and transfer units, Scrubber operation and process design with calculation of mass transfer area for safe scrubbing of released toxic gas. **Humidification:** Saturated & Unsaturated vapour – gas mixture and related terminologies, Use of Psychometric Chart in Humidification & dehumidification. Adiabatic saturation curves, wet bulb temperature theory, Lewis's relation Adiabatic & non-adiabatic operations. Types of cooling tower & design.	CO1	14
2.	**Liquid-Liquid Operation:** **Liquid-Liquid Extraction**: Equilibrium in extraction; Ternary diagram & tie line data, System of three liquids-one pair & two pairs partially soluble, Single stage & multistage extraction, Co-current and cross current extraction, continuous counter current multistage extraction with and without reflux, Theory & performance of batch & continuous contact equipment.	CO2	7
3.	**Solid-Liquid Operations:** **Adsorption & Ion Exchange:** Definition of Adsorption and industrial applications. Types of adsorption & most commonly used adsorbents. Adsorption Equilibria & hysteresis. Effect of temperature on adsorption & Heat of adsorption. Adsorption of solute from dilute liquid, Surface area calculation of adsorbents. Material balance and Freundlich's equation for single stage operation and multistage cross-current operation, counter current operation, Equipment for adsorption. Ion-Exchange Principles, Applications, Equilibria and Rate of ion exchange **Leaching:** Steady state and unsteady state leaching operations, Single stage leaching, Multistage cross current and counter current leaching, Rate of leaching. Application of leaching. Study of leaching equipment. **Crystallization**: Principle of crystallization, Saturation & methods of saturation. Nucleation & Crystal Growth. Crystallization rate, Equilibria and yields, Caking of crystals, Application of crystallization, Crystallization equipment, Crystallization from melts.	CO3	16

4.	**Solid-liquid-Vapor Operations:** **Drying:** Equilibrium in drying. Batch drying & Continuous drying and their mechanism. Various types of moisture in drying. Rate of drying & time of drying. Cross-circulation drying. Batch & continuous drying equipment- Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer, Spin flash dryer, etc. Safety issues related to drying of volatile hydrocarbons.	**CO4**	**5**
5.	**Introduction to Novel Separation Techniques:** Types of Novel Séparation techniques. Membrane Séparation Processes like Ultra filtration, Nano filtration, Reverse Osmosis etc.	**CO5**	**3**
6.	**Safety and Ethical aspects related to various mass transfer operation and design:** Understanding of process parameters and their effects for the safe operation and design of mass transfer operation and equipments.	**CO6**	**2**

D. PRACTICAL AND TERM WORK:

1. To determine the diffusion coefficient of liquid Acetic acid in water.
2. To determine the diffusion coefficient of organic vapor (ACETONE) in air.
3. To determine the mass transfer coefficient for evaporation of liquid H_2O into air under natural convection.
4. To determine the diffusivity of naphthalene in stagnant air
5. To determine the adsorption isotherms of acetic acid on activated charcoal
6. To study the principles governing leaching and compare the results obtained by conducting the batch leaching test and a mixture of sodium hydroxide and sand.
7. To determine the drying characteristics of a given sample by drying in a Tray dryer.
8. To verify 'Rayleigh's Equation' by conducting simple distillation of given binary mixture
9. To find the stage efficiency of single stage and multi stage liquid extraction.
10. To determine the % yield of crystallization of boric acid with seeding and without seeding

E. TEXT BOOKS

1. Treybal, R.E. Mass Transfer Operations,3rdEd.; Tata McGraw Hill: New Delhi, 2012.
2. McCabe, W.L.; Smith. J.C.; Harriot, P. Unit Operations in Chemical Engineering, 4th Ed.; McGraw Hill Publications: NY, 1985.

F. REFERENECE BOOKS

1. Dutta, B.K. Principles of Mass Transfer and Separation Processes, 2nd Ed.; Prentice Hall of India: 2007.
2. Foust, S. Principles of Unit Operations, 2nd Ed.; Wiley: New York, 1980

G. ONLINE RESOURCES

1. https://archive.nptel.ac.in/courses/103/103/103103154/
2. https://archive.nptel.ac.in/courses/103/104/103104046/

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Design, analyze, and optimize gas-liquid mass transfer operations relating theoretical concepts to practical applications.
CO2	Evaluate, optimize and design liquid-liquid extraction for single and multi-stage operation.
CO3	Design, evaluate, and improve solid-liquid mass transfer processes, linking theoretical ideas to real applications.
CO4	Analyze drying principles and mechanisms, and select suitable drying methods and equipment for effective industrial processes.
CO5	Learn and understand the novel separation methods and their applications.
CO6	Analyze process parameters for safe design of different mass transfer equipments and operation.

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	3	3	**3.0**
PO 3	2	2	3	3	3	3	**2.7**
PO 4	2	2	3	2	3	3	**2.5**
PO 5	1	2	3	3	3	2	**2.3**
PO 6	1	1	2	2	2	3	**1.8**
PO 7	1	1	2	2	2	2	**1.7**
PO 8	3	2	2	2	3	3	**2.5**
PO 9	2	2	2	3	3	3	**2.5**
PO 10	2	3	3	3	3	3	**2.8**
PO 11	3	3	3	3	3	3	**3.0**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	3	2	3	3	3	3	**3.0**

B.TECH. – SEMESTER-V
NUMERICAL TECHNIQUES IN CHEMICAL ENGINEERING (25CH514)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	0	3	5	3.5	60	40	25	25	150

A. COURSE OVERVIEW
Numerical solutions of various mathematical models describing steady state and dynamic behaviors of Chemical Process Systems and parameter estimation using numerical methods in Chemical Engineering.

B. PREREQUISITES:
A student must have the foundation of calculus and linear algebra, basic matrix operations, core chemical engineering subjects, computational skills in programming language.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (34)
1.	**Basics of Vectors, Scalars and matrix algebra** Addition/subtraction, multiplication/division of vectors, matrix multiplication, inverse of matrix, determinant and rank of matrix, eigen values, sparse matrices, Use of appropriate software for matrix algebra, approximation and concept of error and error analysis	CO1 CO2	2
2.	**Numerical methods for linear algebraic equations** LU Decomposition, Gauss elimination method, Gauss-Jordan method, Jacobi method, Successive – over relaxation method, tri-diagonal matrix, computational programming	CO3	6
3.	**Numerical methods for nonlinear algebraic equations** Successive substitution method, Newton-Raphson method, Secant method, False position method, single variable and multivariable case studies, computational programming for nonlinear algebraic equations	CO3	5
4.	**Eigen Value Problems:** Eigen value analysis of linear and nonlinear systems and solution of homogeneous equations using eigen values	CO6	5
5.	**Regression, interpolation, curve fitting, numerical integration** Simple interpolation, Lagrange's interpolation, Newton's interpolation, Simpson's rule, trapezoid method, linear regression, polynomial regression, exponential and power regression, computational programming	CO5	6
6.	**Numerical methods for IVP and BVP ordinary differential equations** Explicit and implicit ODEs, Euler's explicit and implicit methods, explicit Adams-Bashforth methods, implicit Adams-Mouton methods, Predictor – corrector methods, Runge-Kutta methods, use of appropriate software for ODEs, Finite difference computations.	CO1 CO4	7
7.	**Numerical methods for Partial differential equations** Steady state and dynamic PDES, method of lines, Crank-Nicholson method, finite-difference.	CO1	3

D. PRACTICAL AND TERM WORK:
1. Introduction to Computational Tools

2. Numerical Methods for Linear and Non-Linear Algebraic Equations:
L U Decomposition Method, Gauss Elimination Method, Gauss Jordan Method, Gauss Jacobi, Gauss Seidel, Newton Raphson Method

3. Numerical Methods for Interpolation:

Linear Interpolation, Lagrangian Interpolation, Newton's Divide Difference Method

4. Trapezoidal Rule of Integration and Simpson's 1/3 Rule of Integration

5. Numerical Methods for Non-Linear Regression – Polynomial Fit

6. Ordinary Differential Equations: Runge Kutta Method, ODE solvers

E. TEXT BOOKS

1. Gupta, S. K. Numerical Methods for Engineers, 3rd ed.; New Age International Publishers: New Delhi, 2015.
2. Chapra, S. C. Applied Numerical Methods with MATLAB for Engineers and Scientist, 3rd ed.; McGraw-Hill: New York, 2012.

F. REFERENECE BOOKS

1. Beers, K J. Numerical Methods for Chemical Engineering Applications in MATLAB, Cambridge University Press: UK, 2006.
2. Constantinides, A.; Mostoufi, N. Numerical Methods for Chemical Engineers with MATLAB Applications, Prentice Hall International Series: New Jercy, 1999.

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Carry out the error analysis in the numerical solutions of chemical engineering problems.
CO2	Apply linear algebraic equation solution techniques and nonlinear algebraic equation techniques for solving steady states of chemical engineering systems. Use computational programs and tools to implement numerical methods in simulations.
CO3	Evaluate and analyze the system stability and Dynamic Behavior of Chemical Processes.
CO4	Analyze models using essential numerical methods—regression, interpolation, curve fitting, and numerical integration
CO5	Understand the various numerical methods to solve various linear and nonlinear steady state and dynamic problems in chemical engineering systems described by ODE and PDE
CO6	Develop computational programs for various numerical methods Carry out the error analysis in the numerical solutions of chemical engineering problems.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	2	2	2	2	2	**2.0**
PO 2	3	3	3	3	3	2	**2.8**
PO 3	3	3	3	3	3	2	**2.8**
PO 4	2	2	2	2	2	2	**2.0**
PO 5	2	2	2	2	2	3	**2.1**
PO 6	-	-	-	-	-	-	**-**
PO 7	3	1	1	1	1	1	**1.3**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	3	1	1	1	1	1	**1.3**
PO 10	-	-	-	-	-	-	**-**
PO 11	3	3	3	3	3	3	**3.0**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-V
ENVIRONMENTAL ENGINEERING (25CH510)
(CORE ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course imparting knowledge of Environment and its protection using the application of engineering principles to the control, modification and adaption of the physical, chemical and biological factors of the environment. It will develop the technical, analytical and problem-solving skills necessary to address some of the most critical challenges facing our planet: Sustainability, Public health and Environmental conservation.

B. PREREQUISITES:

Basic Sciences, Mathematics

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Introduction:** Overview about environment, Types of pollution, Types of Pollutant	CO1	1
2.	**Air pollution:**		
	1: Air Pollution sources and Effects Definition of air pollution, classification and properties of air pollutants, sources of air pollutants, behavior and fate of various air pollutants in atmosphere, Effects of air pollution on man, animal, vegetation and properties. Air pollution laws and standards in India, Case studies of Air pollution: Global and Indian.	CO2	3
	2: Meteorological aspects of air pollutant dispersion Definition of Meteorology, meteorological parameters, [Temperature lapse rate, Inversion, atmospheric stability, Plume behavior], Dispersion of air pollutants – The Gaussian plume model	CO2	4
	3: Air pollution sampling and measurement Ambient air sampling and stack sampling, Collection of gaseous air pollutants and Particulate pollutants, Analysis of air pollutants.	CO2	3
	4: Air pollution control methods and Equipment Various Control methods, Principle and design of particulate matter control devices, Control of gaseous emissions, effluent gas treatment methods.	CO2	4
3.	**Waste Water Treatment**		
	1: Origin of waste water Definition of waste water, Components of waste water flow rates, Sources of waste water, Reasons for waste water treatment, Variation in wastewater flow, overview about analysis of waste water flow rate data, Reduction of waste water flows.	CO3	2
	2: Waste water parameters: Physical, Chemical and Biological characteristics of wastewater	CO3	3
	3: Waste water treatment: Concept and objective of various of waste water treatment methods and system, Design parameters for waste water treatment, Reactor used in waste water treatment	CO4	3
	Physical unit operations in waste water treatment: Objectives, Application, Essential details and Design concept of various units: Screening, Grit chambers, Flow equalization, Flocculation, Flotation, Sedimentation	CO4	3

	Chemical unit processes in waste water treatment: Objectives, Application and Essentials details of: Chemical Precipitation, Disinfection.	**CO4**	**2**
	Biological unit processes in waste water treatment: Important terminology for biological unit processes, Classification of biological unit processes, Kinetics of Bacterial growth, Objectives, Application, Essentials details and Design concept of aerobic biological treatment units, Introduction to anaerobic biological waste water treatment.	**CO5**	**5**
4.	**Solid waste management:** Types and Sources of solid wastes, Need for solid waste management, Composition of solid wastes, Collection and Disposal methods of municipal solid wastes. Overview about biomedical wastes, hazardous wastes, sludge treatment & disposal.	**CO6**	**3**

D. TEXT BOOKS

1. Metcalf & Eddy, Burton, F. L., Stensel, H. D., & Tchobanoglous, G., Wastewater Engineering, treatment and reuse, McGraw Hill Publication.
2. Rao C. S., Environmental Pollution Control Engineering, New Age International Publication
3. G.L. Karia and R.A. Christian, Wastewater treatment – Concepts and Design approach, Easter Economy Edition.

E. REFERENECE BOOKS

1. Rao M. N., Rao H. V. N., Air Pollution, Tata McGraw Hill Publication.
2. Bhatia S. C., Textbook of Air Pollution and its Control, Atlantic Publishers & Distributors.
3. S. P. Mahajan ,Pollution Control in Chemical Process Industries, Tata McGraw Hill Publications
4. Mackenzie, L. D., Water and wastewater engineering: Design principles and practice, McGraw-Hill Education Publication
5. Patwardhan, A. D., Industrial wastewater treatment, PHI Publication

F. ONLINE RESOURCES

1. https://nptel.ac.in/courses/103107084
2. https://nptel.ac.in/courses/103107212
3. https://nptel.ac.in/courses/105102089

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand Environment and various pollution, interpret fundamentals of sources and effects of air pollutants, Monitor the air quality standards and the different sampling techniques
CO2	Analyze the principle involved in the pollutant removal and their control measures, choose appropriate air pollution control systems for the industries
CO3	Interpret the basic knowledge on wastewater and their parameter and apply expertise in analysis and testing of wastewater samples.
CO4	Analyze the working principles and mechanisms of various Unit operation/Processes,
CO5	Evaluate the significance and design of various unit operations /Process. Understand the microbial kinetics,
CO6	Recognize the various sources and types of solid waste, solid waste management, sludge treatment.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	2	**2.0**
PO 3	-	2	2	2	2	-	**1.3**
PO 4	-	1	1	-	-	-	**0.3**
PO 5	-	2	2	2	2	2	**1.6**
PO 6	1	1	1	1	1	1	**1.0**
PO 7	1	1	1	1	1	1	**1.0**
PO 8	1	1	1	1	1	1	**1.0**
PO 9	-	-	-	-	-	-	**-**
PO 10	-	2	2	2	2	2	**1.6**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-V
STATISTICAL THERMODYNAMICS (25CHxxx)
(CORE ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course on Statistical Thermodynamics bridges the gap between classical thermodynamics and the microscopic behaviour of individual molecules. By introducing the concept of partition functions, it provides a molecular-level foundation for deriving key thermodynamic properties and laws. It provides better insights into how macroscopic observables, such as energy, entropy, and free energy, can be systematically linked at molecular level. These concepts will be applied to understand a range of important industrial and academic applications. Moreover, the course highlights the molecular-level behaviour of gases, including their interactions with other gases. The course will also explore the molecular-level behaviour of solids, both as reactants and as catalysts.

B. PREREQUISITES:

Basic Thermodynamics, Calculus, Introductory Physics/Chemistry

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Introduction - Classical thermodynamics to Statistical Thermodynamics** Review of classical thermodynamics and limitations, kinetic theory of gases, classical mechanics, quantum mechanics, need to study statistical thermodynamics.	**CO1**	**3**
2.	**Fundamental of Statistical Thermodynamics** Concepts of ensembles, microstates, macrostates, probability concepts, Different thermodynamic distributions- Boltzmann, Bose – Einstein and Fermi-Dirac.	**CO2**	**6**
3.	**Laws of Thermodynamics** Laws of thermodynamics & their applications, Properties of elementary particles.	**CO3**	**6**
4.	**Behavior of Monoatomic gases and solids** Partition function, partition function for a monoatomic perfect gas.	**CO4**	**6**
5.	**Behavior of Diatomic and Polyatomic gases** Rotational and vibrational contributions to partition function.	**CO5**	**6**
6.	**Chemical Equilibrium** Equilibrium constant, Equilibrium Composition, Simultaneous reactions, Ionization, molecular-level understanding of energy distribution and chemical reactivity for ensuring safe process design and operation.	**CO6**	**6**

D. TEXT BOOKS

1. Sonntag, R. E. & Van Wylen, Gordon J. Fundamentals of Statistical Thermodynamics; First Edition, John Wiley & Sons: United States of America, 1968.

E. REFERENECE BOOKS

1. Sandler, S.I. An Introduction to Applied Statistical Thermodynamics. John Wiley & Sons. Hoboken, NJ, 2010.
2. McQuarrie, D.A. Statistical Mechanics, University Science Books, Sausalito, CA, 2000
3. Elstner, M., Cui, Q. & Gruden, M. Introduction to Statistical Thermodynamics-A molecular perspective. First Edition, Springer International Publishing AG, 2024.

F. ONLINE RESOURCES

1. https://nptel.ac.in/courses/103103355
2. https://nptel.ac.in/courses/104101139

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Link molecular behavior and macroscopic thermodynamic properties.
CO2	Applying Statistical Thermodynamics for addressing change in key thermodynamic properties.
CO3	Interpret fundamental thermodynamic laws statistical viewpoint.
CO4	Introducing concept of quantum mechanics and analyze the effect of various energy levels for behavior of monoatomic gas.
CO5	Estimating behavior of diatomic gas and polyatomic gases.
CO6	Estimate maximum conversion in chemical reactions.

H. COURSE MATRIX

	CO 1	**CO 2**	**CO 3**	**CO 4**	**CO 5**	**CO 6**	**Average**
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	3	-	2	3	2	**2.0**
PO 3	-	-	-	3	3	3	**1.5**
PO 4	2	3	3	3	3	2	**2.7**
PO 5	1	2	3	2	3	2	**2.2**
PO 6	-	-	-	-	1	2	**0.5**
PO 7	-	-	-	-	-	1	**0.2**
PO 8	-	-	-	-	-	1	**0.2**
PO 9	-	-	-	-	-	1	**0.2**
PO 10	-	-	-	-	1	1	**0.2**
PO 11	2	2	2	2	2	2	**2.0**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	2	3	3	3	3	3	**2.8**

B.TECH. – SEMESTER-V
PLANT UTILITIES (25CHxxx)
(CORE ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course provides students with a comprehensive understanding of various utilities that support the Chemical Process Industries. The course emphasizes on the role of essential services like water processing, steam generation, refrigeration, instrument air, compressed air, and power systems, along with their efficient and safe operation. The course also introduces the principles of energy management and conservation, enabling students to evaluate utility systems from both operational and sustainability perspectives.

B. PREREQUISITES:

Basic Chemistry; Introduction to Chemical Engineering; Material and Energy Balance Computations.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Water Processing** Sources of ground and surface water, water analysis, types of hardness, methods of softening of water like lime soda, zeolite, ion exchange methods etc., Purification of water by screening, sedimentation, coagulation, filtration & sterilization, Demineralization treatment for boiler feed water, Reuse & Recycling of water using UV, UF, RO processes.	CO1	6
2.	**Boiler Operations** Definition of enthalpy, dry and wet steam, superheated steam, specific volume, Types-classification & comparison of boilers, Factors affecting the selection of boiler, boiler water treatment, Oxygen Scavengers and Anti-Scalants for boiler, Boiler Feedwater Preheating and economizer, Deaeration and Deaerators in Boilers, boiler start up and shut down procedure, boiler act (1923), blown types for boilers, Boiler Control Alarms and Safety Systems, Energy Management and Waste Heat Recovery, Safety Valves and Pressure Relief Devices, Flame Detection and Failure Systems, Emergency Shutdown Systems and Procedures, Boiler Inspection and Maintenance for Safety Compliance.	CO2	6
3.	**Cooling Tower Operations** Cooling tower open and close circuit, types of cooling towers, jargons associated with cooling tower, details of packing (fills) of cooling tower, cooling tower blowdown, corrosion control, scaling control, microbial growth control in cooling tower, efficiency factors in cooling tower, trouble shooting for cooling tower, cooling tower pump sizing and head calculation.	CO3	6
4.	**Refrigeration, Air and Gases** Air in the form of instrument air, process air, compressed air, fan air and blower air. Purging and inerting methods, Nitrogen as suitable purging and inerting material. Refrigeration by ice, evaporate, vapor, steam jet refrigeration etc, Types of refrigerating agents like brine, various CFCs, HFCs, HCFCs, ammonia (R-717), dry ice (R-744), propane and isobutene (R-290 and R-600a), etc, Concept of Ozone Depleting Substances and Global warming Potential, Selection criteria for refrigerants.	CO4	6
5.	**Storage, Inventory and Offsite Operations** Storage in Bin, Silo and Hopper, Storage conditions (temperature, light and	CO5	6

humidity), Inventory management (stock tracking and stock rotating), Off site storage and third-party logistics (3PL), storage and plant lay outing, safety and security challenges in storage and offsite operations.

