

SCHEME & SYLLABUS
OF TEACHING & EXAMINATION FOR
V & VI SEMESTERS
B.E. CHEMICAL ENGINEERING

2025-2026

[for 2023 admitted batch, 160 credit course, NEP 2.0]



SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

(An autonomous institution affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A++' grade & ISO 9001:2015 Certified)

B.E. in Chemical Engineering, NEP – 2, (160 credits Program)

SCHEME OF TEACHING AND EXAMINATION (2023 Admitted Batch) (w.e.f 2025-26)

Sl. No.	Course and Course Code	Course Title	Teaching / Paper setting Dept.	Teaching hrs /week				Examination				Credits	
				Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks		
				L	T	P	S						
V Semester													
1.	IPCC	S5CHI01	Mass Transfer	ChE	3	0	2	..	3	50	50	100	4
2.	IPCC	S5CHI02	Chemical Reaction Engineering	ChE	3	0	2	..	3	50	50	100	4
3.	HSMS	S5CH01	Process Engineering Economics and Management	ChE	3	0	0	..	3	50	50	100	3
4.	PCCL	S5CHL01	Environmental Engineering Lab	ChE	0	0	2	..	3	50	50	100	1
5.	PEC	S5CHPE1X	Professional Elective Course - I	ChE	3	0	0	..	3	50	50	100	3
6.	MC	ARAS	Aptitude Related Analytical Skills	T&P	0	0	2	..	3	50	50	100	1
7.	MC	SHS05	Environmental Studies (Board: CV)	CV	2	0	0	..	3	50	50	100	2
8.	AEC	RMIP	Research Methodology & IP Rights (Board: IEM)	IM	3	0	0	..	3	50	50	100	3
9.	PROJ	S5CHMP	Mini Project	ChE	0	0	4	..	3	50	50	100	2
10.	MC	SMC01	National Service Scheme (NSS)	NSS	0	0	2	..	-	100	-	100	0
		SMC02	Physical Education (Sports and Athletics)	PED									
		SMC03	Yoga and Pranayama	PED									
		SMC04	National Cadet Corps (NCC)	NCC									
			Total		17	0	13	..	27	550	450	1000	23
		AAP	AICTE Activity Points	40 hours community service to be documented and produced for the exam									
Note: IPCC : Integrated Professional Core Course, PCC : Professional Core Course, PCCL : Professional Core Course Laboratory, PEC : Professional Elective Course, OEC : Open Elective Course, AEC : Ability Enhancement Course, PROJ : Project, MC : Mandatory Course. L : Lecture, T : Tutorial, P : Practical/ Drawing, S : Self-Study Component, CIE : Continuous Internal Evaluation, SEE : Semester End Examination.													

Professional Elective Course (PEC) – I (Offered by the Department) (V Semester)

S5CHPE11	Plant Utilities	S5CHPE12	Chemical Process Industries
S5CHPE13	Bioenergy Engineering	S5CHPE14	Food Engineering



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Sl. No.	Course and Course Code	Course Title	Teaching / Paper setting Dept.	Teaching hrs/week				Examination			Credits		
				Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks		Total Marks	
				L	T	P	S						
VI Semester													
1.	IPCC	S6CHI01	Process Dynamics and Control	ChE	3	0	2	-	3	50	50	100	4
2.	PCC	S6CH01	Separation Processes	ChE	3	2	0	-	3	50	50	100	4
3.	PEC	S6CHPE2X	Professional Elective Course - II	ChE	3	0	0	-	3	50	50	100	3
4.	PCCL	S6CHL01	Process Simulation Laboratory	ChE	0	0	2	-	3	50	50	100	1
5.	NCMC	S6NMC	Soft Skills (Additional Course offered by SIT)	T&P	0	2	0	-	-	100	-	100	0
6.	OEC	OE6X	Open Elective Course - I	Other	3	0	0	-	3	50	50	100	3
7.	PROJ	S6CHMP	Major Project Phase I	ChE	0	0	4	-	3	100	-	100	2
8.	SHS	SHS07	Indian Knowledge System	ChE	2	0	0	-	-	100	-	100	0
9.	MC	SMC01	National Service Scheme (NSS)	NSS	0	0	2	-	-	50	50	100	0
		SMC02	Physical Education (Sports and Athletics)	PE									
		SMC03	Yoga and Pranayama	Yoga									
		SMC04	National Cadet Corps (NCC)	NCC									
			Total		14	4	10	0	18	550	300	900	17
		AAP	AICTE Activity Points		40 hours community service to be documented and produced for the exam								
Note: IPCC : Integrated Professional Core Course, PCC : Professional Core Course, PCCL : Professional Core Course Laboratory, PEC : Professional Elective Course, OEC : Open Elective Course, AEC : Ability Enhancement Course, PROJ : Project, MC : Mandatory Course. L : Lecture, T : Tutorial, P : Practical/ Drawing, S : Self-Study Component, CIE : Continuous Internal Evaluation, SEE : Semester End Examination													
Professional Elective Course (PEC) – II (Offered by the Department) (VI Semester)													
S6CHPE21	Membrane Technology			S6CHPE22	Waste Water Treatment Methods								
S6CHPE23	Petrochemicals			S6CHPE24	Heterogeneous Reaction System								