6.	**Energy Conservation and Management** Energy consumption pattern of various industries, energy saving opportunities, Plant emergency energy backup system, Energy Cogeneration Vs. Trigeneration, Energy Performance Indicators, Energy Management System (ISO 50001) and Energy Audit (ISO 50002).	**CO6**	**6**

D. TEXT BOOKS

1. Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design" by Gavin Towler and Ray Sinnott

E. REFERENECE BOOKS

1. Shreve’s Chemical Process Industries, 5th Ed. By, George F. Austin McGraw Hill International Edition.
2. Dryden’s Outlines of Chemical Technology, 2nd Ed. By M. Gopala Rao & Marshall Sitting, East West Press Pvt. Ltd., New Delhi.
3. Plant Design and Economics for Chemical Engineers" by Max S. Peters and Klaus D. Timmerhaus
4. Plant Utilities by D.B. Dhone, Nirali Prakashan.

F. ONLINE RESOURCES

1. https://archive.nptel.ac.in/courses/103/107/103107211/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Students will understand the significance of water processing as per industrial requirement
CO2	Clarity on boiler operations and its operational issues.
CO3	Knowledge of cooling tower types, its operations and troubleshooting
CO4	Ability to select suitable refrigerant media as per requirement
CO5	Understanding of effective storage and inventory management
CO6	Capability to perform the energy audit and energy saving.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	1	1	1	1	1	1	**1.0**
PO 2	1	1	1	1	1	1	**1.0**
PO 3	1	1	1	1	1	2	**1.2**
PO 4	1	1	1	1	1	1	**1.0**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	2	2	2	2	2	3	**2.2**
PO 7	1	1	1	1	1	1	**1.0**
PO 8	1	1	1	1	1	2	**1.2**
PO 9	1	1	1	1	1	2	**1.2**
PO 10	1	1	1	1	1	2	**1.2**
PO 11	1	1	1	1	1	2	**1.2**
PSO 1	2	2	2	2	2	3	**2.2**
PSO 2	1	1	1	1	1	2	**1.2**

B.TECH. – SEMESTER-V
HEAT EXCHANGER DESIGN AND ANALYSIS (25CHxxx)
(CORE ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course provides in-depth knowledge of heat exchanger technologies used in chemical and process industries. It begins with fundamental concepts, classifications, and applications, followed by core design principles involving thermal and hydraulic aspects. Students will explore various types of heat exchangers, including tubular, compact, plate fin, direct contact, regenerators, and heat pipes, with a focus on their construction, operation, and enhancement techniques. Advanced topics such as microscale systems, phase change mechanisms, and heat exchanger testing methods are also covered. Emphasis is placed on analytical methods like LMTD and ε-NTU, industrial standards, and practical design considerations, preparing students for both professional practice and research.

B. PREREQUISITES:

Mathematics-I and Mathematics -II Thermodynamics, Heat Transfer

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Fundamentals of Heat Exchangers** Background of heat exchangers, Applications in process industries, Classification of heat exchangers, Common terminologies	CO1	3
2.	**Basic Thermal and Hydraulic Design** Thermal and hydraulic aspects, Pressure drop and heat transfer, Heat exchanger sizing and rating, LMTD method, ε-NTU method	CO2	4
3.	**Tubular and Compact Heat Exchangers** Tubular heat exchanger design using Bell Delaware method, Shell and Tube Heat Exchangers, Special types of tubular exchangers, Compact heat exchangers, Heat transfer enhancement techniques, Extended surfaces (fins), Fin-tube heat exchangers	CO3	8
4.	**Plate Fin and Direct Contact Heat Exchangers** Plate Fin Heat Exchangers (PFHE): types and construction, Fabrication and design of PFHE, Applications of PFHE, Multistream PFHE, Direct contact heat exchangers: types and applications, Simple analysis of direct contact heat exchangers	CO4	7
5.	**Regenerators and Heat Pipes** Types of regenerators, Construction and application of regenerators, Theory of regenerators (ε-NTU method), Heat pipes: construction and working principle, Application and analysis of heat pipes, Special heat pipes	CO5	7
6.	**Advanced and Phase Change Heat Exchangers** Microscale heat exchangers and heat sinks, Fluid flow and heat transfer through narrow conduits, Design considerations for microscale systems, Phase change heat exchangers. Heat exchanger testing methods (steady state and dynamic)	CO6	7

D. TEXT BOOKS

1. Kuppan, T., Heat Exchanger Design Handbook, 2nd ed., CRC Press, 2013.
2. Kakaç, S., Liu, H., and Pramuanjaroenkij, A., Heat Exchangers: Selection, Rating, and Thermal Design, 2nd ed., CRC Press, 2012.

E. REFERENECE BOOKS

1. Wang, L., Sundén, B., and Manglik, *R. M.*, Plate Heat Exchangers: Design, Applications and Performance, WIT Press, 2007.

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the fundamental concepts, classification, and applications of heat exchangers used in process industries.
CO2	Apply basic thermal and hydraulic design principles including LMTD and ε-NTU methods for heat exchanger analysis.
CO3	Analyze various tubular and compact heat exchanger designs and enhancement techniques for improved heat transfer.
CO4	Evaluate the design and applications of plate fin and direct contact heat exchangers including multistream configurations.
CO5	Examine the working principles and analysis of regenerators and heat pipes used for heat recovery applications.
CO6	Assess the design and performance of advanced heat exchangers, including microscale and phase change systems with testing methods.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	3	2	3	2	3	**2.5**
PO 3	-	2	3	3	3	3	**2.3**
PO 4	-	2	2	2	2	2	**1.7**
PO 5	-	-	-	2	2	3	**1.2**
PO 6	-	-	-	-	-	-	**-**
PO 7	-	-	-	-	-	-	**-**
PO 8	-	-	-	-	-	-	**-**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	-	-	-	-	1	**0.3**
PO 11	-	-	-	-	-	1	**0.2**
PSO 1	2	3	3	3	3	3	**2.8**
PSO 2	2	2	1	2	2	3	**2.0**

B.TECH. – SEMESTER-V
POLYMER SCIENCE & ENGINEERING (25CHxxx)
(CORE ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course offers a foundational overview of polymer science, covering polymer types, synthesis, properties, and applications, along with engineering polymers, fibers, elastomers, additives, rheology, processing methods, and molecular weight measurement techniques.

B. PREREQUISITES:

Chemistry, Material Science

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Introduction to Polymers:** History of polymers, Polymerization, Types of polymers, Blends, Composites, Basic polymer properties, Materials and applications of polymers	CO1	5
2.	**Engineering Polymers:** Types of engineering polymers, Thermoplastics, Thermosets, Elastomers, Polyolefins, Polyethylene, Polypropylene, polystyrene, acrylic polymers, PVC, poly (vinyl esters), Teflon, Nylon, polyesters, cellulose polymers, phenolic and amino resins, epoxy resins, polyurethanes; silicone polymers; composites, others	CO2	7
3.	**Fibers**: denier, tenacity, fiber spinning – melt spinning, wet spinning, dry spinning, fiber properties **Elastomers**: natural and synthetic elastomers, classification, preparation, properties, application of elastomers, vulcanization; reinforcement. **Polymer Additives and Compounding**: fillers; colorants; stabilizers; plasticizers; flame retardants; lubricants; others	CO3	7
4.	**Polymer Rheology**: Newtonian fluids, non-Newtonian fluids, Hookean solids, viscous flow, rubber-like elasticity, viscoelasticity, viscoelastic models, glassy state, glass transition temperature, crystalline melting temperature, mechanical properties of polymers, orientation	CO4	7
5.	**Polymer Processing**: extrusion, compression molding, injection molding, blow molding, cast film, calendaring, other processing techniques	CO5	6
6.	**Measurement of Molecular Weight and Size**: light scattering; solution viscosity; gel permeation chromatography, colligative properties	CO6	4

D. TEXT BOOKS

1. Text book of Polymer Science, Fred W. Billmeyer, Jr, John Wiley & Sons.
2. Polymer Science" by V.R. Gowariker, N.V. Vishwanathan; J. Sreedhar

E. REFERENCE BOOKS

1. Principles of Polymer Science by P. Bahadur and N.V. Sastry
2. Polymer Science & Technology by P. Ghosh

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the fundamentals of polymers, including their history, polymerization methods, types, blends, composites, properties, and applications.
CO2	Gain knowledge of various engineering polymers, their classifications, properties, and applications across diverse materials.

CO3 Learn fibres, elastomers, and polymer additives in terms of their types, properties, processing methods, and applications.

CO4 Describe the flow, deformation, and mechanical behaviour of polymers through rheological concepts and models.

CO5 Identify key polymer processing techniques and their applications in shaping polymer products.

CO6 Analyze the different techniques to check molecular weight of polymers.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	3	3	**3.0**
PO 3	2	2	3	3	3	3	**2.7**
PO 4	2	2	3	2	3	3	**2.5**
PO 5	1	2	3	3	3	2	**2.3**
PO 6	1	1	2	2	2	3	**1.8**
PO 7	1	1	2	2	2	2	**1.7**
PO 8	3	2	2	2	3	3	**2.5**
PO 9	2	2	2	3	3	3	**2.5**
PO 10	2	3	3	3	3	3	**2.8**
PO 11	3	3	3	3	3	3	**3.0**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	2	2	3	3	3	3	**2.7**

B.TECH. – SEMESTER-V
FLUIDIZATION (25CHxxx)
(CORE ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course explores the principles and applications of fluidization in chemical engineering. It covers fluid-particle systems, solids classification, flow patterns, and bubbling bed dynamics. Key topics include gas distributors, entrainment, elutriation, and attrition phenomena, along with mass and heat transfer in fluidized beds. Students will also learn to design fluidized bed reactors and use modern tools like CFD modeling and flow visualization.

B. PREREQUISITES:

Mathematics, Basics of Fluid Mechanics, Heat and Mass Transfer, Particle and Fluid Particle Processing.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Fundamentals of Fluidization** The phenomenon of fluidization, Comparison with other contacting modes, Advantages and disadvantages, Industrial applications in chemical processing, Basic terminology for fluid-particle systems.	CO1	6
2.	**Solids Characteristics and Flow Patterns** Classification and flow characteristics of solids, Different types of fluidizations, Flow patterns in fluidized beds, Flow pattern transitions and mapping, Frictional pressure drop: models and analysis, Solid movement: mixing, segregation, and staging.	CO2	6
3.	**Gas Distribution and Bubbling Fluidized Beds** Types of gas distributors, Design principles for distributors, bubbling fluidized beds: gas dispersion and interchange, Mixing characteristics and bed dynamics.	CO3	6
4.	**Entrainment, Elutriation, and Attrition** Entrainment mechanisms and modelling, Elutriation: behavior and design implications, Attrition mechanisms, Attrition analysis using suitable models.	CO4	6
5.	**Mass and Heat Transfer in Fluidized Beds** Particle-to-gas mass transfer, Two-phase and three-phase systems, Modeling of mass transfer phenomena, Heat transfer between fluidized solids and surfaces, Models for heat transfer estimation.	CO5	6
6.	**Reactor Design and Modern Tools** Design of fluidized bed systems for: unit operations, Catalytic reactions, Non-catalytic systems; Introduction to FCC (Fluid Catalytic Cracking) systems, Modern experimental tools: flow visualization, measurement techniques, Simulation tools: basics of Computational Fluid Dynamics (CFD) modeling in fluidization.	CO6	6

D. TEXT BOOKS

1. Kunii, D., & Levenspiel, O. (1991). Fluidization Engineering (2nd ed.). Butterworth-Heinemann. ISBN: 978-0-409-90233-4.
2. Rhodes, M. (2008). Introduction to Particle Technology (2nd ed.). Wiley. ISBN: 978-0-470-01428-8.

E. REFERENECE BOOKS

1. Richardson, J. F., Harker, J. H., & Backhurst, J. R. (2002). Coulson and Richardson's Chemical Engineering, Volume 2: Particle Technology and Separation Processes (5th ed.). Butterworth-Heinemann. ISBN: 978-0-7506-4445-7.
2. Yang, W.C. (Ed.). (2003). Handbook of Fluidization and Fluid-Particle Systems (1st ed.). CRC Press. ISBN: 978-0-8247-0259-5.
3. Jackson, R. (2000). The Dynamics of Fluidized Particles. Cambridge University Press. ISBN: 978-0-521-78122-0.

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/103/103103132/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	the basics of fluid-solid interactions and fluidization behavior.
CO2	different types of fluidization regimes and analyze solids' characteristics and behavior.
CO3	various types of gas distributors, and analyze gas dispersion and mixing characteristics in bubbling fluidized beds.
CO4	entrainment, elutriation, and attrition mechanisms within fluidized beds.
CO5	mass and heat transfer processes occurring in fluidized bed systems.
CO6	design of fluidized bed reactors for various industrial applications and explore modern tools like CFD.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	1	2	2	2	3	3	**2.2**
PO 3	-	2	3	2	3	3	**2.6**
PO 4	1	2	2	2	3	3	**2.2**
PO 5	-	1	2	1	2	3	**1.8**
PO 6	1	1	2	1	2	2	**1.5**
PO 7	-	-	-	-	2	3	**2.5**
PO 8	-	1	-	2	-	-	**1.5**
PO 9	-	-	1	-	2	-	**1.5**
PO 10	1	1	2	1	1	2	**1.3**
PO 11	1	2	1	2	3	2	**1.8**
PSO 1	2	2	2	3	3	3	**2.5**
PSO 2	1	1	2	2	3	3	**2.0**

B.TECH. – SEMESTER-V
DATA ANALYSIS AND STATISTICAL METHODS (25CH512)
(OPEN ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course will let students analyse experimental data using statistical methods and design experiments that are critical in the performance analysis and selection for different engineering applications. The students will learn about the quality of generated data and applying it to various hypothesis and modeling. Software tools will be used for the analysis.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Data Types and Descriptive Statistics** Types of Data, Collection and summarizing data – Population and sample, Graphical Description, Numerical Description – central tendencies, variations, outliers	CO1	5
2.	**Probability Distribution** Basics of Probability, Bay's Rule, Probability, Discrete Random variables – Bernoulli Trials, Binomial Distribution and Multinomial, Poisson Distribution; Continuous Random variables - Normal Distribution, Exponential Distribution	CO2	7
3.	**Statistical Inferences** Error Analysis, Type-I and Type-II errors, Confidence intervals, Hypothesis testing – p-value, z-test, t-test, χ^2-test, F-Test	CO3	6
4.	**Regression and Correlation** Covariance, Coefficient of Correlation & Determination, Single and multiple linear regression, Non-linear regression, Goodness of fitting	CO4	7
5.	**Analysis of Variance – ANOVA** Logic behind ANOVA, Single Factor and Two factor ANOVA	CO5	7
6.	**Introduction to Design of Experiments and Statistical Quality Control** Single Factor and Multifactor Experimental Design, Statistical Quality Control	CO6	4

C. TEXT BOOKS

1. Statistics for Engineering and the Sciences 6th ed, William M. Mendenhall, Terry L. Sincich, CRC Press
2. Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control, Springer, Dharmaraja Selvamuthu & Dipayan Das
3. Introduction to Statistics and Data Analysis with Exercises, Solutions and Applications Christian Heumann, Michael Schomaker Shalabh, Springer

D. REFERENECE BOOKS

1. Excel Data Analysis Modeling and Simulation, 2nd Ed, Hector Guerrero, Springer
2. Introduction to Statistics and Data Analysis, Roxy Peck, Chris Olsen, Jay L. Devore, Cengage Learning
3. An Introduction to Statistical Methods & Data Analysis, 7th Ed., R. Lyman Ott, Michael Longnecker. Cengage Learning

E. ONLINE RESOURSES

1. Introduction to Probability and Statistics - https://nptel.ac.in/courses/111106112
2. Probability and Statistics - https://nptel.ac.in/courses/111105041
3. Introduction to statistics - https://nptel.ac.in/courses/111106415

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Different types of data and its representation
CO2	Different Distribution of data
CO3	To evaluate data, based on different testing methods and draw inferences
CO4	Parameter Estimation and assessment of quality of fitting
CO5	The variability and understanding correlation
CO6	Basics of design of Experiments and analyze the quality

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	2	2	2	2	2	**2.0**
PO 2	1	2	2	2	2	2	**1.8**
PO 3	1	2	2	2	2	3	**2.0**
PO 4	1	3	3	3	3	1	**2.3**
PO 5	3	1	3	3	3	1	**2.3**
PO 6	2	2	2	2	2	2	**2.0**
PO 7	1	1	1	1	1	1	**1.0**
PO 8	1	1	1	1	1	1	**1.0**
PO 9	2	2	2	2	2	2	**2.0**
PO 10	1	1	1	1	1	1	**1.0**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-V
GREEN TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT (25CHxxx)
(OPEN ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

The subject covers the principles of green chemistry and engineering, sustainable development goals, circular economy , cleaner production, life cycle assessment, green synthesis methods, green energy, and waste management, aiming to equip students with the knowledge to understand environmentally friendly chemical processes and products

B. PREREQUISITES:

Concept of environment studies and knowledge of conventional unit processes and unit operations.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Introduction to Green Technology and Green Engineering:** Principles of green chemistry and green technology, History of green technology, Role of Chemical Engineering in achieving sustainable development	CO1	4
2.	**Introduction to Sustainable Development:** Overview of the 17 SDGs and their relevance to chemical engineering, The three pillars of sustainability (economic, environmental, and social) , Specific SDGs related to chemical processes and products, Role of Cleaner production in Achieving Sustainability	CO2	5
3.	**Green Catalysts for Industrial reactions & processes:** Green oxidation and photochemical reactions, Synthesis of Green Reagents, Green solvents, green nanotechnology and Ionic liquids. A greener approach and Pollution prevention for industries like polymer, textile, pharmaceutical, dyes, pesticides, process of capturing CO_2, transportation, and storage methods	CO3	5
4.	**Circular economy for sustainability:** Principles, benefits, and practical applications, including concepts like resource efficiency, waste minimization, and the 5R framework (Refuse, Reduce, Reuse, Repair, Recycle), along with examples of circular economy models.	CO4	5
5.	**Green and Clean Energy:** Overview of the global energy landscape, the need for sustainable energy solutions, and the role of chemical engineering in achieving a green energy future, Renewable Energy Sources and concept of solar, wind, biomass, geothermal, hydropower, and ocean energy, Energy Efficiency and Conservation, Energy Storage and Sustainable materials, green hydrogen.	CO5	7
6.	**Challenges and Practical Implementation:** Responsibilities and potentials of companies for action. Green Productivity and emerging technologies. Life cycle assessment (LCA), Implementation of the practical applications of Green emerging technologies and sustainable development. Case studies in Green Technology. Green laws compliance and role of management.	CO6	7

D. TEXT BOOKS

1. Handbook of Green Chemistry and Technology, Clark J.H. and Macquarrie D.J. Wiley-Blackwell Publishers, 2002

2. Renewable Energy & Green Technologies. Gupta S.K., Daya Publication house, 2024

E. REFERENECE BOOKS

1. Green Chemistry: An Introductory Text, Lancaster M. Royal Society of Chemistry, Cambridge, 2002.
2. Environmental Chemistry with Green Chemistry, Das A. K. Books and Allied (P) Ltd., Kolkata, India, 2012.
3. Green Chemistry: Environmentally Benign Reactions, Ahluwalia, V.K. Ane Books India, New Delhi, India, 2006.

F. ONLINE RESOURSES

1. https://onlinecourses.nptel.ac.in/noc23_me138/preview
2. https://onlinecourses.nptel.ac.in/noc21_mg85/preview

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Able to understand the principles of green chemistry and green engineering
CO2	To understand the concept of sustainable development and its importance related to chemical process industries
CO3	To gain greener approach and knowledge on Green industrial processes and challenges.
CO4	To understand and apply the strategies for implementing circular economy practices in their respective fields.
CO5	Implementation of concept in green and clean energy
CO6	Understand and select the different principles of green chemistry and sustainable development for life cycle assessment.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	2	1	1	1	2	**1.5**
PO 2	1	2	1	1	1	2	**1.3**
PO 3	1	1	2	2	1	2	**1.5**
PO 4	1	1	2	1	1	1	**1.2**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	3	3	3	3	3	3	**3.0**
PO 7	3	3	3	3	3	3	**3.0**
PO 8	2	2	1	1	1	2	**1.5**
PO 9	1	1	1	2	1	2	**1.3**
PO 10	1	1	1	3	1	3	**1.7**
PO 11	2	3	3	3	3	3	**2.8**
PSO 1	2	3	3	2	3	3	**2.7**
PSO 2	3	3	2	3	3	2	**2.7**

B.TECH. – SEMESTER-V
CORROSION ENGINEERING (25CHxxx)
(OPEN ELECTIVE-1)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This elective course provides students with a comprehensive foundation in the principles of corrosion science, including the types, mechanisms, and kinetics of corrosion processes. Students will explore methods of corrosion monitoring, materials selection, and protective strategies such as coatings, cathodic protection, and corrosion inhibitors. The role of design, environmental factors, in controlling corrosion will also be covered.

B. PREREQUISITES:

Engineering Chemistry – Basic understanding of chemical bonding, electrochemistry, and material properties; Material Science – Knowledge of metals, alloys, and material behavior under different conditions; Chemical Engineering Thermodynamics – Understanding of phase equilibria, Gibbs free energy, and electrochemical thermodynamics.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Introduction to Corrosion and Electrochemical Principles** Definition and significance of corrosion, economic impact, basics of electrochemistry including electrochemical cells and EMF series, thermodynamics of corrosion, electrochemical reactions and mixed potential theory, environmental factors affecting corrosion.	CO1	3
2.	**Forms of Corrosion and Mechanisms** Uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching and erosion corrosion, stress corrosion cracking (SCC) and hydrogen embrittlement, factors influencing corrosion mechanisms.	CO2	5
3.	**Corrosion Testing and Evaluation Methods** Corrosion rate measurement techniques including weight loss and penetration rate calculations, electrochemical techniques such as Tafel extrapolation and Linear Polarization Resistance (LPR), corrosion testing standards including ASTM and ISO, accelerated corrosion testing methods such as salt spray test and high-temperature exposure, corrosion monitoring and inspection techniques.	CO3	7
4.	**Corrosion Prevention and Control Strategies** Material selection for corrosion resistance, protective coatings including organic, inorganic, and metallic coatings, cathodic protection methods such as sacrificial anode and impressed current systems, anodic protection and passivation of metals, environmental modification and corrosion control in industrial systems, design considerations to reduce corrosion risks.	CO4	6
5.	**Electrochemical Polarization and Corrosion Rate Prediction** Activation polarization and concentration polarization, mixed potential theory and corrosion kinetics, passivity and transpassivity of metals, understanding of Pourbaix diagrams for predicting corrosion behavior, Electrochemical Impedance Spectroscopy (EIS), case studies on electrochemical corrosion in industrial applications	CO5	6
6.	**Corrosion Inhibitors and Industrial Applications** Mechanism of corrosion inhibitors and types, application of corrosion	CO6	6

inhibitors in the oil and gas industry, case studies on corrosion failures in industrial plants, environmental considerations and green corrosion inhibitors, future trends in corrosion engineering and research.

D. TEXT BOOKS

1. M. G. Fontana, Corrosion Engineering, McGraw-Hill.
2. Denny A. Jones, Principles and Prevention of Corrosion, Prentice-Hall.

E. REFERENECE BOOKS

1. H. H. Uhlig & R. W. Revie, Corrosion and Corrosion Control, Wiley.
2. P. Roberge, Corrosion Engineering: Principles and Practice, McGraw-Hill.

F. ONLINE RESOURSES

1. https://nptel.ac.in/courses/113108051
2. https://archive.nptel.ac.in/courses/113/104/113104082/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand corrosion fundamentals and electrochemical aspects.
CO2	Remember different testing procedures for corrosion evaluation.
CO3	Apply knowledge to identify and mitigate various types of corrosion.
CO4	Analyse and identify corrosion failures and recommend control strategies.
CO5	Evaluate polarization behavior in corrosion systems.
CO6	Predict the effectiveness of corrosion inhibitors.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	3	3	2	3	3	**2.7**
PO 3	1	2	3	2	2	2	**2.0**
PO 4	1	2	3	3	2	3	**2.3**
PO 5	1	1	2	2	2	2	**1.7**
PO 6	2	2	2	2	1	1	**1.7**
PO 7	2	1	2	3	2	3	**2.2**
PO 8	-	-	1	1	-	1	**0.5**
PO 9	-	-	-	-	-	-	**0.0**
PO 10	2	2	1	2	1	-	**1.3**
PO 11	2	2	1	2	2	-	**1.5**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-V
UNIVERSAL HUMAN VALUES (25CH515)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	0	0	2	2	60	40	-	-	100

A. COURSE OVERVIEW

This course focuses on developing a holistic perspective through self-exploration, enabling individuals to understand their roles in society and nature. It emphasizes gaining clarity about oneself, relationships within the family, and interconnectedness with nature. Key areas include exploring harmony at the levels of the individual, family, society, and nature, while fostering self-reflection as a tool for growth. The course highlights the significance of commitment and the courage to act responsibly, aiming to cultivate a balanced and sustainable approach to life.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (24)
1.	**Course Introduction - Need, Basic Guidelines, Content and Process for Value Education** Purpose and motivation for the course, recapitulation from Universal Human Values-I. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration. Continuous Happiness and Prosperity- A look at basic Human Aspirations. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority. Understanding Happiness and Prosperity correctly- Acritical appraisal of the current scenario. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.	CO1 CO3	4
2.	**Understanding Harmony in the Human Being - Harmony in Myself** Understanding human being as a co-existence of the sentient 'I' and the material 'Body'. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer). Understanding the characteristics and activities of 'I' and harmony in 'I'. Understandingt he harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail. Programs to ensure Sanyam and Health.	CO1 CO3	5
3.	**Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship** Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship. Understanding the meaning of Trust; Difference between intention and competence. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.	CO2 CO5	5

4.	**Understanding Harmony in the Nature and Existence - Whole existence as Coexistence** Understanding the harmony in the Nature. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self- regulation in nature. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space. Holistic perception of harmony at all levels of existence	**CO2** **CO5**	**4**
5.	**Implications of the above Holistic Understanding of Harmony on Professional Ethics** Natural acceptance of human values. Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order. Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people- friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems. Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations	**CO4** **CO6**	**6**

C. TEXT BOOKS

1. R R Gaur, R Asthana, G P Bagaria, "A Foundation Course in Human Values and professional Ethics", 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-47-l
2. R R Gaur, R Asthana, G P Bagaria, "Teachers' Manual for A Foundation Course in Human Values and Professional Ethics", 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034-53-2

D. REFERENECE BOOKS

1. Jeevan Vidya: Ek Parichaya, A. Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999
2. A. N. Tripathi, Human Values, New Age International Publishers, New Delhi, 2004
3. The Story of Stuff (Book)
4. Mohandas Karamchand Gandhi, The Story of My Experiments with Truth
5. E. F. Schumacher, Small is Beautiful
6. Cecile Andrews, Slow is Beautiful
7. J. C. Kumarappa, Economy of Permanence
8. Pandit Sunderlal, Bharat Mein Angreji Raj
9. Dharampal, Rediscovering India
10. Mohandas K. Gandhi, Hind Swaraj or Indian Home Rule
11. Maulana Abul Kalam Azad, India Wins Freedom
12. Romain Rolland, Vivekananda (English)

E. ONLINE RESOURSES

1. https://nptel.ac.in/courses/109104068

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Development of a holistic perspective based on self-exploration about human being and surrounding.
CO2	Understanding of the harmony in the human being, family, society and nature/existence

CO3 Defining and strengthening of self-reflection.
CO4 Development of commitment and courage to act.
CO5 Analysing issues/problems and their role in society.
CO6 Improving human values and humanities.
Development of a holistic perspective based on self-exploration about human being and surrounding.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	-	-	-	-	-	-	**-**
PO 2	-	-	-	-	-	-	**-**
PO 3	-	-	-	-	-	-	**-**
PO 4	-	-	-	-	-	-	**-**
PO 5	-	-	-	-	-	-	**-**
PO 6	1	3	1	1	2	1	**1.5**
PO 7	3	3	3	3	3	3	**3.0**
PO 8	2	3	1	2	3	1	**2.0**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	-	-	-	-	-	-	**-**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	-	-	-	-	-	-	**-**
PSO 2	1	1	1	1	1	1	**1.0**

Semester – VI

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
25CH613	Chemical Reaction Engineering-II	3	0	3	6	4.5	60	40	25	25	150
25CH616	Instrumentation and Process Control	3	1	3	7	5.5	60	40	25	25	150
25CH615	Process Equipment Design & Drawing	3	0	3	6	4.5	60	40	25	25	150
25CH617	Chemical Process Safety	3	0	0	3	3.0	60	40	0	0	100
PCE	Core Elective - II	3	0	0	3	3.0	60	40	0	0	100
OE	Open Elective - II	3	0	0	3	3.0	60	40	0	0	100
	Total	**18**	**1**	**9**	**28**	**23.5**	**360**	**240**	**75**	**75**	**750**

ELECTIVES OFFERED

Core Elective-2 SEM-VI	
1.	Energy Technology
2.	Petrochemical Technology
3.	Chemical System Modeling
4.	Multicomponent Distillation

Open Elective-2 SEM-VI	
1.	Introduction to Machine Learning
2.	Nanotechnology and Applications
3.	Operation Research

B.TECH. – SEMESTER-VI
CHEMICAL REACTION ENGINEERING–II (25CH613)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	4.5	60	40	25	25	150

A. COURSE OVERVIEW

To make the students understand about the real reactor selection**,** performance, analysis, design and operation under non-ideal, non- isothermal and heterogeneous conditions in chemical process industries. Fundamentals of non-ideality, basic concepts of non-isothermal reactors, fundamentals of catalytic reaction mechanisms and kinetics of catalytic reactions, fundamentals and design of non-catalytic multiphase reactors (fluid-fluid, fluid-solid). Basic analysis and design of multiphase reactors such as fixed bed, fluidized bed, trickle bed and slurry reactors.

B. PREREQUISITES

Thermodynamics-I and -II, Chemical Reaction Engineering-I, Mass Transfer-I and -II

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (38)
1.	**Non-ideal Reactors** RTD theory, understanding RTD curves and moments, finding out RTD by experiments – Pulse and Step Input, Models for non-ideal flow – zero (segregation& maximum mixedness), one (Dispersion and TIS) and two parameter models, Engineering Considerations	**CO1** **CO6**	9
2.	**Non-isothermal Operations and Reactor Design** Material and Energy balances for CSTR and PFR/PBR, Design Algorithms for CSTR and PFR/PBR, Adiabatic and non-adiabatic reactors design Procedures, Unsteady- state Batch reactor design Procedures, Concept of Multiple Steady states in CSTR, Concept of thermal runaway, surface to volume ratio for reactor heat exchange and reactor safety, Engineering Ethical, Environmental Considerations	**CO2** **CO6**	8
3.	**Fundamentals of Catalytic Reactions** Mechanism of solid catalyzed reaction, Experimental Methods for studying kinetics of catalytic reactions and data analysis, Design of Fixed bed catalytic reactors, Design of Fluidized bed catalytic reactors, Design of Trickle bed catalytic reactors, Engineering Ethical, Environmental and Social Considerations	**CO3** **CO6**	9
4.	**Fundamentals of Fluid-Fluid Reactors and Reactor Design** Kinetic regimes for mass transfer & reaction, Enhancement factor in gas-liquid reactions, Design of towers/tanks for fast & slow reactions	**CO4** **CO6**	6
5.	**Fundamentals of Fluid-Solid Reactors and Reactor Design** Rate equation for heterogeneous reactions, the concept of rate controlling step,Design of Plug flow, Fluidized bed reactors	**CO5** **CO6**	6

D. PRACTICAL & TERM WORK

1. Non- Ideality study in flow through Helical Coil
2. Non- Ideality study in Laminar Flow
3. Non- Ideality study in Annular Flow (Applying TIS Model)
4. Non- Ideality study in Flow through Packed Bed (Applying Dispersion Model)
5. Non-ideal behaviour in a Single Stirred Tank
6. Non-Ideality Study in a Cascade of Stirred Tanks
7. Liquid-Liquid Heterogeneous Reaction
8. Gas-Liquid Reaction in an Agitated Bubble Column

E. TEXT BOOKS

1. Levenspiel, O. Chemical Reaction Engineering; 3rd ed.; John Wiley & Sons (Asia) Pvt. Ltd : Singapore, 2014
2. Scott, Fogler. H. Elements of Chemical Reaction Engineering; 5th ed.; Prentice Hall India (p) Ltd.: New Delhi, 2016

F. REFERENCE BOOK

1. Smith, J. M. Chemical Engineering Kinetics; 3rd ed.; McGraw Hill New York, 2000

G. ONLINE RESOURCES

1. Chemical Reaction Engineering-II - https://nptel.ac.in/courses/103101008
2. Chemical Reaction Engineering-II - https://nptel.ac.in/courses/103101141
3. Chemical Reaction Engineering-I Heterogeneous Reactors https://nptel.ac.in/courses/103106116
4. Chemical Reaction Engineering-II Heterogeneous Reactors https://nptel.ac.in/courses/103106117

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand and analyze the non-ideality in the reactors and evaluate its performance
CO2	Analyze and Design Batch, PFR, CSTR and non-isothermal reactors
CO3	Develop Kinetic Expression from heterogeneous solid catalyzed reaction, analyze mechanism and controlling resistances, evaluate performance and design
CO4	Analyze different control regimes and selection and design of fluid-fluid contactors
CO5	Analyze and Design of non-catalytic fluid-solid reactors
CO6	Analyze and design industrial reactors

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	2	**2.0**
PO 3	2	2	2	2	2	2	**2.0**
PO 4	3	3	3	3	3	3	**3.0**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	1	1	1	1	1	1	**1.0**
PO 7	1	1	1	1	1	1	**1.0**
PO 8	1	1	1	1	1	1	**1.0**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	1	1	1	1	1	**1.0**
PO 11	2	2	2	2	2	2	**2.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-VI
INSTRUMENTATION & PROCESS CONTROL (25CH616)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	1	3	7	5.5	60	40	25	25	150

A. COURSE OVERVIEW

This course introduces the fundamental principles of instrumentation and process control in chemical engineering. It covers the modeling of dynamic systems and their representation in both time and Laplace domains. Students will study the behavior of first and second-order systems, develop transfer functions, and analyze system responses to various input types. The course emphasizes the design and analysis of open and closed-loop control systems, with a focus on PID controller tuning and performance evaluation. Stability analysis using techniques such as Routh-Hurwitz, Root Locus, Bode, and Nyquist plots is explored in depth. Additionally, students will be exposed to advanced control strategies employed in the process industries. The course also includes the study of instrumentation characteristics and the selection of appropriate sensors for measuring key process variables such as temperature, pressure, level, and flow. Practical aspects such as developing and interpreting Process and Instrumentation Diagrams (P&IDs) are also included to prepare students for real-world industrial applications.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (48)
1.	**Introductory Concepts**: Introduction to automation, closed loop block diagram, Time invariance, transportation lag and its approximation. **Mathematical Preliminaries**: linearity, Linearization, Laplace representation of inputs, outputs and process systems. Laplace theorems, solving differential equations using Lapalce transforms.	**CO1**	**8**
2.	**First order systems:** Development of transfer function for representative first order systems. Response of first order systems to step, impulse and sinusoidal inputs. **Second order systems:** transfer function development for Interacting, non-interacting tank systems, manometer system and control valve system. Response of second order systems to step, impulse and sinusoidal inputs	**CO2**	**8**
3.	**Linear closed loop systems**, servo and regulatory problems, feed forward and feedback control systems. Closed loop transfer function, classical feedback controllers. Closed loop response, PID Controller tuning: Ziegler-Nichol's method, Cohen-Coon method and direct synthesis method. Digital implementation of PID controller.	**CO3**	**8**
4.	Stability analysis, Routh stability criterion, Root locus diagrams (rule based). Introduction to frequency response. Bode diagrams, Nyquist plots, Bode and Nyquist stability criterion	**CO4**	**8**
5.	**Industrial applications:** Introduction to advanced controllers like cascade control, feed forward control, ratio control, Smith- predictor, IMC, MPC, dead-time compensation. Characteristics control valves, Piping and instrumentation Diagrams.	**CO5**	**8**
6.	Introduction to instrumentation, static and dynamic characteristics of instruments. Temperature, Pressure, Level and flow sensors	**CO6**	**8**

C. PRACTICAL & TERM WORK

1. Simple Level in tank system
2. Two tanks interacting system
3. Two tanks non-interacting system
4. Flow system
5. Temperature system
6. Pressure system
7. Response of thermometer
8. Response of thermowell
9. Response of manometer
10. Valve characteristics, interlocks and Alarm (Study)

D. TEXT BOOKS

1. Coughanowr D R; LeBlanc S E, Process System Analysis & Control,3rd Edition, Chemical Engineering series, McGraw Hill Publishing Co.: Newyork,2009
2. Eckman D, Industrial Instrumentation, Wiley & Sons: 1950.

E. REFERENCE BOOK

1. Stephanopoulos G, Chemical Process Control: An introduction to theory and practice, P T R Prentice Hall: NewJersey,2003.
2. https://archive.nptel.ac.in/courses/103/105/103105064/

F. COURSE OUTCOME

Cos	STATEMENT
CO1	Appreciate the significance of automation in chemical processes and demonstrate familiarity with systems engineering concepts and associated mathematical tools.
CO2	Develop mathematical models and transfer functions for first and second-order systems and analyze their dynamic responses to standard input signals.
CO3	Construct closed-loop control system models and effectively tune PID controllers for desired performance.
CO4	Analyze the stability of control systems using Routh-Hurwitz criteria, Root Locus plots, Bode plots, and Nyquist diagrams.
CO5	Demonstrate the ability to tune and implement advanced control strategies and prepare standard Process and Instrumentation Diagrams (P&ID).
CO6	Understand the characteristics of various instrumentation devices and select appropriate instruments for specific process applications.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	2	2	**2.6**
PO 3	2	2	3	3	3	2	**2.5**
PO 4	1	1	2	3	2	2	**1.9**
PO 5	-	-	2	2	2	3	**1.5**
PO 6	-	-	-	-	-	-	**-**
PO 7	-	-	-	-	-	-	**-**
PO 8	-	-	-	-	1	1	**0.3**
PO 9	1	1	1	1	2	2	**1.3**
PO 10	-	-	1	1	2	2	**1.0**
PO 11	1	1	2	2	2	2	**1.7**
PSO 1	2	1	2	2	3	2	**2.0**
PSO 2	3	3	3	3	3	3	**3.0**

B.TECH. – SEMESTER-VI
PROCESS EQUIPMENT DESIGN & DRAWING (25CH615)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	4.5	60	40	25	25	150

A. COURSE OVERVIEW

Design and fabrication of components of Industrial Chemical Vessels under various operating conditions. This course is pre-requisite to Chemical Project Engineering and Economics, Process Dev and Engineering

B. PREREQUISITES:

Structural Mechanics (Stress-strain, mechanical properties), general chemical technology (Diagram and flow sheeting), Materials Science and Engineering (Properties of material and selection of material), Engineering Graphics (Engineering Drawing), Heat transfer (Design of heat exchanger), Mass transfer (Design of Distillation with tray hydraulic), Chemical Reaction Engineering (Design of chemical reactor)

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Introduction** Introduction to design and drawing, Deciding operating condition to design Basic considerations in mechanical design of process equipment. Concept of pressure vessel, definition and type, selection of type of vessel. Methods of fabrication of vessel, economic consideration. Safety in pressure vessel design	CO1	2
2.	**Vessel Design** Selection Criteria for unfired pressure vessel design. Design Preliminaries Introduction to vessel codes and standards.	CO1	3
3.	**Vessels under Internal Pressure** Design of pressure vessels under internal pressure, Design of wall thickness based on Lame theorem and membrane stress theory, Types of closers for pressure vessel, design thickness of closer, Design of nozzles and reinforcement pads, Introduction to flanges and gasket, types and selection, design of flanges for pressure vessels.	CO2 CO6	8
4.	**Storage Vessels** Identification for storage for non-volatile & volatile liquids, storage of gases Types & constructional features of storage vessels along with safety aspects Rectangular storage tank design, Design of cylindrical storage tank, course to course calculation of wall thickness, bottom design, dyke wall concept Fixed roof and self-supported roof design	CO2 CO6	3
5.	**Vessels under External Pressure** Industrial pressure vessels under external pressure, Design of vessel wall in presence and absence of stiffeners using analytical & graphical methods, Design of circumferential stiffeners, Design of closers subjected to external pressure.	CO3 CO6	3
6.	**Reaction vessels** Introduction to various components of reaction vessel, Selection and design of various jackets and Coil, Design of Agitators based on torque, moment and critical speed. Safety in reaction vessel design	CO3 CO4 CO6	3
7.	**Design of Tall Columns** Industrial requirement of tall vessels, Construction & features in column stress & determination of shell thickness considering safe operation.	CO3 CO4 CO6	3
8.	**High Pressure Vessel** Types of high-pressure vessel, Design of high-pressure vessel, Construction features, materials for high pressure shell design, vessel closures	CO3 CO6	2

9.	**Design of Heat Exchanger** Basic introduction to heat exchanger and selection of heat exchanger, Mechanical design of shell and tube heat exchanger based on TEMA class.	**CO5** **CO6**	**3**
10.	**Supports for Vessels** Selection and design of different types – bracket or lug support, skirt support & saddle support, design calculations based on safety	**CO5** **CO6**	**3**

D. PRACTICAL & TERM WORK

1. Process Block Diagram
2. Process Flow Diagram
3. Piping and Instrumentation Diagram
4. Closer Design and Drawing including shell, flat closer, dished closer and conical closer
5. Pressure vessel design and drawing including shell, closer, nozzle and flanges
6. Storage tank design and drawing
7. Reactor design and drawing
8. Distillation design and drawing
9. STHE Design and drawing

E. TEXT BOOKS

1. Brownel, L. E.; Young, E. H. *Process Equipment Design & Drawing*; 2nd ed.; Wiley Eastern Ltd.: New Delhi, 2005.
2. Umarji, S. B.; Mahajani, V.V. *Joshi's Process Equipment Design*; 5th ed.; Trinity Press: New Delhi, 2016.

F. REFERENCE BOOK

1. Bhattacharya, B.C. *Process Equipment Design: Mechanical Aspect*; 1st ed.; CBS Publisher and Distributors Pvt. Ltd.: New Delhi, 2014.
2. Bhattacharya, B.C.; Narayanan, C.M. *Computer Aided Process Equipment Design*; 1st ed.; New Central Book agency (p) ltd.: Kolkata, 1992.