V Semester

MASS TRANSFER

Contact Hours/ Week	3+0+2 (L+T+P)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S5CHI01	Semester	5

Course Objectives:

1	Develop familiarity with the basic principles of diffusion, mass transfer coefficients and interphase mass transfer to enable selection of appropriate recovery process.
2	Introduce the fundamentals of molecular diffusion and convective diffusion in the context of distillation, drying and humidification processes.
3	Train students to apply mass transfer principles, material and energy balance to solve problems related to distillation, drying and humidification processes.
4	Facilitate the students to carry out selection of appropriate recovery process and perform basic design of the mass transfer equipment involved.
5	Describe sustainable operations including distillation, drying and humidification in the context of environment and economics.

UNIT I

Introduction to Mass Transfer Operations: Classification of mass transfer operations, Molecular and Eddy diffusion, Diffusivity, Steady state molecular diffusion in fluids, molecular diffusion in gases & liquids, pseudo steady state diffusion, Diffusion in solids.

7 Hours

UNIT II

Mass transfer coefficients and Interphase mass transfer: Mass transfer coefficients, mass transfer theories: Film theory, Penetration theory, Surface renewal theory. Interphase mass transfer: Equilibrium, two-phase mass transfer, overall mass transfer coefficient. Types of operations: co-current process, counter-current process.

8 Hours

UNIT III

Distillation: Vapor liquid equilibria, relative volatility, computation of vapor liquid equilibria, types of distillation columns – batch column, continuous column, steam distillation, equilibrium distillation, simple distillation, Continuous rectification: McCabe Thiele Method: location of feed tray, reflux ratio. Introduction to Extractive distillation and Azeotropic distillation.

8 Hours

UNIT IV	
Drying: Moisture content - wet and dry basis, equilibrium moisture, bound moisture, unbound moisture, free moisture, critical moisture content, constant rate drying period, falling rate drying period, classification of drying operations: batch and continuous drying. Parameters affecting drying rate during constant rate drying period. Dryers: rotary dryer, drum dryer, spray dryer, freeze dryer.	
8 Hours	

UNIT V	
Humidification: Molal absolute humidity, saturated absolute humidity, dry bulb temperature, relative humidity, percentage saturation, dew point, humid heat, enthalpy, humid volume, adiabatic saturation curves, wet bulb temperature, design of cooling tower, re-circulation humidifier, Equipment: packed cooling towers, spray chambers, spray ponds.	
8 Hours	

Text Books		
1	R. E. Treybal	Mass Transfer Operation. Mc Graw Hill. NY; 3 rd Edition, 2017, ISBN:978-1259029158
2	K. V. Narayanan and B. Lakshmikutty	Mass Transfer-Theory and Applications. CBS Publishers, New Delhi, 2 nd Edition, 2023, ISBN:978-9354666094

Reference Books		
1	N. Anantharaman and K. M. M. S. Begum	Mass Transfer: Theory and practice. PHI Learning Private Limited, 2013, ISBN: 978-81-203-4169-2
2	J. M. Coulson and J. F. Richardson	Chemical Engineering. Vol I/Vol II, Elsevier India, 7th Edition, 2017, ISBN: 978-0081010990
3	W. McCabe and J. M. Smith	Unit Operations in Chemical Engineering. McGraw Hill; 7 th Edition, 2017, ISBN:978-8184959635
4	C. J. Geankoplis	Transport Processes and Unit Operations. Prentice Hall of India, New Delhi; 4 th Edition, 2013, ISBN:978-1292026022

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Apply the fundamentals of mass transfer to solve for diffusion coefficient and mass transfer rates and analyze the solutions
CO2	Apply the concepts of interfacial mass transfer to calculate mass transfer coefficient and mass transfer rates and analyze the solutions
CO3	Solve problems in distillation and perform basic design of distillation columns by applying the concepts of thermodynamic equilibrium and operating lines, analyze and communicate the solutions
CO4	Solve problems in drying and perform basic design of dryers by applying the concepts of thermodynamic equilibrium and drying curve, analyze and communicate the solutions
CO5	Develop humidification and dehumidification systems by applying the fundamentals of humidity, enthalpy and adiabatic saturation curves, analyze and communicate the solutions