G. ONLINE RESOURCES

1. Noc25-ch39 Swayam course for mechanical design of process equipment.

Cos	**STATEMENT**
CO1	Understand the general design procedure for chemical process equipment based on codes and standards.
CO2	Design and draw pressure vessels, storage tank and its parts subjected to internal pressure.
CO3	Design and draw reactors, columns and its parts subjected to internal and external pressure
CO4	Critiquing Real life Industrial Problem and Implement solution Methodology for optimum Design
CO5	Understand different types of supports for chemical process equipment including heat exchangers.
CO6	Generate a detail design report along with drawing to plan the fabrication of equipment's.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	3	3	**3.0**
PO 3	3	3	3	3	3	3	**3.0**
PO 4	2	3	3	3	2	3	**2.7**
PO 5	2	2	2	2	2	2	**2.0**
PO 6	3	3	2	2	3	3	**2.7**
PO 7	2	2	2	2	2	2	**2.0**
PO 8	2	1	2	2	2	3	**2.0**
PO 9	2	2	3	2	3	3	**2.5**
PO 10	1	2	3	2	2	3	**2.2**
PO 11	2	3	3	2	2	3	**2.5**
PSO 1	3	3	3	3	2	2	**2.7**
PSO 2	3	3	3	2	3	2	**2.7**

B.TECH. – SEMESTER-VI
CHEMICAL PROCESS SAFETY (25CH617)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

This course is introduced to inculcate the safety culture among the undergraduate students of Chemical Engineering. The subject covers the fundamentals of process safety practiced in Chemical Process Industries. Modern risk assessment tools like HAZOP, Fault Tree, Event Tree, Bow Tie and Failure Mode Effect Criticality Analysis are covered in this course. Significant Industrial Accidents like Flixborough, 1974 (UK), Seveso, 1976 (Italy), Union Carbide, 1984 (India), Pasadena-Texas, 1989 (USA), Oklahoma Storage, 2003 (USA), T2 Laboratory, 2007 (USA) and Jaipur LPG, 2024 (India) are also covered as the case studies to critically examine the mistakes made and lessons to learn.

B. PREREQUISITES:

Knowledge of Probability, Reliability, Conditional probability, CET-1 and MEBC.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Fundamentals of Chemical Process Safety:** Understanding of Jargons like safety, hazard, risk, accident, incident, likelihood, consequence, loss prevention, domino effect, first aid, incident rate, lost workdays, occupational injury and illness, frequency rate, severity rate, fatality rate and fatal accident rate. Concept of Inherent, Passive, Active and Procedural Strategies, and Detection of hazard through senses. Entry routes of toxicants into biological system and appropriate control strategies. Elimination of toxicants from biological system by various ways, target organ, acute and chronic toxicity and its toxicological studies, chemical and physical asphyxiates, TLV-TWA, TLV-STEL and TLV-C, LD 50 and LC 50.	CO1	5
2.	**Case Studies on Significant Industrial Accidents:** Nature of accident process and theory of accident causation. Critical examination of mistakes made and lessons to learn from following Case Studies: Flixborough, 1974 (UK), Seveso, 1976 (Italy), Union Carbide, 1984 (India), Pasadena-Texas, 1989 (USA), Oklahoma Storage, 2003 (USA), T2 Laboratory, 2007 (USA) and Jaipur LPG, 2024 (India).	CO2	5
3.	**Industrial Hygiene:** PSM and RMP principles, Piping and Electric colour code system, Safety Work Permit System, Pre-start up and shut down procedures, emergency planning and response, mock drill, ISO 45001 (OHSMS), Safety Audit as per IS14489. Role of industrial hygienist: Identification using MSDS and NFPA diamond, Evaluation (quantification methods) and Control methods like Dyke and Enclosures, dilute and local ventilation, wet methods, good housekeeping and Personal Protective Equipment (PPE).	CO3	6
4.	**Fundamentals of Fire, Explosion and its Prevention:** Basic definitions like fire, combustion, explosion, fire and flash point, ignition energy and auto-ignition etc., Concept of fire triangle, flammability limits (LFL and UFL) and its estimation, limiting oxygen concentration and inerting, Classification of fires as per NFPA, Suitable extinguishing medium and its selection, Mobile and stationary fire-fighting methods. Explosion types like Mechanical Explosion, Detonation and Deflagration, Deflagration to Detonation transition (DtoD transition), Confined and Unconfined Explosion, Vapor Cloud Explosion, BLEVE (causes and prevention) and dust explosion.	CO4	6

5.	**Reactivity Hazard, Thermal Run Away and Relief Systems:** Concept of reactivity hazard and thermal run away, Discussion on various calorimeters like DSC, ARC, ARRST, APTAC, VSP2 etc. Strategies to control reactive hazard, need for relief devices, few terminologies like set pressure, max. Allowable working pressure, operating pressure, accumulation, overpressure, backpressure, blow down, max. allowable accumulated pressure etc., Location of reliefs, various relief devices like spring loaded (relief valve, safety valve and safety relief valve), mechanical, buckling pin and rupture dick. Selection criteria and combination criteria, effluent system, knock-out drum, cyclone, condenser, quench tank, scrubber, flare and incinerator. Concept of Basic process control systems (BPCS) and Safety instrumented system (SIS), sensor location criteria and redundancy of system, fail-safe mechanism, safety interlocks and alarm systems.	**CO5**	**6**
6.	**Risk Assessment:** HAZID tools like hazard checklist, job safety assessment, hazard survey (Dow Fire & Explosion Index). Hazard Operability (HAZOP with case study), safety reviews, ALARP and Risk Management as per ISO 31000 (RM). HAZAN using probabilistic methods, bath tub failure curve, MTBF, MTTR, MTBC, Revealed and Unrevealed failures, Common Failure Modes and Reliability calculations. Use of tools like Fault Tree (FT), Event Tree (ET), Bow Tie (BT), Directed Graphs (Cyclic and Acyclic), Failure Mode Effect Criticality Analysis (FMECA) and LOPA analysis.	**CO6**	**8**

D. TEXT BOOKS

1. Crawl, D. A.; Louvar, J. F. Chemical Process Safety (fundamentals with applications); 3rd Ed.; Prentice Hall International Series, 2011.

E. REFERENCE BOOKS

1. Lees, F. P. Loss Prevention in the Process Industries (Hazard Identification, Assessment and Control); 2nd Ed.; Butterworth-Heinemann, 1980.
2. Kletz, T. Learning from Accidents; 3rd Ed.; Gulf Professional Publishing, 2001.
3. Stoessel, F. Thermal Safety of Chemical Processes (Risk Assessment and Process Design); Wiley-VCH, 2008.
4. Banerjee, S. Industrial Hazards and Plant Safety; 1st Ed.; CRC Press, 2002.

F. ONLINE RESOURCES

1. https://archive.nptel.ac.in/courses/103/107/103107156/
2. https://archive.nptel.ac.in/courses/103/106/103106071/

G. COURSE OUTCOME

Cos	STATEMENT
CO1	Students will understand and apply the fundamentals of chemical process safety.
CO2	Ability to critically analyse the industrial accidents in terms of mistakes made and lessons to learn.
CO3	Identification and quantification of potential hazards associated with occupational safety and ethical aspects aligned with it.
CO4	Knowledge of fire & explosion types and its preventive measures.
CO5	Understanding of reactivity hazard, characteristics of thermal run away and relief systems.
CO6	Capability to perform the risk assessment incorporating research ability for future endeavours.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	1	1	2	2	2	3	**1.8**
PO 2	1	2	2	2	2	3	**2.0**
PO 3	2	2	2	2	2	3	**2.2**
PO 4	1	2	2	2	2	3	**2.0**
PO 5	1	1	1	1	1	2	**1.2**
PO 6	2	2	2	2	2	3	**2.2**
PO 7	2	2	2	2	2	3	**2.2**
PO 8	1	2	2	2	2	3	**2.0**
PO 9	1	2	1	1	1	3	**1.5**
PO 10	1	1	1	1	1	2	**1.2**
PO 11	1	2	2	2	2	3	**2.0**
PSO 1	2	2	2	2	2	3	**2.2**
PSO 2	2	2	2	2	2	3	**2.2**

B.TECH. – SEMESTER-VI
ENERGY TECHNOLOGY (25CHxxx)
(CORE ELECTIVE-2)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	-	-	-	60

A. COURSE OVERVIEW

The motivation of the course is students shall understand current practices of fuel usages and future prospectus of new and non-conventional energy resources exploration. Moreover, they shall understand various energy sources including conventional and non-conventional including solar thermal, geothermal, wind, Ocean, biomass, etc. and also demonstrate knowledge of various energy technologies and learn present energy scenario and the need for energy conservation.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**An Introduction to Energy Sources** energy sources (conventional & non-conventional), renewable energy resources, primary & secondary energy sources, energy chain, energy demand, national energy strategy & plan, energy management, energy audit & conservation **Definitions, Units & Measures** proximate & ultimate analysis, calorific values, rank of coal, coking & caking, gasification, basis for reporting results of analysis, units & conversion factors	CO1 CO2	3
2.	**Solid Fuels** wood & charcoal, peat, lignite, sub-bituminous & bituminous coals, semi- anthracite and anthracite coals, cannel & boghead coal, origin of coal, composition of coal, analysis & properties of coal, problems	CO1 CO2 CO3	3
3.	**Processing of Solid Fuels** coal preparation, washability curve, dry & wet washing methods of coal, washer efficiency, gasification & liquefaction of solid fuels, problems	CO1 CO2 CO7	3
4.	**Solar Energy** solar constant, solar radiation & related terms, measurement of solar radiation, solar energy collectors – flat plate collector, air collector, collectors with porous absorbers, concentrating collectors, applications & advantages of various collectors, selective absorber coatings, solar energy storage systems (thermal, electrical, chemical & mechanical), solar pond, applications of solar energy	CO1 CO3	3
5.	**Wind Energy** basic principles, power in wind, force on blades & turbines, wind energy conversion, site selection, basic components of wind energy conversion systems (WECS), classification of WECS, wind energy collectors, applications of wind energy	CO1 CO3	3
6.	**Energy from Biomass** Introduction, energy plantation, biomass conversion technologies, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants & their comparisons, types of biogas plants (including those used in India),biogas from plant wastes, community plants & site selection, digester design considerations, design calculations, methods of maintaining & starting biogas plants, properties & utilization of biogas, thermal gasification of biomass, pyrolysis, alternative liquid fuels	CO1 CO3 CO4	3

7.	**Geothermal Energy** Geothermal resources, hydrothermal resources, liquid dominated systems, geopressured resources, petrothermal systems, magma resources, energy conservation & comparison with other resources, applications of geothermal energy	**CO1** **CO3**	**3**
8.	**Energy from Oceans** OTEC, methods (open cycle & close cycle) energy from tides, components of tidal power plants, operation, methods of utilization of tidal energy, storage, ocean waves, wave energy conversion devices	**CO1** **CO5**	**3**
9.	**Fuel Cell** introduction, hydrogen – oxygen fuel cell, ion exchange membrane cell, fossil fuel cell, molten carbonate cell, advantages & disadvantages, conversion efficiency, polarization, type of electrodes, applications of fuel cells	**CO1** **CO6**	**3**
10.	**Hydrogen & Methanol** properties of Hydrogen, production of hydrogen, thermochemical methods, fossil fuel methods, solar methods, storage & transportation, safety & management	**CO1** **CO6**	**3**
11.	**Magneto Hydro-Dynamic (MHD) Power Generation** principle, MHD system, open cycle system, closed cycle system, design problems & developments, advantages, materials for MHD generators, magnetic field & superconductivity	**CO1** **CO6**	**3**
12.	**Nuclear Energy** fission, fusion, fuel for nuclear fission reactor (exploration, mining, milling, concentrating, refining, enrichment, fuel fabrication, fuel use, reprocessing, waste disposal), storage & transportation, fast & slow neutrons, multiplication factors & reactor control, uranium enrichment process, nuclear reactor power plant, fast breeder reactor, boiling water reactor, pressurized heavy & light water reactor	**CO1** **CO6**	**3**

C. TEXT BOOKS

1. Energy Sources 2nd Ed. by G. D. Rai, Khanna Publications, New Delhi
2. Fuels & combustion by Samir Sarkar, Orient Longmans (1974)

D. REFERENCE BOOKS

1. Solar Energy by Sukatame. Tata McGraw Hill, New Delhi
2. Energy Technology by Rao & Parulaker

E. COURSE OUTCOME

Cos	STATEMENT
CO1	Understand the types of energy sources, forms of energies basic definition and terminology.
CO2	Explain the origin of solid fuel coal and its characteristic, analysis and properties of coal and various coal washing process.
CO3	Classify the non-conventional energy resources like solar energy, WECS and biomass conversion techniques. Design the biogas plant and analyses the factors affecting the biochemical biomass conversions.
CO4	Demonstrate the basic knowledge of renewable energy resources like geothermal energy and OTEC systems for electricity generation.
CO5	Apply the use of chemical energy sources like hydrogen, fuelcell and MHD for satisfy the energy need at various sectors.
CO6	Analyse the National energy strategies and policies for energy conservation, energy Audit and causes of increase in energy demand.

F. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	2	3	3	3	2	**2.6**
PO 2	1	2	3	2	2	2	**1.9**
PO 3	1	2	3	1	3	1	**2.0**
PO 4	1	1	2	1	3	1	**1.7**
PO 5	2	2	3	2	3	1	**2.3**
PO 6	3	1	2	3	3	2	**2.3**
PO 7	2	1	2	2	2	3	**2.0**
PO 8	2	2	1	2	2	2	**1.9**
PO 9	2	2	2	3	1	2	**2.0**
PO 10	2	2	2	3	1	3	**2.1**
PO 11	1	2	1	2	1	2	**1.4**
PSO 1	1	2	3	2	3	2	**2.0**
PSO 2	2	3	3	2	2	3	**2.3**

B.TECH. – SEMESTER-VI
PETROCHEMICAL TECHNOLOGY (25CHxxx)
(CORE ELECTIVE-2)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

The Petrochemical Technology course covers the essential processes and technologies used to convert petroleum and natural gas into valuable chemicals and materials. It includes the study of key unit processes like steam cracking, alkylation, and polymerization, as well as the production of first, second, and third-generation petrochemicals such as olefins, aromatics, and polymers. The course also addresses process safety, ethics, and environmental impacts, preparing students for roles in petrochemical engineering, plant operations, and safety management.

B. PREREQUISITES

Basics of Unit operations & Processes, General Chemical Technology, Petroleum Technology

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Petrochemical unit processes:** **Overview of Petrochemical Industry**: The key growth area of India, Economics – Feed stock selections for Petrochemicals – Steam cracking of Gas and Naphtha to produce Olefins, Diolefins and Production of Acetylene. **Primary Unit Processes:** Fundamental and Technological principled involved in Alkylation – Oxidation – Nitration and Hydrolysis. **Secondary Unit Processes:** Fundamental and Technological principled involved in Sulphonation, Sulfation and Isomerisation. **Tertiary Unit Processes:** Fundamental and Technological principles involved in Halogenation and Esterification.	CO1	6
2.	**Petrochemical Precursors:** Indian Petrochemical Industry - Sources of Petrochemicals - Classification of Petrochemicals -Classification of Hydrocarbons - Alternate routes with flow diagram for production of methane, ethylene, propylene, acetylene. Chemicals from methane, ethylene, propylene, acetylene.	CO2	6
3.	**First generation petrochemicals:** Alternate routes with flow diagram for production of butadiene, related dienes, Aromatics: Benzene, toluene, xylene – Chemicals from butadiene.	CO3	6
4.	**Second generation petrochemicals:** Alternate routes with flow diagram for production of Ethylene glycol, Ethylene oxide, Ethyl benzene, Vinyl chloride monomer, Acrylonitrile, phenol, Adipic acid, Hexamethylenediamine, Dimethyl terephthalate, Terephthalic acid, Maleicanhydride, Styrene.	CO4	6
5.	**Third generation petrochemicals:** Polymerization – Modes and techniques – Production of polyethylene – LDPE, HDPE, polypropylene, SBR, SAN, ABS, PU. Polyacrylonitrile, polyvinyl chloride, polycarbonates, nylon 6, nylon 66, polyesters, resins, explosives, organic dyes.	CO5	6
6.	**Process safety and Ethics in petrochemical industries:** Petroleum products classification & hazards: Petroleum and Petroleum products – Fuels- Petroleum solvents – Lubricating oils – Petroleum wax, greases – Miscellaneous product. Safety in handling of hydrocarbon, Rules and regulation: OISD-STD-114, 241, 115.	CO6	6

D. TEXT BOOKS

1. Margaret Wells, “Handbook of Petrochemicals and Processes”, 2nd Edition, Ash Gate Publishing Limited, 2002.
2. Sami Matar, and Lewis F. Hatch., “Chemistry of Petrochemical Processes”, 2nd Edition, Gulf Publishing Company, 2000.
3. Bhaskara Rao, B.K., “A Text on Petrochemicals”, Khanna Publishers, 2000.

E. REFERENCE BOOKS

1. Dryden, C.E., “Outlines of Chemical Technology”, 2nd Edition, Affiliated East-West Press, 1993.
2. Sukumar Maiti, “Introduction to Petrochemicals”, 2nd Edition, Oxford and IBH Publishers,

F. ONLINE RESOURCES

1. https://archive.nptel.ac.in/courses/103/107/103107156/

G. COURSE OUTCOME

Cos	STATEMENT
CO1	The principles of various unit processes in the petrochemical industry.
CO2	The various techniques and their alternate production of precursors of petrochemicals.
CO3	The various chemicals from first generation petrochemicals and their alternate routes for production.
CO4	The various chemicals from second generation petrochemicals and their alternate routes for production.
CO5	The various chemicals from third generation petrochemicals and their alternate routes for production.
CO6	The various classes of petrochemical products, various rules and regulations of petroleum industries.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	1	1	1	1	1	1	**1.0**
PO 3	-	-	-	-	-	-	**-**
PO 4	2	3	3	2	3	3	**2.7**
PO 5	3	3	3	2	3	3	**2.8**
PO 6	3	2	2	2	2	2	**2.2**
PO 7	3	3	3	3	3	3	**3.0**
PO 8	1	1	1	1	1	1	**1.0**
PO 9	3	3	3	3	3	3	**3.0**
PO 10	1	1	1	-	1	1	**1.0**
PO 11	2	2	2	1	2	2	**1.8**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	1	1	1	1	1	1	**1.0**

B.TECH. – SEMESTER-VI
CHEMICAL SYSTEM MODELLING (25CH614)
(CORE ELECTIVE-2)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW
To have a good grasp of mathematical modelling and its basic classification of various process, such as deterministic and stochastic processes. Students are made aware with specific applications of mathematical modelling in chemical engineering, which is generally referred to as chemical systems modelling

B. PREREQUISITES
Student should have foundation of basic mathematics and grasp of chemical engineering principles, including mass and energy balances, thermodynamics, reaction kinetics, and transport phenomena, is also essential.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Modeling Overview** Physical modelling, mathematical modelling and its classification, principles of similarity in physical modelling, concepts of independent variables, dependent variables, boundary conditions partial Differential Equations & finite Difference	CO1 CO6	3
2.	**Mathematical Modelling in Fluid Mechanics** Continuity equation, model formulation of flow through a packed bed column, models on momentum transfer such as laminar flow in a narrow slit, model of flow between concentric cylinders and concentric spheres	CO2 CO6	7
3.	**Mathematical Modelling in Mass Transfer** Single stage, 2 stage & N stage extraction of steady state mass transfer process, unsteady state formulation of single stage extraction, unsteady state mass transfer (Fick's second law), gas absorption accompanied by chemical reaction (mathematical model formulation), finite difference – solvent extraction in N stage process, gas absorption in N stages (Kremser – Brown), N stirred tanks reactors in series, etc.	CO3 CO6	8
4.	**Mathematical Modelling in Heat Transfer** Steady state heat conduction through hollow cylindrical pipe using various boundary conditions, unsteady state process of steam heating of liquid, heat transfer through extended surfaces (triangle & rectangle), steady state counter current cooling of tanks, unsteady state heat loss through maturing tank, unsteady state heat conduction, gas pre-heater, heat loss through circular flanges	CO4 CO6	7
5.	**Mathematical Modeling in Reaction Engineering** The model of the chemical reaction with diffusion in a tubular reactor, chemical reaction with heat transfer in a packed bed reactor, gas absorption accompanied by chemical reaction and reactors in series.	CO5 CO6	6
6.	**Professional Ethics in Chemical System Modeling** Fundamentals of Professional Ethics in Engineering, Data Integrity and Model Transparency, Model Validation and Verification Ethics, Risk Assessment and Public Safety, Bias in Modeling and Interpretation, Ethical Use of Software and Tools, Ethical Implications of AI/ML in Chemical System Modeling	CO2 CO3 CO4 CO5	2

D. TEXT BOOKS

1. B.V. Babu, Process Plant simulation, Oxford University Published in India.
2. Jensen V. G.; Jeffreys G. V., Mathematical Methods in Chemical Engineering, Academic Press, New York

E. REFERENCE BOOKS

1. Mickley H S; Sherwood T S; Reed C E, Applied Mathematics in Chemical Engineering 2nd Ed. Tata McGraw Hill Publishing Co. Ltd., New Delhi

F. COURSE OUTCOME

Cos	**STATEMENT**
CO1	Understand and state the fundamentals of general approach on the modeling of chemical systems
CO2	Explain the concept of mathematical modeling of fluid flow unit operations
CO3	Explanation of the concept of mathematical modeling of mass transfer unit operations
CO4	Conceptual modeling of heat transfer unit operations
CO5	Fundamentals of mathematical modeling in reaction engineering
CO6	Discussion on the modelling approach of real industrial problems

G. COURSE MATRIX

	CO 1	**CO 2**	**CO 3**	**CO 4**	**CO 5**	**CO 6**	**Average**
PO 1	2	2	2	2	2	2	**2**
PO 2	1	3	3	3	3	1	**2.3**
PO 3	2	3	3	3	3	2	**2.6**
PO 4	2	2	2	2	2	2	**2**
PO 5	-	-	-	-	-	-	**0**
PO 6	2	2	2	2	2	2	**2**
PO 7	2	2	2	2	2	2	**2**
PO 8	1	3	3	3	3	3	**2.6**
PO 9	3	3	3	3	3	3	**3**
PO 10	1	1	1	1	1	1	**1**
PO 11	1	3	3	3	3	3	**2.6**
PSO 1	1	3	3	3	3	3	**2.6**
PSO 2	1	2	2	2	2	2	**1.8**

B.TECH. – SEMESTER-VI
MULTICOMPONENT DISTILLATION (25CHxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW
The objective of this course is to apply the principles of mass transfer operations to specific applications, separation and/or purification processes which involves multi components. The goal is to provide students with the theoretical/analytical aspects to design multi component distillation equipment and to deal with complex problems of separating multi components.

B. PREREQUISITES
Understanding of mass and energy balances, thermodynamics (especially VLE), and basic separation processes. Prior knowledge of heat and mass transfer principles.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Selection of Key Component & Sequencing of Distillation Column:** Light and heavy key component, Split key and Adjacent key, Distribution of key and non-key components, Concept, Selection criteria with industrial examples	CO1	4
2.	Specification of design variables and Degrees of freedom analysis in distillation	CO2	4
3.	**Selection of Operating Pressure:** Determination of operating pressure for the various industrial distillation columns, Criteria for vacuum distillation, Advantages & Disadvantages of vacuum distillation, Determination of vapor-liquid Equilibrium data	CO3	5
4.	**Methods for Finding Theoretical Stages:** Short cut methods: Fenskey-Underwood-Gilliland's method Rigorous methods: Lewis-Metheson method, Theile-Geddes method, Equation tearing procedures using tridiagonal matrix algorithm	CO4	9
5.	**Azeotropic and Extractive Distillation**: Concept and Working principle, Industrial examples, Determination of number of theoretical stages for azeotropic and extractive distillation, advantage and disadvantage over each other.	CO5	6
6.	**Tower Diameter and Pressure Drop:** Criteria of selection between tray tower and packed tower, Various type of packings, Selection of tray type, Determination of tower diameter and pressure drop, Tray Efficiency and HETP.	CO6	5

D. TEXT BOOKS

1. Introduction to Process Engineering & Design by S.B. Thakore & B.I. Bhatt. Tata McGraw-Hill, 2007.
2. Equilibrium-stage separation operation in chemical engineering by Ernest J. Henley and J.D. Seader.

E. REFERENCE BOOKS

1. Distillation dynamics and control by P.B. Deshpande, Arnold USA 1985.
2. Perry's chemical engineer's handbook, 7th edition, McGraw-Hill, USA, 2000.
3. Distillation design by H.Z. Kister, McGraw-Hill, USA,1992.
4. Coulson and Richardson's Chemical Engineering Volume 6 (Design), 2nd Edition, by R.K. Sinnott, Pergamon Press, Oxford, UK (1993).

F. ONLINE RESOURCES

1. https://archive.nptel.ac.in/courses/103/107/103107156/

G. COURSE OUTCOME

Cos	STATEMENT
CO1	Explain the concept of key components in distillation and apply the criteria for their selection using industrial examples.
CO2	Analyse and determine the degrees of freedom and specify design variables in distillation processes.
CO3	Select suitable operating pressure for various distillation systems, including vacuum distillation, based on equilibrium data and process requirements.
CO4	Apply shortcut and rigorous methods to determine the number of theoretical stages in distillation columns.
CO5	Differentiate between azeotropic and extractive distillation techniques with respect to their principles, applications, and operational advantages/disadvantages.
CO6	Design and evaluate tower internals by selecting appropriate tower type, packings or trays, and calculating tower diameter, pressure drop, and efficiency parameters.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	2	3	3	2	3	**2.67**
PO 2	3	2	3	3	2	3	**2.67**
PO 3	2	2	3	3	2	3	**2.50**
PO 4	2	1	2	3	2	3	**2.17**
PO 5	1	1	1	1	1	1	**1**
PO 6	2	1	1	1	1	1	**1.17**
PO 7	2	2	1	2	2	2	**1.83**
PO 8	1	1	1	2	1	1	**1.17**
PO 9	1	1	1	2	2	1	**1.33**
PO 10	1	1	2	2	1	1	**1.33**
PO 11	2	2	3	3	3	3	**2.33**
PSO 1	2	3	3	3	2	3	**2.67**
PSO 2	3	3	3	2	3	2	**2.67**

B.TECH. – SEMESTER-VI
NANOTECHNOLOGY AND APPLICATIONS (25CH620)
(OPEN ELECTIVE-2)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

The recent developments in science & technology at nanoscale demands engineering students to enhance their knowledge and skills about the subject. This aims at enabling students to learn about nanotechnology including concepts related to nanosized materials, their preparation, properties and its applications.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (32)
1.	**The multidisciplinary nature of Nanotechnology:** Definition, terminologies, scope, importance, and need to understand nanotechnology. Historical and modern applications of nanotechnology Engineered nanomaterials, Classification of nanomaterials (0D, 1D, 2D, 3D).	CO1	4
2.	**Synthesis, properties, and characterization of nanomaterials: Synthesis -** Top-down approach & Bottom-up approach; Synthesis of nanomaterials: Conventional approach and Green synthesis approach. **Properties -** Physical, thermal, magnetic, chemical, mechanical, electronic, and optical properties. **Characterization -** Electron microscopy, Scanning electron microscopy, Tunneling electron microscopy, X-ray energy dispersive spectroscopy, Atomic force microscopy, X-ray diffraction, X-ray synchronous diffraction, Single crystal X-ray diffraction, X-ray powder diffraction, Spectroscopy, Raman spectroscopy, UV-Vis spectroscopy, X-ray photoelectron spectroscopy	CO2	6
3.	**Nanotechnology in pollution control, and agriculture:** Nanocarbon catalysts, Bio-derived nanocatalysts, Applications, Biofuel production, Pollution control, Nanofiltration, Nanoadsorbents, Heavy metal remediation, Zero-valent nanomaterials, Nanophotocatalysts, Phyto Nanoremediation, Agriculture: Nanofertilizers, Nanopesticides	CO3	6
4.	**Nanotechnology in renewable energy, storage, and textiles:** Renewable energy, Photovoltaics (PV), PV cells (Crystalline silicon, Organic, Dye-sensitized), Fuel Cells (FC), Proton exchange membrane FCs (PEMFC), Solid Oxide FCs (SOFC), Definition, characteristics and synthesis of metal organic frameworks (MOFs), Nanofiber production, Principles of electrostatic atomization, Electrospinning and electrospraying, Melt Spinning, Nanofibers, Carbon nanotubes and nanocomposites, Nanocoatings.	CO4	6
5.	**Nanotechnology in electronics, photonics, optics:** Electronics: Semiconductors, nanoelectronics, nanotransistors, and data storage, Photonic: Carbon nanotube-liquid crystal nanophotonic devices, Optics: Optical gain and lasing, nano-scale fiber lasers, solid-state lasers, Optoelectronics, Light-emitting diodes	CO5	5
6.	**Nanotechnology in medicines:** Pharmaceutical drug delivery, Nanomedicines, Tissue engineering, Bio-sensors, Biological building blocks, biological nanostructures, and nucleic acids, Sensors: Thin-film gas sensors, Nanosensors for environmental pollution.	CO6	5

C. TEXT BOOKS

1. Introduction to Nanotechnology, Poole, C. P., & Owens, F. J. (2003, May 30). John Wiley & Sons. ISBN-10: 0471079359
2. Klabunde, K.J. (Ed.), "Nanoscale Materials in Chemistry", (2001). John Wiley & Sons Inc.

D. REFERENCE BOOKS

1. Nano Essentials, Pradeep, T. (2008, March 16). McGraw Hill Professional. ISBN-13: 9780070617889
2. Nanotechnology 101, Mongillo, John, Publisher: Greenwood Press, ISSN 1931-3950, ISBN–13: 978–0–313–33880–9
3. An Introduction to Nanoscience and Nanotechnology, Nouailhat, Alain, Publisher: Wiley, ISBN 978-1-84821-007-3
4. Nanotechnology for Dummies, 2nd edition, Boysen, Earl; Boysen, Dudley, Publisher: For Dummies, ISBN-10: 0470891912, ISBN-13: 978-0470891919

E. ONLINE RESOURCES

1. https://nptel.ac.in/courses/118102003
2. https://nptel.ac.in/courses/113106093

F. COURSE OUTCOME

Cos	STATEMENT
CO1	Students will be able to learn the terminologies, scope and importance of nanotechnology.
CO2	Students will be able to relate the importance of various nanotechnologies and analyze the factors responsible for developing nanomaterials
CO3	Students will be able to learn applications of nanotechnology in catalysis, pollution control, and agriculture
CO4	Students will be able to learn application of nanotechnology in field of renewable energy and textiles
CO5	Students will be able to learn application of nanotechnology in field of electronics, photonics, optics
CO6	Students will be able to learn application of nanotechnology in field of medicines

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	2	2	2	2	**2.33**
PO 2	2	2	2	2	2	2	**2**
PO 3	2	2	3	3	2	3	**2.5**
PO 4	1	1	1	1	1	1	**1**
PO 5	2	2	2	2	2	2	**2**
PO 6	2	3	3	3	3	3	**2.83**
PO 7	1	2	2	2	2	2	**1.83**
PO 8	2	2	3	3	3	3	**2.67**
PO 9	2	3	3	2	2	2	**2.33**
PO 10	2	3	3	2	2	2	**2.33**
PO 11	2	2	2	2	2	2	**2**
PSO 1	2	2	2	2	2	2	**2**
PSO 2	2	2	2	2	2	2	**2**

B.TECH. – SEMESTER-VI
INTRODUCTION TO MACHINE LEARNING (25CH621)
(OPEN ELECTIVE-2)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

This course introduces chemical engineering undergraduates to machine learning concepts tailored for engineering applications. It covers essential mathematical tools, including probability, linear algebra, and optimization, along with core topics like regression, classification, decision trees, neural networks. Emphasizing practical applications, the course equips students to analyze and solve complex engineering problems using data-driven approaches while fostering skills in model evaluation and validation. By the end, students will be proficient in applying machine learning techniques to tackle real-world challenges in chemical engineering and related fields.

B. PREREQUISITES

Data Analysis and Statistics.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (33)
1.	**Introduction to Machine Learning** Overview, importance in chemical engineering, types of learning (supervised, unsupervised, reinforcement), Regression, Classification, and Clustering – Key differences and applications, Mathematical Foundations – Probability, statistics, linear algebra basics, Data Preprocessing – Handling missing values, normalization, feature engineering.	CO1	4
2.	**Regression Models** Linear Regression – Theory, assumptions, least squares method, Gradient Descent Algorithm – Optimization techniques, cost function, Polynomial Regression – Handling non-linearity in regression models, Regularization Techniques (L1 & L2) – Overfitting, bias-variance trade-off, Logistic Regression – Introduction, sigmoid function, decision boundary, Evaluation Metrics for Regression – R^2 score, RMSE, MAE	CO2	5
3.	**Classification Models** Discriminative vs. Generative Models – Key differences, examples, Naïve Bayes Classifier – Bayes' theorem, assumptions, applications, Artificial Neural Networks (ANN) – Basics – Structure, activation functions, Backpropagation Algorithm – Training neural networks, gradient descent in ANNs, Decision Trees – Concept, Gini index, entropy, pruning techniques, Random Forest Classifier – Ensemble learning, bagging technique	CO3	6
4.	**Clustering Methods** K-Means Clustering – Centroid-based clustering, choosing k**,** Hierarchical Clustering – Agglomerative & divisive clustering, dendrograms, K-Nearest Neighbours (KNN) Algorithm – Distance metrics, choosing k, Applications of Clustering in Chemical Engineering – Fault detection, anomaly detection	CO4	4
5.	**Model Evaluation and Performance Metrics** Confusion Matrix & Metrics – Precision, recall, specificity, F1 Score & ROC Curve – Trade-off between precision & recall, AUC, Bias-Variance Trade-off – Underfitting vs overfitting, Cross-Validation Techniques – k-fold, leave-one-out, bootstrap	CO5	4
6.	**Advanced Topics in Machine Learning** Feature Selection & Dimensionality Reduction – PCA, LDA, feature importance, Hyperparameter Tuning – Grid search, random search, Bayesian	CO6	5

	optimization, Handling Imbalanced Data – Oversampling, under sampling, SMOTE, Unsupervised Learning Beyond Clustering – Association rules, anomaly detection, Introduction to Deep Learning for Chemical Engineering – CNNs, RNNs, transformers, Reinforcement Learning Basics – Applications in process control and optimization		
7.	**Applications of Machine Learning in Chemical Engineering** Process Modelling & Optimization – Predictive maintenance, soft sensors, Fault Detection & Diagnosis – ML techniques for anomaly detection, Reaction Engineering & Kinetics Modelling – Data-driven kinetic models, ML in Process Control – Advanced control strategies using ML, Real-World Case Studies – ML applications in energy, pharmaceuticals, petrochemicals	**CO6**	**5**

D. TEXT BOOKS

1. Bishop, C. M. Pattern Recognition and Machine Learning; Information science and statistics; Springer (India) Private Limited, 2013.
2. Alpaydin, Ethem. Introduction to Machine Learning. United Kingdom: MIT Press, 2014.

E. REFERENCE BOOKS

1. Rogers, Simon., Girolami, Mark. A First Course in Machine Learning. United States: Taylor & Francis Limited (Sales), 2020.

F. ONLINE RESOURCES

1. https://onlinecourses.nptel.ac.in/noc25_cs46/preview
2. https://www.youtube.com/watch?v=Bl4Feh_Mjvo
3. https://www.youtube.com/watch?v=h0e2HAPTGF4

G. COURSE OUTCOME

Cos	STATEMENT
CO1	Students will be able to learn what machine learning is and how it is useful in solving real problems in chemical engineering.
CO2	Students will learn how to use models like linear regression, logistic regression, decision trees, and neural networks.
CO3	Students will learn how to use different classification models like Naïve Bayes, neural networks, decision trees, and random forests.
CO4	Students will be able to check how well a model is working using common evaluation methods.
CO5	Students will learn how to group similar data using clustering methods like K-Means, hierarchical clustering, and KNN
CO6	Students will explore how machine learning is used in real chemical plants for tasks like fault detection, process control, and making predictions.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	3	3	2	–	3	**2.2**
PO 3	–	3	3	–	–	3	**1.5**
PO 4	–	2	2	3	–	3	**1.7**
PO 5	2	3	3	3	3	3	**2.8**
PO 6	2	–	–	–	2	3	**1.2**
PO 7	–	–	–	–	–	–	**0.0**
PO 8	–	–	–	–	–	2	**0.3**
PO 9	–	–	–	–	–	2	**0.3**
PO 10	–	–	–	–	–	2	**0.3**
PO 11	2	2	2	2	2	3	**2.2**
PSO 1	2	3	3	3	3	3	**2.8**
PSO 2	3	3	3	2	3	2	**2.7**

B.TECH. – SEMESTER-VI
OPERATION RESEARCH (25CHxxx)
(OPEN ELECTIVE-2)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

Study, understand and utilize the appropriate mathematical Techniques and tools to solve the process problems associated with any field or industry in the most optimistic manner.

B. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (36)
1.	**Introduction to Operational Research:** Introduction, Formulation, Methods of Operation Research,	CO1	4
2.	**Linear Programming Methods:** Graphical**,** Simplex method and Big-M method	CO2	7
3.	**Transportation Model:** North-West Corner rule, Row and Column Minima method, Least-cost method, Vogel's approximation method & Modi methods for profit maximization problem & trans-shipment problems	CO3	7
4.	**Assignment Model:** Hungarian method for solution Variation of the assignment problem - non-square matrix, restriction on assignments. Maximization problem	CO4	6
5.	**Scheduling Optimization and Related Models on Sequencing:** Batch Scheduling, Formulation of sequencing models and its applications, Introduction to Gantt Chart and its Application to Different types of Transfer policies.	CO5	6
6.	**Advanced topics in Linear Programming:** Duality in Linear Programming, Primal to Dual conversion, Duality Theorem and Dual Simplex method	CO6	6

C. TEXT BOOKS

1. Gupta P., Hira D.S., "Operation Research", S. Chand & Company Ltd
2. Rao S.S., "Engineering Optimization: Theory and Practice", Willey Publication.
3. Vohra N D, Quantitative Techniques in Management, Tata McGraw Hill, New Delhi

D. REFERENCE BOOKS

1. Sharma S D & Sharma H, Operations Research: Theory, methods & applications,
2. K. Nath R. Nath Arora J.S., "Introduction to Optimum Design", Elsevier Academic Press.
3. Hiller & Libermann, Introduction to Operations Research, Tata McGraw Hill
4. Hamdy A. Taha, "Operation Research", Pearson Education.
5. Operation Research – V. K. Kapoor, S. Chand Publication

E. COURSE OUTCOME

Cos	STATEMENT
CO1	Describe the formulation of the problem into mathematical approach/model
CO2	Define the type of the problem in terms of Linear programming problem or Non-linear programming problem
CO3	Students will apply various transportation models to optimize and solve real-world logistics cum distribution problems efficiently.
CO4	Students will be able to apply assignment models to solve problems related to task allocation, resource optimization and job assignment.
CO5	Students will be able to apply sequencing and scheduling techniques to optimize production and

resource allocation.

CO6 Students will understand the concept of duality in linear programming and how to formulate and solve dual problems.

F. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	2	**2.0**
PO 3	2	2	2	2	2	2	**2.0**
PO 4	2	2	2	2	2	2	**2.0**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	1	1	1	1	1	1	**1.0**
PO 7	1	3	3	1	1	1	**1.7**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	1	1	1	1	1	**1.0**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B. TECH. – SEMESTER-VII (CH)
SUMMER TRAINING

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext	S	TW	P	Total
0	0	0	0	6.0	0	0	100	0	100

A. COURSE OVERVIEW

The summer Internship initiative aims to equip students with practical skills in chemical process engineering, bridging the gap between theory and practice. The primary objective is to provide hands-on experience, focusing on industry operations, system optimization, safety and engineering excellence.

B. COURSE CONTENT

	TOPICS	COs
1.	Analyze product details, global capacity, market value, and raw materials, including technical and commercial competitors, technology providers, and reaction schemes with block diagrams and line codes.	**CO1**
2.	Evaluate thermodynamics and physiochemical properties, perform material balances. Examine raw material consumption, suggest improvements for conversion and yield, and identify unit processes, reactors, pumps, and separation equipment in the industry.	**CO2**
3.	Assess energy balances with block diagrams, control valve details, options, selection basis, costs, operational specifics and draw control loops.	**CO3**
4.	Design major and minor equipment, identify safety measures and auxiliary equipment. Identify the factors affecting Plant location.	**CO4**
5.	Draw P&ID with guide approval, identify pollution control measures	**CO5**
6.	Understand chemical process safety, including safety policies, frequency and severity rates, MSDS, green chemistry, and inherent safety. Familiarize with work permits, color codes, emergency planning, firefighting systems, DoW F&EI calculations, HAZOP studies, BPCS, Interlock, SIS systems, LOPA diagrams, and safety audits per IS:14489:1998.	**CO6**

C. COURSE OUTCOMES

COs	STATEMENT
CO1	Understand the basics of plant, process, commerce involved, local and global market.
CO2	Apply the thermodynamics for property calculations and analyze the material balance and their consumption pattern
CO3	Assess the energy requirement in the process and analyze various operational utilities and controlling strategies
CO4	Design different equipments, identify safety measures and auxiliary equipments
CO5	Creating the detailed P&ID and identify pollution control measures
CO6	Analyzing detailed safety guidelines and best practices relevant to process.

D. COURSE MATRIX

	CO1	CO2	CO3	CO4	CO5	CO6	AVG.
PO1	3	3	3	3	3	3	**3.0**
PO2	3	3	3	3	3	3	**3.0**
PO3	3	3	3	3	3	3	**3.0**
PO4	3	3	3	3	3	3	**3.0**
PO5	3	3	3	3	3	3	**3.0**
PO6	3	3	3	3	3	3	**3.0**
PO7	3	3	3	3	3	3	**3.0**
PO8	3	3	3	3	3	3	**3.0**
PO9	3	3	3	3	3	3	**3.0**
PO10	3	3	3	3	3	3	**3.0**
PO11	3	3	3	3	3	3	**3.0**
PSO1	3	3	3	3	3	3	**3.0**
PSO2	3	3	3	3	3	3	**3.0**

Semester – VII

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
25CH616	Transport Phenomena	3	0	3	6	4.5	60	40	25	25	150
25CH617	Design and Simulation	2	0	4	6	4.0	60	40	25	25	150
PC	Chemical Engineering Plant Design and Economics	3	0	0	3	3.0	60	40	0	0	100
PCE	Core Elective-III	3	0	0	3	3.0	60	40	0	0	100
OE	Open Elective-III	3	0	0	3	3.0	60	40	0	0	100
INT	Summer Training	0	0	0	0	6.0	0	0	100	0	100
	Total	**14**	**0**	**7**	**21**	**23.5**	**300**	**200**	**150**	**50**	**700**

ELECTIVE COURSES

Core Elective-3 SEM-VII	
1.	Chemical Process Optimization
2.	New Separation Techniques
3.	Fuel Cell Technology
4.	Chemical Engineering Practices

Open Elective-3 SEM-VII	
1.	Advanced Process Control
2.	Environment Impact Assessment
3.	Research Methodology
4.	Banking and Taxation
5.	Industrial Safety Engg. and Management

B.TECH. – SEMESTER-VII
TRANSPORT PHENOMENA (25CH716)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	4.5	60	40	25	25	150

A. COURSE OVERVIEW

The objective of this course is to make students aware and to teach them how to deal with the movement of different physical quantities such as momentum, energy and mass in any chemical or mechanical process and combination of the basic principles (conservation laws) and laws of various types of transport

B. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (45)
1.	Review of momentum, energy & mass transport by molecular motion, Vector and Tensor Analysis: Basic concepts, Euler/ Lagrangian viewpoint, laminar and turbulent flows, boundary layers, stress tensor	CO1	9
2.	**Momentum Transport:** shell momentum balances, velocity profiles in cases like adjacent flow of two liquids. **Energy Transport:** shell energy balances, temperature profiles, heat conduction with an electrical heat source, heat conduction viscous heat source & heat conduction chemical heat source. **Mass Transport:** concentration distribution in solids & laminar flow, shell mass balances, diffusion with heterogeneous chemical reaction, diffusion in falling liquid film	CO2	9
3.	**Momentum Transport:** equation of change for isothermal system, equation of continuity & motion in rectangular, cylindrical & spherical co-ordinates. **Energy Transport:** non-isothermal systems, equation of energy of motion for forced & free convection in non-isothermal flow. **Mass Transport:** equation of continuity for binary mixtures, equation of change for multi-component systems, mass flux in terms of transport properties, use of equation of change	CO3	6
4.	**Momentum Transport:** unsteady state viscous flow, two-dimensional viscous flow, boundary layer momentum transport. Energy Transport: heat conduction in viscous flow, boundary layer energy transport. **Mass Transport:** unsteady diffusion, diffusion in viscous flow, two-dimensional diffusion in solids, boundary layer theory	CO4	3
5.	**Momentum Transport:** time smoothing of equation of change for incompressible fluid & review of logarithmic law of viscosity. **Energy Transport:** temperature fluctuations & time smoothing of temperature & energy equation, semi-empirical equations for turbulent energy flux. **Mass Transport:** time smoothing of equation of change, turbulent concentration profiles	CO4	6
6.	**Momentum transport:** friction factors for flow in tubes, flow rate & pressure drop relations, friction factor for packed beds. **Energy Transport:** non-isothermal system, heat transfer coefficients, dimensionless correlations for forced & free convection in tubes & around submerged objects, heat transfer coefficient for forced convection through packed bed. **Mass Transport:** mass transport coefficient, correlations for binary systems in one phase & at low mass transfer rates, definition & correlation for binary mass transfer coefficients in two phases at low mass transfer rates, transfer coefficients for high mass transfer rates, boundary layer theory	CO5	6
7.	**Microscopic Momentum, Energy and Mass balances**, estimation of friction losses, macroscopic energy balance in non-isothermal systems, use of balances to solve steady state & unsteady state problems involving single as well as multiple compounds. Ethical practices for designing of equipment's using equations of change	CO6	6

C. PRACTICAL AND TERM WORK

1. Viscosity by pipeline method
2. Viscosity by Canon-Fenskey Concentration method
3. Viscosity by Canon-Fenskey Temperature method
4. Efflux time
5. Heat Transfer Coefficient over flat plate
6. Batch cooling
7. Mass transfer coefficient mixing effect
8. Mass transfer coefficient Temperature effect
9. Source Model for pipeline and tank
10. Viscosity of non-Newtonian fluid (Study)

D. TEXT BOOKS

1. Bird R B; Stewart W E; Lightfoot F W, Transport Phenomena, John Wiley & Sons
2. Gupta S K, Momentum Transfer Operations, Tata McGraw Hill Corp

E. REFERENECE BOOKS

1. Laddha G S; Degaleesan T E, Transport Phenomenon in Liquid Extraction, McGraw Hill Publishing
2. Sherwood T K; Pigford R L, Absorption & Extraction, McGraw Hill Publishing
3. Holland D D, Multi-component Distillation, Prentice Hall, India

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the fundamental mechanisms of momentum, heat, and mass transfer at the molecular level.
CO2	Apply shell balance techniques to analyze momentum, heat, and mass transport in various engineering systems.
CO3	Derive and Utilize equations of change to model and interpret transport phenomena in complex systems.
CO4	Examine transport processes involving multiple independent variables and characterize flow behavior in turbulent regimes.
CO5	Study of inter-phase transport in momentum, Heat, and mass transfer systems
CO6	Study of momentum, Heat, and mass transfer systems at macroscopic level

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3**
PO 2	2	3	3	3	3	3	**3.4**
PO 3	-	2	3	3	2	3	**2.6**
PO 4	-	2	3	3	2	2	**2.4**
PO 5	-	2	3	2	3	2	**2.4**
PO 6	-	-	-	-	1	2	**0.6**
PO 7	-	-	-	-	-	-	**-**
PO 8	-	-	-	-	-	-	**-**
PO 9	-	-	-	-	-	-	**-**
PO 10	-	-	-	-	-	-	**-**
PO 11	2	2	2	2	2	2	**2**
PSO1	2	3	3	3	3	3	**3.4**
PSO2	3	2	3	3	2	2	**3**

B.TECH. – SEMESTER-VII
DESIGN AND SIMULATION LAB (25CH717)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
2	0	4	6	4.0	60	40	25	25	150

A. COURSE OVERVIEW

Students will learn to use modern softwares to get an insight on various chemical processes and unit operations, analyze and evaluate them qualitatively through modeling and simulations. **Process Simulation -** use of suitable property methods and their effects, simulation of basic unit operations and processes and sensitivity towards operating conditions; developing flowsheets and performing simulations along with sensitivity study. **CFD Simulation** –Developing 2D and 3D geometries, meshing; Defining initial and boundary conditions, performing simulations and analyzing the behavior for different systems

B. PREREQUISITES

Thermodynamics, Materials and Energy Balance, Unit Operations, Reaction Engineering, Transport Phenomena, Numerical Techniques.

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (18)
1.	Introduction to process Simulation, Steady and Unsteady state Simulation, Sequential Modular and Equations Oriented approach, Selection of property methods, analyzing pure substances and mixture property data, Solubility, Ternary diagrams, Residue Curve maps, prediction of azeotrope formation, Computer Ethics and value sensitive design	CO1	4
2.	Simulation of individual unit operations and processes, Setting Models, performing simulation, sensitivity study, confidentiality, data safety and management, trust, accountability	CO2	3
3.	Concept of design of a new process, simulation of existing processes and Sensitivity study, confidentiality, data safety and management, trust, accountability	CO3	3
4.	Analysis of technical feasibility of Industrial scale chemical processes and evaluate their performance	CO6	2
5.	Introduction to the concept of CFD, Conservation Equations, Turbulence Models, Developing geometry for the Simulations and Meshing		
6.	Setting up of model for simulations – boundary and initial conditions, Solver strategies, Result analysis	CO4	6

D. PRACTICAL AND TERM WORK

1. **Process simulations -** basic unit operations and processes such as – piping, mixing tanks, distillation columns, reactors, absorption columns, heat exchangers and process flowsheets.
2. **CFD simulations** - different geometries – pipe flow, venturi/orifice meter, annular flow, annular flow with heat transfer, CSTR

E. TEXT BOOKS

1. ASPEN PLUS - Chemical Engineering Applications, Kamal I.M. Al-Malah, John Wiley & sons
2. An Introduction to Computational Fluid Dynamics, H. K. Versteeg and W. Malalsekera, Longman Scientific & Technical

F. REFERENECE BOOKS

1. Fundamentals of Analytical Chemistry by D. A. Skoog, D. M. West, F. James Holler and S. R. Crouch, Cengage Learning, 2014
2. Chemical Process Design and Simulation - Aspen Plus and Aspen HYSYS Juma Haydary, AIChE / John Wiley & sons

G. ONLINE RESOURSES

1. Aspen Plus – Basic Course for Beginners - https://nptel.ac.in/courses/103103209
2. Introduction to CFD - https://nptel.ac.in/courses/101105085

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Select appropriate thermodynamic properties, analyze pure component and mixture properties
CO2	simulate unit operations and processes and their sensitivity towards operating variables,
CO3	Develop flowsheet, Simulate various chemical engineering problems
CO4	Understand the concept of CFD, create geometry, mesh and set initial and boundary conditions
CO5	Analyze the transport/thermal behavior in different types flows and apply the solution strategies
CO6	Analyze the technical feasibility of Industrial scale chemical processes and evaluate their performance

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	2	2	**2.7**
PO 3	3	3	3	3	3	3	**3.0**
PO4	3	3	3	3	3	3	**3.0**
PO 5	3	3	3	3	3	3	**3.0**
PO 6	2	3	3	3	1	1	**2.2**
PO 7	2	2	2	2	1	1	**1.7**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	2	2	2	2	2	2	**2.0**
PO 10	2	2	2	2	2	2	**2.0**
PO 11	2	2	2	2	2	2	**2.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-VII
CHEMICAL ENGINEERING PLANT DESIGN & ECONOMICS (25CHxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	3.0	60	40	-	-	100

A. COURSE OVERVIEW

This course equips students with key skills in plant design and engineering economics, ensuring commercial sustainability. It bridges technical knowledge with practical economic analysis, enhancing employability and meeting industry demands.

B. PREREQUISITES

Basic knowledge of chemical engineering principles, process calculations, fluid mechanics, and basic of engineering economics

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	**Chemical Engineering Design:** Product Selection, Process Selection and Flow Diagram, Equipment Selection, Building Design	CO1	3
2.	**Chapter 2: Process Research and Development:** Factors Affecting Process Selection, Process Development, Importance of Laboratory Development, Pilot Plant Scale-up Methods (Semi to Commercialization)	CO2	5
3.	**Chapter 3: Equipment and Project Design:** Selection of Process Equipment, Standard vs. Special Equipment, Material of Construction for Process Equipment, Material Handling Equipment, Selection Criteria and Technical Specifications **Project Design:** Objectives of Project Design, Factors Affecting Project Design, Technical, Economic, and Legal Factors, Plant Location & Layout	CO3	6
4.	**Depreciation:** Purpose of Calculating Depreciation, Types Depreciation, Methods of determining depreciation, Selection of depreciation methods	CO4	6
5.	**Profitability:** Methods for profitability evaluation, Practical factors in alternative investment & replacement studies	CO5	6
6.	**Cost Estimation:** **Types of Capital Investment:** Distinction between fixed capital investment and working capital, with an overview of total capital investment, factors influencing cost estimates, total capital investment, fixed vs. working capital and methods for estimating equipment and production costs. **Cost of Production Estimation:** Breakdown of direct production costs, plant overheads, and methods for estimating operational costs. **Total Product Costing:** Factors affecting investment and production costs, including fixed charges, general expenses, and overheads.	CO6	10

D. TEXT BOOKS

1. Plant Design & Economics for Chemical Engineers by M. S. Peters & K. D. Timmerhaus 2nd Ed. McGraw Hill Publication
2. Plant Design & Economics for Chemical Engineers by M. S. Peters & K. D. Timmerhaus 2nd Ed. McGraw Hill Publication

E. REFERENECE BOOKS

1. Chemical Engineering Design: Principles, Practice, and Economics of Plant and Process Design by Gavin Towler and Ray Sinnott.
2. Introduction to Chemical Engineering Economics by N. M. Lieberman.
3. Chemical Engineering Design by J. M. Coulson and J. F. Richardson.

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Students understand to select products, processes, equipment, design flow diagrams and building layouts for efficient plant operations.
CO2	This equips students with knowledge of process selection, development, lab work, pilot plants, and scaling up to commercialization.
CO3	Students are taught for process equipment selection, project design factors plant location/layout planning, focusing on technical, economic, and legal considerations.
CO4	The **Depreciation** covers the purpose, types, methods and selection of depreciation methods.
CO5	The **Profitability** focuses on evaluating profitability and practical factors in alternative investment and replacement studies.
CO6	Students will learn to estimate project costs, evaluate capital investments and calculate total product costs for effective financial planning.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	2	**2.0**
PO 3	2	2	2	2	2	2	**2.0**
PO4	2	2	2	2	2	2	**2.0**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	1	1	1	1	1	1	**1.0**
PO 7	1	3	3	1	1	1	**1.7**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	1	1	1	1	1	**1.0**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-VII
CHEMICAL PROCESS OPTIMIZATION (25CH720)
(CORE ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW
The course is intended to identify and develop the optimization techniques in engineering practices Understanding of objective function, constraints, variables and Linear and Non-Linear optimization

B. PREREQUISITES
Basic Understanding of Mathematics

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	**Introduction** Importance of optimization in Chemical process industry, Formulation of optimization problems, Classification of Optimization Problems - Single variable problems, Multivariable problems.	CO1	6
2.	**Linear programming (LP)** Concept of LP, Methods for solving LP problems- Graphical Method, Simplex Method, Dual simplex Method	CO2	6
3.	**Non-Linear programming (NLP)** Optimization of One-Dimensional Functions-Concept of Unimodality, Elimination methods- Exhaustive Search Method, Dichotomous Search Method, Interval Halving Method, Fibonacci Series Method, Golden Section Method, Optimization of Multi-dimensional Functions-Gradient-based methods - Lagrange multiplier method, Direct Substitution method.	CO1 CO2 CO3	10
4.	**Chemical engineering optimization problems** Optimal Design of Tank, Pipe diameter, Refinery blending problems and product mix problem, Optimal Shell-and-Tube Heat Exchanger Design, Optimal Design of an Ammonia Reactor.	CO3 CO5	8
5.	**Integrated Planning and Scheduling** Integrated Planning and Scheduling in batch process industries to optimize production operations, Formulation and application of sequencing models to improve process efficiency, Introduction and use of Gantt Charts for effective visualization and management of schedules, Study of different types of transfer policies to streamline material and task transitions, Batch process scheduling to manage time and resources in batch-oriented production, Multi-product scheduling to handle scheduling complexities in systems producing multiple products	CO5 CO6	6

D. TEXT BOOKS

1. Edgar, T. F., Himmelblau, D. M. and Lasdon, L.S. Optimization of Chemical Processes, McGraw-Hill, 2001.
2. Babu, B.V., Process Plant Simulation, Oxford University Press, 2004.

E. REFERENECE BOOKS

1. Kalyanmoy, D., Optimization for Engineering Design, Prentice Hall,1998.
2. Reklaitis, G. V., Ravindran, A., and Ragsdell, K. M., Engineering Optimization - Methods and Applications, John Wiley, 1983.
3. Pike, R. W., Optimization for Engineering Systems, Van Nostrand Reinhold, 1986.
4. Box, G. E. P., Hunter, W. G., Hunter, J. S., Statistics for Experimenters – An Introduction to Design, Data Analysis, and Model Building, John Wiley, 1978.

F. ONLINE RESOURSES

1. https://www.vrand.com/education.html
2. https://www.vrand.com/education.html
3. http://www.liacs.nl/~emmerich/pdf/EGH+00.pdf

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the importance of optimization in Chemical Engineering.
CO2	Learn the different methods and techniques for Optimization of Linear and Non-linear programming
CO3	Able to use optimization techniques and theory in real chemical engineering field.
CO4	Evaluate the economical aspect of the chemical process or design engineering
CO5	Describe the design parameters for selection of appropriate optimization methods in chemical process industry.
CO6	Understand the integrated planning and scheduling in the Process Industries by considering environmental & safety constraints.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	3	3	**3.0**
PO 3	3	3	3	2	3	3	**2.8**
PO4	3	3	3	2	2	2	**2.5**
PO 5	2	3	3	2	3	2	**2.5**
PO 6	2	2	2	3	3	3	**2.5**
PO 7	2	3	3	3	3	3	**2.8**
PO 8	3	2	2	2	3	3	**2.5**
PO 9	2	2	2	2	3	3	**2.3**
PO 10	2	2	2	2	3	3	**2.3**
PO 11	3	3	2	3	3	3	**2.8**
PSO 1	3	2	3	2	3	3	**2.7**
PSO 2	2	3	2	3	2	3	**2.5**

B.TECH. – SEMESTER-VII
NEW SEPARATION TECHNIQUES (25CHxxx)
(CORE ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

The course deals with the understanding of conventional separation techniques and new separation techniques used in chemical process industries. The subject focusing on the basics of all types of membrane-based separation operations. The emphasis is given on the synthesis of membrane, its characterization and selection of suitable type of membrane separation processes with their industrial applications. The subject is also focus on other types of separation operations like pressure swing adsorption, super critical fluid extraction, zone refining operations.

B. PREREQUISITES

Basic Concepts of Chemistry and various unit operations.

C. COURSE CONTENT

S. N.	TOPICS	Cos	Hrs. (32)
1.	**Introduction to New Separation Methods** Fundamentals of Separation Processes and its classification, advantage and limitation of various conventional separation processes and need of new separation methods, basic terms associated with the membrane technology and, classification of membrane-based operations	**CO1**	**4**
2.	**Membrane types, materials, synthesis and characterization** Definition of Membrane, Advantages and limitations of membrane technology compared to other separation processes, Membrane materials and its properties, Synthesis methods of membrane, types of membrane and membrane modules, Flux equation, transport mechanism, factors affecting on membrane operation, Fouling and Scaling of membrane	**CO2**	**8**
3.	**Membrane Processes** Types of pressure driven membrane processes like microfiltration, ultra-filtration, reverse osmosis, nano filtration using membrane and their industrial applications	**CO3**	**8**
4.	**Other types of Separation processes –** Gas separation, pervaporation, Ion exchange membrane and electrodialysis, introduction to emulsion liquid membrane, membrane distillation, membrane reactor, Relevant industrial applications of all the processes	**CO4**	**6**
5.	**Supercritical Fluid extraction:** Working Principal, unique properties and solubility behavior of supercritical fluids, Advantages of supercritical extraction, Decaffeination, ROSE process for purification of crude oil, hydrothermal oxidation, and Commercial applications of supercritical extraction.	**CO5**	**3**
6.	**Pressure Swing Adsorption (PSA) and Zone refining:** Concept & Working of PSA, Advantages & Disadvantages of PSA over cryogenic distillation, four step PSA, six step PSA, Purification of hydrogen, oxygen, Nitrogen & other commercial applications, Principles and Process of zone refining, application in process industry, Merits and demerits. Melt Crystallization	**CO6**	**3**

D. TEXT BOOKS

1. Membrane Technology and Applications, Richard W. Baker, 2 Ed(2000) Wiley
2. Membrane separation processes – Kaushik Nath, second edition, PHI learning private limited
3. Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition
4. University Chemistry by Mahan, Bruce H, 4th Edition, Pearson Education India, Year: 2009

E. REFERENECE BOOKS

1. Basic Principles of Membrane Technology, Mulder M, Kluwer Academic Publishers, London,1996
2. Membrane Technology and Research, Baker R. W., Inc. (MTR), Newark, California, USA, 2004
3. Separation Process Principles – J.D. Seader , E.J. Henley , Second edition, Wiley

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/105/103105060/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Recognize the selection criteria between advanced separation techniques and conventional separation techniques.
CO2	Explain membrane types, materials, synthesis methods, and characterize membranes based on their properties and performance.
CO3	Apply the flux equation and analyze transport mechanisms in pressure-driven membrane processes such as MF, UF, NF, and RO.
CO4	Understand membrane-based separations including gas separation, electrodialysis, and liquid membranes with respect to their principles, operation, and applicability.
CO5	Explain the working principles, advantages, and applications of supercritical extraction processes in various industries.
CO6	Understand concept of PSA, Zone refining and melt crystallization and its industrial applications

H. COURSE MATRIX

	CO 1	**CO 2**	**CO 3**	**CO 4**	**CO 5**	**CO 6**	**Average**
PO 1	2	1	2	2	3	2	**2.0**
PO 2	1	2	2	2	1	1	**1.5**
PO 3	3	2	1	2	2	2	**2.0**
PO4	2	2	1	1	2	2	**1.67**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	3	2	3	1	1	1	**1.83**
PO 7	3	2	2	1	1	1	**1.67**
PO 8	1	1	2	2	2	1	**1.50**
PO 9	1	1	1	2	1	1	**1,17**
PO 10	1	1	2	1	1	1	**1.17**
PO 11	3	2	3	2	3	2	**2.50**
PSO 1	2	2	2	3	2	2	**2.17**
PSO 2	2	3	2	3	2	3	**2.50**

B.TECH. – SEMESTER- VII
CHEMICAL ENGINEERING PRACTICES (25CHxxx)
(CORE ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

This course aims to equip students with the practical skills necessary to address real-world challenges in chemical process engineering. Students will gain insights into industry operations, system optimization, safety protocols, economic decision-making, and engineering excellence.

B. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	Analyze product details, global capacity, market value, and raw materials, including technical and commercial competitors, technology providers, and reaction schemes with block diagrams and line codes.	CO1	**4**
2.	Evaluate thermodynamics and physiochemical properties, perform material balances, examine raw material consumption, suggest improvements for conversion and yield.	CO2	**7**
3.	Assess energy balances with block diagrams, control valve details, options, selection basis, costs, operational specifics and draw control loops.	CO3	**7**
4.	Design major and minor equipment, identify safety measures and auxiliary equipment. Identify the factors affecting Plant location.	CO4	**6**
5.	Collect costs for equipment including auxiliary equipment, piping and plant, estimating the fixed cost, working cost and overall cost. Evaluate rate of return, breakeven points and payback periods.	CO5	**6**
6.	Draw P&ID with guide approval, identify pollution control measures and create plant layouts. Understand chemical process safety, including safety policies, frequency and severity rates, MSDS, green chemistry, and inherent safety.	CO6	**6**

C. COURSE OUTCOMES

COs	STATEMENT
CO1	Understand the basics of plant, process and commerce involved local and global market.
CO2	Apply the thermodynamics for property calculations and analyze the material balance.
CO3	Assess the energy requirement in the process and analyze various operational utilities and controlling strategies
CO4	Design different equipment's and understanding the importance of location.
CO5	Evaluate the economic feasibility of the process by applying cost estimation.
CO6	Creating the detailed P&ID, plant layout, detailed safety guidelines and best practices relevant to process.

D. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	2	**2.0**
PO 3	2	2	2	2	2	2	**2.0**
PO4	2	2	2	2	2	2	**2.0**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	1	1	1	1	1	1	**1.0**
PO 7	1	3	3	1	1	1	**1.7**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	1	1	1	1	1	**1.0**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-VII
FUEL CELL TECHNOLOGY (SUB. CODE)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course provides foundational knowledge essential for the development of fuel cell technology. It integrates concepts from thermodynamics, chemical reaction engineering, mass transfer, and electrochemistry to analyze fuel cell systems. Key focus areas include hydrogen energy systems—its generation from renewable sources, storage solutions, and safety considerations—preparing students for research and development in sustainable energy technologies.

B. PREREQUISITES

Chemistry, Chemical Engineering Thermodynamics, Mass Transfer, Chemical Reaction Engineering

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (33)
1.	**Introduction to Fuel Cells** History and evolution of fuel cell technology, Fundamentals of electrochemical energy conversion, Comparison of fuel cells with conventional energy systems, Applications and significance of fuel cell technology in modern energy systems.	CO1	3
2.	**Thermodynamics and Electrochemistry of Fuel Cells** Gibbs free energy and its relevance in fuel cell reactions, Nernst equation and reversible cell potential calculations, Effects of temperature, pressure, and concentration on fuel cell performance, Energy balance and efficiency considerations	CO2	6
3.	**Fuel Cell Types and Their Characteristics** Proton Exchange Membrane Fuel Cells (PEMFC), Solid Oxide Fuel Cells (SOFC), Alkaline Fuel Cells (AFC), Molten Carbonate Fuel Cells (MCFC), Direct Methanol Fuel Cells (DMFC), Operational principles, advantages, and limitations of each type	CO3	6
4.	**Fuel Cell Components and Materials** Electrolytes: types and properties, Electrodes and catalysts: materials and functions, Bipolar plates and current collectors	CO4	5
5.	**Fuel Cell Performance, Efficiency, and Applications** Voltage-current characteristics and polarization curves, efficiency calculations and factors affecting efficiency, Losses in fuel cells: activation, ohmic, and concentration losses, Applications in transportation, stationary power generation, and portable devices, Economic and environmental considerations.	CO5	8
6.	**Fuel Processing for Fuel Cell Systems** Hydrogen production methods: steam reforming, electrolysis, biomass gasification, Hydrogen storage technologies and safety considerations, Fuel processing for different fuel cell types.	CO6	5

D. TEXT BOOKS

1. Principles of Fuel Cells by X. Li, Taylor and Francis
2. Fuel Cell Systems Explained by J. Larminie and A. L. Dicks, Wiley

E. REFERENECE BOOKS

1. Hydrogen and Fuel Cells: Emerging Technologies and Applications by B. Sorensen and G. Spazzafumo, Academic Press
2. Fuel Cell Science and Technology by S. Basu, Springer

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/101/103101215/
2. https://archive.nptel.ac.in/courses/103/102/103102015/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	The evolution, working principles, and applications of fuel cells.
CO2	Termodynamic and electrochemical aspects influencing fuel cell efficiency.
CO3	The various fuel cell types based on principles, characteristics and applications
CO4	The materials and components used in fuel cells and their roles in performance.
CO5	To interpret performance curves and assess efficiency losses in practical fuel cell systems.
CO6	Different hydrogen production and storage systems, including safety and sustainability aspects.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	3.00
PO 2	1	1	-	-	3	1	1.00
PO 3	-	1	1	2	3	3	1.67
PO4	-	1	1	1	2	1	1.00
PO 5	1	2	-	1	1	1	1.00
PO 6	2	2	1	2	2	3	2.00
PO 7	1	1	1	1	1	2	1.17
PO 8	1	1	1	1	1	1	1.00
PO 9	-	-	-	-	-	-	0.00
PO 10	-	1	1	2	2	2	1.33
PO 11	1	3	2	2	3	3	2.33
PSO 1	2	2	3	3	3	3	2.67
PSO 2	2	2	2	3	2	2	2.17

B.TECH. – SEMESTER-VII
ADVANCE PROCESS CONTROL (25CH721)
(OPEN ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

This course introduces modern control techniques used in chemical processes. It starts with SISO control and model linearization, followed by the use of z-transforms and development of grey-box, ARX, and ARMAX models. It will cover random behaviour in systems using stochastic processes and analyze the stability of discrete systems. Advanced topics include multi-loop and multivariable control, soft sensing, and state estimation using Leuenberger observers and Kalman filters. The course also covers the design of state feedback controllers, LQG regulators, and Model Predictive Control (DMC), enabling students to model, analyze, and design controller for complex industrial systems effectively.

B. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (35)
1.	Review of Single Input Single Output (SISO) Control.	CO1	2
2.	Linearization of Mechanistic models. Introduction to z-transform. Development of grey-box models	CO2	4
3.	Development of output error models. Introduction to stochastic processes Development of Box Jenkins Models, ARX and ARMAX models. Model structure selection and issues in model development	CO3	7
4.	Stability analysis of discrete time systems. Lyapunov Functions and interaction analysis. Multi-loop control. Multivariable-decoupling control. Soft sensing and state estimation	CO4	6
5.	Development of Leuenberger observer. Introduction to Kalman filtering	CO5	6
6.	State feedback control design. Introduction to Linear Quadratic Gaussian control (LQG). Design of Linear Quadratic Gaussian regulator and controller. Design of DMC and Model Predictive control	CO6	10

C. TEXT BOOKS

1. B.wayne Bequette, Process Control Modeling, Design & Simulation, PHI
2. L.Ljung, System Identification - Theory for the User, Prentice Hall, 1987.
3. E. Camacho and C. Bordons, Model Predictive Control in the Process Industry, 1995

D. REFERENECE BOOKS

1. Process Dynamics and Control, D. E. Seborg, T. F. Edgar, D.A. Mellichamp, Wiley, 2003.
2. Control System Design, by Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, Prentice Hall, 2000.
3. Franklin, G. F., Powell, J. D., and M. L. Workman, Digital Control Systems, Addison Wesley, 1990.
4. Astrom, K. J., and B. Wittenmark, Computer Controlled Systems, Prentice Hall India (1994).

E. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/101/103101003/

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Students will understand the basics of Single Input Single Output Control systems and how they are used in process control.
CO2	Students will learn how to simplify nonlinear process models using linearization and apply z-transforms and grey-box modeling techniques for control applications.
CO3	Students will be able to develop dynamic models using output error, ARX, and ARMAX structures, and understand stochastic behaviour and model selection issues.
CO4	Students will analyze the stability of discrete-time systems, apply Lyapunov-based methods, and understand multivariable control and soft sensing.
CO5	Students will learn how to estimate unmeasured process states using Leuenberger observers and Kalman filters in control systems.
CO6	Students will be able to design state feedback controllers, implement Linear Quadratic Gaussian (LQG) control, and develop Model Predictive Controllers (MPC) for advanced process control.

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	3	3	2	3	**2.5**
PO 3	–	–	–	2	2	3	**1.2**
PO4	–	2	3	3	3	3	**2.3**
PO 5	2	3	3	3	3	3	**2.8**
PO 6	–	–	–	2	–	2	**0.7**
PO 7	–	–	–	–	–	–	**0.0**
PO 8	–	–	–	–	–	–	**0.0**
PO 9	–	–	–	–	–	–	**0.0**
PO 10	–	–	–	–	–	2	**0.3**
PO 11	2	2	3	3	3	3	**2.7**
PSO 1	3	3	3	3	3	3	**3.0**
PSO 2	1	2	2	3	3	3	**2.3**

B.TECH. – SEMESTER- VII
ENVIRONMENT IMACT ASSESSMENT (25CHxxx)
(OPEN ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	2	5	4.0	60	40	25	25	150

A. COURSE OVERVIEW

Sustainable development is an approach to the economic development of a country without compromising with the quality of the environment for future generations. Sustainability is generally described as Environmental, Economic, and social. However, in the name of economic development, the price of environmental damage is paid in the form of land degradation, soil erosion, air and water pollution, deforestation, etc. This damage shall not surpass the advantages of having more quality output of goods and services. The objective of the course is to introduce student about a tool/process of Environmental Impact assessment and its stepwise procedures.

The course introduces the basic techniques and assessment of environment impact, legal compliances and case studies for better understanding. Similarly, an Environmental Audit, as a tool of environmental sustainability is also introduces to learn various components of assessment

B. PREREQUISITES

Environment Engineering

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	**Environmental Impact Assessment (EIA)** Basic Concept & procedure of EIA, overview of Environmental Laws-Water Act 1974, the Air Act 1981 and the umbrella legislation for entire Environment in 1986 Act. EIA notifications,1994,2006, and draft 2020.	CO1	6
2.	**Evaluation Methodologies** Baseline description, environmental examination, screening, scoping, checklist, matrix, network, overlay, cost benefits analysis, public participation	CO2	6
3.	**Environment Components - Water, Land, Air,** Impact predictions and assessments of land, water environment, air Environment - case studies	CO3	6
4.	**Environment Components - Noise, Biological & socio-economic** Impact predictions and assessments of Noise, , biological, socio-economic impacts- case studies	CO4	6
5.	**Environment management Plan/system** Environmental management systems and strategies: ISO 9000, ISO14001certifiations, environmental standards	CO5	6
6.	**Environment Audit** Concept & importance of Environment Audit, audit terms, procedures case studies	CO6	6

D. TEXT BOOKS

1. Annjaneyulu Y., “Environment Impact Assessment Methodology” B S Publications (2002)
2. Canter L.W., “Environment Impact Assessment” McGraw Hill, second Edition (2005)
3. G.Burke, B. R. Singh and L Theodore, Handbook of Environmental Management and technology, second edition Jhon Wiley & sons, 2000

E. REFERENECE BOOKS

1. Excel Data Analysis Modeling and Simulation, 2nd Ed, Hector Guerrero, Springer
2. Introduction to Statistics and Data Analysis, Roxy Peck, Chris Olsen, Jay L. Devore, Cengage Learning
3. An Introduction to Statistical Methods & Data Analysis, 7th Ed., R. Lyman Ott, Michael Longnecker. Cengage Learning

F. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understands the importance of various rules and regulation in EIA.
CO2	Apply various techniques in impact assessment studies.
CO3	Identify the impact on water, land, Air environments.
CO4	Identify the impact on Noise, Biological and socio-economic environments.
CO5	Evaluate the impact assessment using management plan and suggestions
CO6	Ability to apply knowledge acquired for predications in various case studies

G. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3	3	3	3	**3.0**
PO 3	-	-	-	-	-	-	**-**
PO4	3	3	3	3	3	3	**3.0**
PO 5	-	3	2	2	3	3	**1.0**
PO 6	3	3	3	3	3	3	**1.0**
PO 7	3	3	3	3	3	3	**1.7**
PO 8	-	3	3	3	3	3	**2.0**
PO 9	3	3	3	3	3	3	**1.0**
PO 10	-	3	3	3	3	3	**1.0**
PO 11	3	3	3	3	3	3	**1.0**
PSO 1	3	3	3	3	3	3	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-VII
RESEARCH METHODOLOGY (SUB. CODE)
(OPEN ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course provides a comprehensive introduction to research methodology, covering the fundamentals of research design, literature review, data collection, statistical analysis, and ethical practices. It equips students with essential tools and techniques required to plan, conduct, analyze, and present research in a systematic and scientific manner. The course also emphasizes the importance of intellectual property rights, research communication, and the use of modern tools for data analysis and reporting

B. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (33)
1.	**Introduction to Research Methodology** **Motivation and Objectives of Research:** Importance of research in academics, industry, and society. **Types of Research:** Basic, Applied, Descriptive, Analytical, Quantitative, Qualitative, Exploratory, Experimental, etc. **Criteria of Good Research:** Systematic, logical, replicable, empirical, and objective. **Common Problems in Research:** Topic selection, data collection, funding, time management, etc. **Sources of Information:** Journals, databases, theses, reports, government publications, etc. **Interaction with Supervisor and Research Groups:** Communication, collaboration, and international exposure.	CO1	4
2.	**Research Process and Literature Review** **Research process:** Formulating problem, Literature review, Development of working hypothesis, Research design, Data collection, Execution of project, Data analysis, Hypothesis testing, Conclusions **Literature Sources and Review:** Primary, secondary, tertiary sources; importance of a thorough review. **Critical Review of Literature:** Identifying gaps, strengths, weaknesses, relevance, and reliability. **Gray Areas in Research:** Unexplored or underexplored domains. **Selecting a Research Problem:** Criteria for choosing a relevant and feasible topic. **Defining a Research Problem:** Need, objectives, boundaries, scope. **Techniques for Defining a Problem:** Logical structuring, framework building. **Writing a Literature Review:** Synthesis of current knowledge and research trends.	CO2	5
3.	**Research and Sampling Design** **Research Design:** Purpose, importance, components, steps. **Features of a Good Research Design:** Validity, reliability, flexibility, efficiency. **Principles of Experimental Designs:** Randomization, replication, local control. **Introduction to Design Software:** Minitab, Design Expert, JMP. **Sampling Design:** Importance, steps, implications. **Types of Sampling:** Probability and non-probability methods. **Random Sampling Techniques:** Simple, stratified, systematic, cluster sampling.	CO3	5
4.	**Data Collection, Measurement, and Scaling** **Concepts in Research:** Variables, parameters, constants, attributes. **Hypotheses:** Types, formulation, null and alternative hypotheses. **Measurement in Research:** Types of scales, measurement errors. **Tests of Sound Measurement:** Validity, reliability, precision. **Scaling Concepts:** Classification, scaling techniques, construction methods. **Tools Development:** Questionnaires, checklists, rating scales. **Data Collection:** **Primary Data Collection Methods:** Surveys, interviews, observations,	CO4	6

experiments. **Secondary Data Collection:** Literature, records, reports. **Choosing the Right Method:** Based on research objective, population, resource availability.

5.	**Data Analysis and Hypothesis Testing** **Data Processing:** Coding, editing, tabulation, data cleaning. **Statistical Analysis:** Measures of central tendency (mean, median, mode). Dispersion (range, variance, standard deviation). Skewness and kurtosis **Regression and Correlation:** Simple and multiple regression, Partial correlation, Principal Component Analysis (PCA), Correspondence analysis. **Sampling Fundamentals:** Sampling distributions, CLT, standard error, sample size estimation. **Hypothesis Testing:** Parametric (t-test, z-test, ANOVA) and non-parametric (Chi-square, Mann–Whitney U) tests. **Software Tools:** Introduction to SPSS, Excel, and other statistical packages.	**CO5**	**7**
6.	**Ethics in Research, Intellectual Property Rights and Research Communication** **Research Ethics:** Honesty, objectivity, integrity, carefulness, respect for intellectual property. **Intellectual Property (IP):** Types of IP—patents, copyrights, trademarks. **Basics of Patents and Copyright Laws:** Patentable subject matter, copyright eligibility, application process. **Plagiarism:** Types, consequences, plagiarism check tools (Turnitin, iThenticate, Drillbit). **Ethical Publishing:** Proper citation, avoiding duplication and data fabrication. **Research Reporting:** Writing short and long reports, drafting technical papers and patents, Data presentation and visualization, Writing research proposals, Publication ethics	**CO6**	**6**

C. TEXT BOOKS

1. Kothari C. R. (2006); Research Methodology, New Age Publishers, 2nd edition

D. REFERENECE BOOKS

1. Research in Education- John V. Best, John V. Kahn 7th edition
2. Presentation skills - Michael Hallon- Indian Society for Institute education
3. Practical Introduction to copyright. - Gavin Mcfarlane
4. Thesis projects in Science & Engineering – Richard M. Davis.
5. Scientist in legal Systems- Ann labor science
6. Thesis & Assignment – Jonathan Anderson
7. Writing a technical paper- Donald Menzel
8. Effective Business Report Writing –Leland Brown
9. Protection of industrial Property rights- P. Das & Gokul Das
10. Manual for evaluation of industrial projects-United Nations
11. Manual for the preparation of industrial feasibility studies

E. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the basic concepts, objectives, types, and challenges of research, and identify appropriate sources of information and collaboration.
CO2	Identify and define a research problem through literature review and gap analysis, and write a state-of-the-art literature review.
CO3	Design appropriate research and sampling frameworks using relevant methods and software tools.
CO4	Apply suitable techniques for data collection, measurement, and tool development.
CO5	Analyze data and test hypotheses using statistical methods and software.
CO6	Follow research ethics, understand intellectual property rights, and communicate research effectively.

F. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	2	**2.8**
PO 2	2	3	2	2	3	-	**2.0**
PO 3	-	2	3	-	-	-	**0.8**
PO4	-	3	3	3	3	-	**2.0**
PO 5	-	-	2	2	3	-	**1.2**
PO 6	1	-	-	-	-	2	**0.5**
PO 7	-	-	-	-	-	-	**0.0**
PO 8	-	-	-	-	-	3	**0.5**
PO 9	3	-	-	-	-	2	**0.8**
PO 10	2	2	-	1	1	3	**1.5**
PO 11	-	-	2	-	-	2	**0.7**
PSO 1	2	2	1	3	3	3	**2.3**
PSO 2	3	3	3	2	3	3	**2.8**

B.TECH. – SEMESTER-VII
BANKING & TAXATION (25CHxxx)
(OPEN ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	3	60	40	-	-	100

A. COURSE OVERVIEW

To provide a comprehensive understanding of the banking system, the products and services offered, the role of IT in banking, and the tax laws, with a focus on both domestic and international financial management.

B. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	**Overview of the Banking System:** Understanding the structure, functions, and different types of banks.	CO1	4
2.	**Electronic Banking and IT in Banks:** Learning about online banking, mobile banking and IT infrastructure in banks.	CO2	6
3.	**Loans and Advances:** Learning about different types of loans and credit analysis.	CO3	6
4.	**Banking Products and Services:** Familiarizing with various banking products like deposits, loans, and investment options.	CO4	6
5.	**International Banking Management:** Understanding global banking operations, foreign exchange, and international transactions.	CO5	6
6.	**Indian Taxation:** Direct and indirect taxes, including Income Tax, Goods and Services Tax (GST) and other relevant tax laws and procedures.	CO6	8

C. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the structure, functions, and types of banks. Gain insight into the role of banking in the economy.
CO2	Understand the structure, functions, and types of banks. Gain insight into the role of banking in the economy.
CO3	Understand different types of loans, credit analysis, and the loan approval process in banks.
CO4	Familiarize with various banking products such as deposits, loans, and investment options available to customers.
CO5	Gain knowledge of global banking operations, foreign exchange markets, and the management of international transactions.
CO6	Understand the principles of direct and indirect taxes, including Income Tax and GST, along with the relevant tax laws and procedures.

D. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	2	2	2	2	2	2	**2.0**
PO 3	2	2	2	2	2	2	**2.0**
PO4	2	2	2	2	2	2	**2.0**
PO 5	1	1	1	1	1	1	**1.0**
PO 6	1	1	1	1	1	1	**1.0**
PO 7	1	3	3	1	1	1	**1.7**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	1	1	1	1	1	1	**1.0**
PO 11	1	1	1	1	1	1	**1.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-VII
INDUSTRIAL SAFETY ENGINEERING & MANAGEMENT (25CHxxx)
(OPEN ELECTIVE-3)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	3	6	3	60	40	-	-	100

A. COURSE OVERVIEW
The objective of this course is to impart knowledge on different facts and aspects of engineering systems safety, focusing on techniques and methodologies needed for prevention of occurrences of unsafe operations and accidents under different industrial settings. Upon completion of the course, the students will be equipped with concepts of engineering systems safety, dimensions of engineering systems safety, safety design and analysis mathematics, design for engineering systems safety and control for safety, and integrating safety with other operational goals such as quality and reliability.

B. PREREQUISITES
Engineering Mathematics, Process Safety.

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	**Introduction** Introduction to Industrial Safety Engineering, Key concepts, Safety domain ontology; Terminologies, and safety quantification, Safety by design.	CO1	2
2.	**Hazard Identification techniques** Preliminary hazard list (PHL), Preliminary hazard analysis (PHA), Hazard and operability study (HAZOP), Failure modes, effects and criticality analysis (FMECA), Fault tree analysis (FTA)-Construction & Methods (Gate by Gate method and Cut set method), Event tree analysis (ETA), Fault tree analysis: Importance Measures, Bow – Tie, Common Cause Cut Sets, cut – Sets for Accident Scenarios, Identification of Safety Barriers,	CO2	8
3.	**Risk Assessment & Systems Safety Quantification** Individual & Societal risk assessment, Consequence assessment, Energy control model and Hazard control hierarchy. Truth tables, Structure functions, Minimal cut sets.	CO4	8
4.	**Safety function deployment** SFD Steps, Case example, Ranking of design solutions: Analytic hierarchy process (AHP) approach.	CO6	4
5.	**Safety vs Reliability** Quantification of Basic Events for Non - repairable Components: Reliability and failure distribution, Failure distribution function, Hazard rate, Exponential distribution, Weibull distribution. Quantification of basic events for repairable components, Failure & Repair Intensities, and Computation of combined process parameters- Laplace transform analysis & Markov Analysis.	CO5	10
6.	**Human error analysis and safety** Human Error, Classification and Causes, Human Error Identification, Human Reliability Assessment, Accident investigation, analysis and management. Accident Investigation & Analysis: Descriptive Analytics, Control Chart Analysis, Accident Data Analysis: Regression.	CO3	4

D. TEXT BOOKS

1. Probabilistic Risk Assessment and Management for Engineers and Scientists, by H Kumamoto and E J Henley, IEEE Press.
2. Crawl, D. A.; Louvar, J. F. Chemical Process Safety (fundamentals with applications);3rd Ed.; Prentice Hall International Series, 2011

E. REFERENECE BOOKS

1. An Introduction to Statistical Learning by James, G., Witten, D., Hastie, T., and Tibshirani, R., Springer.
2. Introduction to data mining by Tan, P. N., Steinbach, M., & Kumar, V. (2016). Pearson Education India.
3. Krishnan N.V. "Safety Management in Industry" Jaico Publishing House, Bombay, 1997
4. Industrial safety management, L M Deshmukh, TATA McGraw Hill, Forth edition, 2010

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/110/105/110105094/
2. https://archive.nptel.ac.in/courses/110/105/110105160/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	The fundamentals of industrial safety and key concepts
CO2	Identify and quantify the potential hazards associated with different industrial processes.
CO3	Issues pertaining to Human error and Accident investigation and ethical aspects associated with industrial safety.
CO4	The process system through mathematical modelling and implementation of the outcomes for the mitigation and prevention of accidents.
CO5	The safety and reliability of various major industrial safety related occurrences.
CO6	The research and innovation in the field of industrial safety for sustainable future.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	3.00
PO 2	2	3	2	2	2	1	2.00
PO 3	2	3	-	-	-	-	0.83
PO4	1	1	2	3	1	2	1.67
PO 5	1	1	1	1	2	1	1.17
PO 6	3	3	3	3	3	3	3.00
PO 7	3	3	3	3	2	3	2.83
PO 8	2	3	2	2	1	2	2.00
PO 9	2	2	2	2	-	-	1.33
PO 10	2	2	1	1	1	1	1.33
PO 11	2	2	2	1	2	2	1.83
PSO 1	2	2	2	2	2	2	2.00
PSO 2	1	1	1	1	1	1	1.00

Semester – VIII

Sub Code	Subject	Teaching Scheme (hrs/week)			Total	C	Examination Scheme				
		L	T	P	hr		Ext	S	TW	P	Total
PCE	Core Elective-IV	3	0	0	3	3.0	60	40	0	0	100
PC	CAD Lab	0	0	2	2	1.0	0	0	25	25	50
INT	Industrial Internship	0	0	0	0	14.0	0	0	100	250	350
INT	Seminar	1	0	4	5	3.0	0	0	100	0	100
	Total	**4**	**0**	**6**	**10**	**21.0**	**60**	**40**	**225**	**275**	**600**

ELECTIVE COURSES

Core Elective-4 SEM-VIII	
1.	CAD in Chemical Engineering
2.	Process Synthesis
3.	Heat Exchanger Network

B.TECH. SEM-VIII
CAD IN CHEMICAL ENGINEERING (25CHxxx)
(CORE ELECTIVE-4)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

Development of customized solution of chemical engineering design / optimization problems using various CAD tools. Use of computer for solving complex problems reduces human error, improves efficiency, removes redundancy and cost-effective optimal solutions can be obtained.

B. PREREQUISITES

Chemical Process Optimization, PEDD, IPC, HT, Numerical Methods

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (24)
1.	**Introduction to Computer Aided Design:** Motivation for using CAD in chemical engineering, Preliminaries of CAD, Tools of CAD, Onion model of process design	CO1	2
2.	**Nonlinear Optimization using Computer tools:** Unconstraint and Constraint optimization using computers: Nelder-Mead, Gradient based methods, Conjugate direction, Steepest Descent, Newton's method, Modified Newton's method, Quasi-Newton's method, Chemical Engineering Applications	CO2	4
3.	**Optimization in Practice:** Chemical Plant Optimization	CO3	4
4.	**Heat Integration:** Pinch Technology: Composite curve, Problem table algorithm, MER design	CO4	4
5.	**Process Flow-sheeting:** Flow sheet simulation algorithms, sequential modular and simultaneous modular approaches, Equation Oriented approach	CO5	5
6.	**Recycle loops and tearing algorithms:** Graph theory, SFG, Pho-Lapidus, Barkely-Motard, Hussain-Murthy	CO6	5

D. TEXT BOOKS

1. Bhattacharya, C. M.; Narayanan, C. M. Computer Aided Design of Chemical Equipment; New Central Book Agency (P) Ltd.: Calcutta, India, 1992.
2. Husain, A. Chemical Process Simulation, Wiley Eastern Limited: New Delhi, 1986.
3. Smith, R. Chemical Process Design and Integration, John Wiley & Sons Ltd.: England, 2005.
4. Seborg, D. E.; Edger, T. F.; Mellichamp, D. A. Process Dynamics and Control, 2nd ed.; Wiley India, New Delhi, 2004.

E. REFERENECE BOOKS

1. 1.Edger, T. F.; Himmelblau, D. M.; Lasdon, L. S. Optimization of Chemical Processes; 2 nd ed. McGraw-Hill: New York, 2001.
2. B. V. Babu, Process Plant Simulations; Oxford Press, 2004

F. ONLINE RESOURSES

1. https://nptel.ac.in/courses/103102352 (Computational Process Design)
2. https://nptel.ac.in/courses/103103164 (Computer based single objective optimization)
3. https://nptel.ac.in/courses/103105139 (Optimization in Chem Eng)
4. https://nptel.ac.in/courses/103103209 (**Aspen Plus simulation software - a basic course for beginners**)
5. https://nptel.ac.in/courses/103105215 (**Mathematical modelling and simulation of chemical engineering process)**
6. https://nptel.ac.in/courses/103105220 (Matlab based programing Lab Chemical Eng)

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understand the significance of CAD in chemical engineering and its use in evolution of process flow sheet
CO2	To be able to use various optimization solvers using computer for solving LP/NLP in chemical engineering
CO3	To be able to apply/implement optimization at process plant level
CO4	Ability of identifying the scope of heat recovery and possibility of process changes
CO5	Understanding of flowsheet solution strategies
CO6	Identify the recycle loops and selection of better tearing strategy in order to simulate the cyclic process

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	2	2	2	2	2	**2.0**
PO 2	-	-	-	-	-	-	**-**
PO 3	2	2	2	2	2	2	**2.0**
PO 4	-	-	-	-	-	-	**-**
PO 5	3	3	3	3	3	3	**3.0**
PO 6	2	2	2	2	2	2	**2.0**
PO 7	2	2	2	2	2	2	**2.0**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	1	1	1	1	1	1	**1.0**
PO 10	-	-	-	-	-	-	**-**
PO 11	2	2	2	2	2	2	**2.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B.TECH. – SEMESTER-VIII
HEAT EXCHANGER NETWORK SYNTHESIS (25CHxxx)
(CORE ELECTIVE-4)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3	60	40	-	-	100

A. COURSE OVERVIEW

This course provides a comprehensive understanding of Heat Exchanger Network (HEN) Synthesis and Process Integration (PI), focusing on optimizing energy efficiency and reducing costs in industrial processes. Students will learn to apply Pinch Technology for energy and area targeting, design maximum energy recovery systems, and handle multiple utilities in network optimization. The course also covers heat integration in equipment like distillation columns and refrigeration systems, and explores power integration in systems like co-generation and gas turbines. Practical applications, targeting methods, and cost-energy trade-offs are emphasized throughout.

B. PREREQUISITES

Heat Transfer, Thermodynamics, Basics of plant design and economics.

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	**Introduction:** Process Integration and its Building Blocks: Definition of Process Integration (PI), School of thoughts, Areas of application and Techniques available for PI, Onion diagram.	CO1	6
2.	**Pinch Technology:** Basic concepts, role of thermodynamic laws. Concept of $\Delta T_{min,}$ Grid diagram, Composite curve, Problem table algorithm, Grand composite curve.	CO2	5
3.	**Targeting of Heat Exchanger Network (HEN):** Energy targeting, Area targeting, Number of units targeting, Shell targeting, Cost targeting.	CO3	5
4.	**Designing of HEN:** Pinch design methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Use of multiple utilities and concept of utility pinches, Design of multiple utilities and pinches, Design for threshold problem and design strategy, Network evolution and evaluation identification of loops and paths, Loop breaking and path relaxation. Targeting and designing of HENs with different ΔTmin values, Variation of cost of utility, fixed cost, TAC, number of shells and total area with ΔTmin Capital-Energy trade offs	CO4	14
5.	**Heat Integration of Equipment:** Heat engine, Heat pump, Distillation column, Reactor, Evaporator, Drier, Refrigeration systems.	CO5	4
6.	**Power Integration and Case studies:** Co-generation, Steam turbine, Gas turbine	CO6	2

D. TEXT BOOKS

1. Kemp I.C., “Pinch Analysis and Process Integration: A User Guide on Process Integration for the Efficient Use of Energy”, 2nd Ed., Butterworth-Heinemann.
2. Smith R., “Chemical Process Design and Integration”, 2nd Ed., Wiley

E. REFERENECE BOOKS

1. Shenoy U.V., “Heat Exchanger Network Synthesis”, Gulf Publishing.
2. El-Halwagi M.M., “Process Integration”, 7th Ed., Academic Press.

F. ONLINE RESOURSES

1. https://archive.nptel.ac.in/courses/103/107/103107094/

G. COURSE OUTCOMES

Cos	STATEMENT
CO1	The basic understanding of process integration and its need.
CO2	In depth understanding of pinch methodology and its application.
CO3	To create an ability to do pinch analysis.
CO4	To analyse heat exchanger networks.
CO5	The understanding of heat and power integration
CO6	Applications for the modification of processes for minimization of power and heat with case studies.

H. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	2	2	**2.7**
PO 2	1	3	3	3	1	1	**2.0**
PO 3	3	3	3	3	1	1	**2.3**
PO 4	3	2	3	1	1	1	**1.8**
PO 5	-	-	1	1	1	1	**0.7**
PO 6	1	1	1	1	1	1	**1.0**
PO 7	2	2	2	2	1	1	**1.7**
PO 8	3	1	3	2	-	1	**1.7**
PO 9	-	1	1	1	-	1	**0.7**
PO 10	1	1	1	1	1	1	**1.0**
PO 11	2	3	3	1	1	1	**1.8**
PSO 1	2	3	2	2	2	1	**2.0**
PSO 2	3	2	2	2	2	1	**2.0**

B.TECH. – SEMESTER-VIII
PROCESS SYNTHESIS (25CHxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
3	0	0	3	3.0	60	40	-	-	100

A. COURSE OVERVIEW

This course provides a fundamental understanding of chemical bonding, molecular interactions, and molecular geometry. It explores thermodynamic principles, chemical equilibrium, electrochemistry, and corrosion prevention. Emphasis is placed on applications in engineering, including electrolysis, industrial processes, and material stability. This course covers fundamental concepts of organic chemistry, including key reactions. It explores engineering materials such as glass, ceramics, composites, and polymers, emphasizing their properties and uses. Additionally, it examines water chemistry, treatment methods, and industrial water-related challenges.

B. PREREQUISITES

High school chemistry foundation covering atomic structure, periodic table, chemical formulas, equations, and basic concepts of matter, solutions, and acids/bases is essential.

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (36)
1.	**Introduction:** Introduction to design and process synthesis. Preliminary process design. Basic steps in process flow sheet synthesis. Decomposition strategies for process synthesis. A Case study: Synthesis of Ethyl Alcohol process.	CO1	6
2.	**Scheduling:** Introduction to design and scheduling of batch processes. Concepts of single and multi product batch plants, transfer policies, parallel units and intermediate storage. Synthesis of flow shop plants.	CO2	6
3.	**Simulation in process design:** Process simulation modes, Methods of solving nonlinear equations, recycle partitioning and tearing.	CO3	6
4.	**Heat and power integration:** The basic concepts of Heat Ex-changer Network Synthesis (HENS) and Mass Exchange Networks (MEN). Synthesis of ideal multi-component distillation systems. Heat integrated distillation systems.	CO4	6
5.	**Synthesis of reactors and reactor networks:** Mathematical approach and Heuristic approach.	CO5	3
6.	**Process flexibility:** Introduction to the concept of flexibility, Mathematical formulas for flexibility analysis and some solution methods.	CO5	3
7	**Optimization for Process Synthesis:** Introduction to optimization techniques. MINLP problems. MINLP models to solve HENS, distillation sequences, reactor network synthesis.	CO6	6

D. TEXT BOOKS

1. Biegler, Grossmann, and Western berg., Systematic methods of chemical process design.
2. Rudd Dole, F, Powers Gray J, Siirola, Jeffrey J, Process, Process synthesis, Engle wood cliffs, Printice hall, 1973.

E. COURSE OUTCOMES

Cos	STATEMENT
CO1	Understanding the fundamentals of process design and synthesis, including the basic steps for process flow sheet development.
CO2	Techniques for scheduling multi-product and multipurpose batch plants, along with the design of flow shop plants for optimal operation

CO3 Exploration of process simulation methods, including partitioning and tearing algorithms to solve complex process design problems.

CO4 Introduction to the concepts and methodologies for the synthesis of heat exchanger and mass exchange networks to optimize energy and material flows.

CO5 Methods for synthesizing reactors and reactor networks, applying various approaches for efficient chemical processing.

CO6 Application of optimization techniques, focusing on their use in process synthesis for improved efficiency and performance.

F. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	3	3	3	3	3	3	**3.0**
PO 2	3	3	3		3	-	**2.0**
PO 3	3	2	3	3	3	3	**2.8**
PO 4	-	2	2	-	-	2	**1.0**
PO 5	-	-	3	3	-	-	**1.0**
PO 6	-	-	-	-	-	3	**0.5**
PO 7	-	-	-	-	-	3	**0.5**
PO 8	-	-	-	-	-	3	**0.5**
PO 9	-	2	-	-	2	-	**0.7**
PO 10	-	-	-	-	-	-	**0.0**
PO 11	-	-	3	-	-	3	**1.0**
PSO 1	-	-	-	-	-	-	**0.0**
PSO 2	-	-	-	-	-	-	**0.0**

B.TECH. – SEMESTER-VIII
LAB COURSE ON COMPUTER AIDED CHEMICAL ENGINEERING (25CHxxx)

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext.	Int.	TW	P	Total
0	0	2	2	1	-	-	25	25	50

A. COURSE OVERVIEW
Development of customized tool applicable to chemical engineering design / optimization problems using various CAD soft-wares. To study applications of computer aided tools in design, optimization and control of chemical engineering systems. Emphasis is to develop CAD modules using CAD soft-ware for solving various design problems, dynamic problems and optimization problems in chemical engineering

B. PREREQUISITES
Chemical Process Optimization, PEDD, IPC, HT, Numerical Methods

C. COURSE CONTENT

S. N.	TOPICS	COs	Hrs. (18)
1.	**Optimization using CAD software** LP, NLP problems in chemical engineering	CO1	3
2.	**Optimization using software** MILP and MINLP problems in chemical engineering	CO2	3
3.	**Computer aided design of process equipment** Computer aided design of pressure vessel, Nozzle design, Head design	CO3	3
4.	**Computer aided design of process equipment involving heat transfer**	CO4	3
5.	Heat Exchanger Network Design	CO5	2
6.	**Process Plant Simulation** Steady state and dynamic process simulation	CO6	4

D. PRACTICAL AND TERM WORK
1. Use of LP/NLP solvers using optimization package
2. Use of MILP/MINLP solvers using optimization package
3. Development of CAD module for pressure vessel having nozzles with head
4. Development of CAD module for Heat Exchanger Design
5. Design of heat exchanger network for maximum heat recovery using Aspen Energy Analyzer
6. Dynamic Simulation in close loop with PID controllers

E. TEXT BOOKS

1. Bhattacharya, C. M.; Narayanan, C. M. Computer Aided Design of Chemical Equipment; New Central Book Agency (P) Ltd.: Calcutta, India, 1992.
2. Husain, A. Chemical Process Simulation, Wiley Eastern Limited: New Delhi, 1986.
3. Smith, R. Chemical Process Design and Integration, John Wiley & Sons Ltd.: England, 2005.
4. Seborg, D. E.; Edger, T. F.; Mellichamp, D. A. Process Dynamics and Control, 2nd ed.; Wiley India, New Delhi, 2004.

F. REFERENECE BOOKS

1. 1.Edger, T. F.; Himmelblau, D. M.; Lasdon, L. S. Optimization of Chemical Processes; 2 nd ed. McGraw-Hill: New York, 2001.
2. B. V. Babu, Process Plant Simulations; Oxford Press, 2004

G. ONLINE RESOURSES

1. https://nptel.ac.in/courses/103102352 (Computational Process Design)
2. https://nptel.ac.in/courses/103103164 (Computer based single objective optimization)
3. https://nptel.ac.in/courses/103105139 (Optimization in Chem Eng)
4. https://nptel.ac.in/courses/103103209 (**Aspen Plus simulation software - a basic course for beginners**)
5. https://nptel.ac.in/courses/103105215 (**Mathematical modelling and simulation of chemical engineering process)**
6. https://nptel.ac.in/courses/103105220 (Matlab based programing Lab Chemical Eng)

H. COURSE OUTCOMES

Cos	STATEMENT
CO1	Use of optimization solvers using computer for solving LP, NLP in chemical engineering
CO2	Use of optimization solvers using computer for solving MILP and MINLP in chemical engineering
CO3	Develop Computer aided design module of process equipment without heat transfer
CO4	Develop Computer aided design module of process equipment with heat transfer
CO5	Heat Integration using ASPEN ENERGY ANALYSER
CO6	Flowsheet Simulation (open loop and close loop) using ASPEN PLUS and ASPEN DYNAMICS

I. COURSE MATRIX

	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6	Average
PO 1	2	2	2	2	2	2	**2**
PO 2	-	-	-	-	2	2	**0.66**
PO 3	1	2	1	2	2	2	**1.66**
PO 4	1	1	2	2	2	2	**1.66**
PO 5	3	3	3	3	3	3	**3.0**
PO 6	1	2	1	2	2	2	**2.0**
PO 7	2	2	2	2	2	2	**2.0**
PO 8	2	2	2	2	2	2	**2.0**
PO 9	2	2	2	2	2	2	**2.0**
PO 10	1	-	-	-	-	2	**0.5**
PO 11	2	2	2	2	2	2	**2.0**
PSO 1	2	2	2	2	2	2	**2.0**
PSO 2	2	2	2	2	2	2	**2.0**

B. TECH. – SEMESTER-VIII (CH)
INDUSTRIAL INTERNSHIP

Teaching Scheme (Hours/Week)				Credits	Examination Scheme				
L	T	P	Total		Ext	S	TW	P	Total
0	0	0	0	14	0	0	100	250	350

E. COURSE OVERVIEW

Motivation and Objective:

The motivation behind this training initiative is to empower students to become adept professionals capable of addressing real-world challenges with diligence, creativity and a commitment to excellence in chemical process engineering.

The major objective of the final semester industrial training is to provide students with hands-on experience aims to bridge the gap between theoretical knowledge and practical application. Emphasizing key aspects such understanding of industry operations, optimizing systems for efficiency, advocating for safety measures, honing economic decision-making skills, showcasing engineering excellence.

F. COURSE CONTENT

	TOPICS	COs
1.	Analyze product details, global capacity, market value, and raw materials, including technical and commercial competitors, technology providers, and reaction schemes with block diagrams and line codes.	**CO1**
2.	Evaluate thermodynamics and physiochemical properties, perform material balances, and identify unit processes, reactors, pumps, and separation equipment in the industry.	**CO2**
3.	Assess energy balances with block diagrams, control valve details, options, selection basis, costs, operational specifics and draw control loops.	**CO3**
4.	Design major and minor equipment, identify safety measures and auxiliary equipment. Identify the factors affecting Plant location.	**CO4**
5.	. Collect costs for equipment including auxiliary equipment, piping and plant, estimating the fixed cost, working cost and overall cost. Evaluate rate of return, breakeven points and payback periods.	**CO5**
6.	. Draw P&ID with guide approval, identify pollution control measures and create plant layouts.	**CO6**
7.	Examine raw material consumption, suggest improvements for conversion and yield. Explore statutory requirements for project initiation.	**CO7**
8.	Understand chemical process safety, including safety policies, frequency and severity rates, MSDS, green chemistry, and inherent safety. Familiarize with work permits, color codes, emergency planning, firefighting systems, DoW F&EI calculations, HAZOP studies, BPCS, Interlock, SIS systems, LOPA diagrams, and safety audits per IS:14489:1998.	**CO8**

G. COURSE OUTCOMES

COs	STATEMENT
CO1	Understand the basics of plant, process, commerce involved, local and global market.
CO2	Apply the thermodynamics for property calculations and analyze the material balance.
CO3	Assess the energy requirement in the process and analyze various operational utilities and controlling strategies
CO4	Design different equipments and understanding the importance of location.
CO5	Evaluate the economic feasibility of the process by applying cost estimation.
CO6	Creating the detailed P&ID and plant layout
CO7	Detailed evaluation of overall process, consumption pattern, suggesting improvements and examining statutory requirements for project initiation
CO8	Analyzing detailed safety guidelines and best practices relevant to process.

H. COURSE MATRIX

	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	AVG.
PO1	3	3	3	3	3	3	3	3	3.0
PO2	3	3	3	3	3	3	3	3	3.0
PO3	3	3	3	3	3	3	3	3	3.0
PO4	3	3	3	3	3	3	3	3	3.0
PO5	3	3	3	3	3	3	3	3	3.0
PO6	3	3	3	3	3	3	3	3	3.0
PO7	3	3	3	3	3	3	3	3	3.0
PO8	3	3	3	3	3	3	3	3	3.0
PO9	3	3	3	3	3	3	3	3	3.0
PO10	3	3	3	3	3	3	3	3	3.0
PO11	3	3	3	3	3	3	3	3	3.0
PSO1	3	3	3	3	3	3	3	3	3.0
PSO2	3	3	3	3	3	3	3	3	3.0