MASS TRANSFER LAB

Experiments:	
1.	Determine the diffusivity of a given liquid to air
2.	Verify application of Rayleigh's equation for simple distillation
3.	Estimate the HETP using Fenske's equation and McCabe Thiele method under total reflux conditions
4.	Estimate the vaporization efficiency and thermal efficiency for steam distillation
5.	Determine the Himus constants k and n for the given liquid under evaporation
6.	Determine the constants k and n of the Freundlich equation at room temperature, for the adsorption of acetic acid on activated carbon
7.	Determine the percentage recovery of solute from a solution using a solvent in each stage of multistage cross current extraction
8.	Determine the percentage recovery by leaching for a given feed under each stage under multi stage operation
9.	Determine the percentage recovery by leaching for a given feed using counter current leaching by shank system
10	Estimate the critical moisture content and equilibrium moisture content by drawing the rate of drying curve for a given sample.
11	Examine the effect of various parameters such as feed flow rate, air flow rate, inlet water temperature etc. on the performance of the cooling tower
12	Determine the Vapor-Liquid Equilibrium (VLE) curve for the CCl ₄ toluene mixture

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3											3			
CO2		3										3			
CO3		3										3			
CO4		3										3			
CO5		3										3			

CHEMICAL REACTION ENGINEERING

Contact Hours / Week	3+0+2 (L+T+P)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S5CHI02	Semester	5

Course objectives:	
1	Describe the kinetics of reactions
2	Interpret reactor data and rate equation
3	Identify ideal reactors and explain the various aspects of design for single reactions
4	Understand the non-ideal behavior of reactors with suitable models
5	Explain the various aspects of design for multiple reactions

UNIT I

Kinetics of Homogeneous Reactions: Concentration-dependent term of a rate equation: (Single, Multiple reactions, Elementary and Nonelementary Reactions, Molecularity and order of reaction, Rate Constant, Representation of elementary reaction, Representation of Nonelementary reactions, Kinetic Models of Nonelementary Reactions, Testing Kinetic Models) **Temperature-dependent term of a rate equation:** Temp. dependency from Arrhenius law, Collision theory, Transition state theory, Thermodynamic approach, Activation Energy.

8 Hours

UNIT II

Interpretation of Batch Reactor Data: Constant-Volume batch Reactor: Analysis of Total pressure data, Integral Method of Analysis of Data (Irreversible I order Reactions, II order, nth order, Zero-order, Overall order of Irreversible reactions from the half-life, Irreversible Reactions in parallel, Homogeneous catalyzed reactions, Auto catalytic reactions, Irreversible Reactions in series, First order reversible reactions, Reactions of shifting order) Differential method of analysis of data. **Varying-Volume batch Reactor:** For Zero, First, Second order Reactions.

8 Hours

UNIT III

Ideal Reactors for a Single Reaction: Ideal Batch Reactor, Space-Time and Space-Velocity, Mixed flow reactor, Plug flow Reactor, Holding time and space time for flow reactors. General features of reactors, Numericals.

8 Hours

UNIT IV

Design for Single Reactions: Size comparison of single reactors, Multiple- Reactor systems (PFR in series and/or in parallel, Equal size MFR in series, Reactors of different types in series), Recycle Reactor, Numericals. **Basics of Non-Ideal flow:** Importance & interpretation of RTD, C, E & F curves and Statistical interpretation, Dispersion model. Tanks in series model, Conversion in non- ideal flow reactors for simple systems.

8 Hours

UNIT V

Multiple Reactions: Design for Parallel Reactions: Qualitative Discussion about product distribution, Contacting patterns for reactions in parallel, Operating conditions for parallel reactions. **Design for Series Reactions:** First order irreversible reactions in series, Qualitative discussion about product distribution, Quantitative treatment, Plug flow or batch reactor, Quantitative treatment, mixed flow reactor.

8 Hours

Text Books		
1	Octave Levenspiel	Chemical Reaction Engineering, Wiley Publishers, 3e, 2006, ISBN-13: 978-8126510009
2	Himadri Roy Ghatak	Reaction Engineering Principles, CRC Press, 1e, 2016, ISBN-13: 978-1-4987-5858-1

Reference Books		
1	Fogler H Scott	Elements of chemical Reaction Engineering, Pearson Education India, 4e, 2015, ISBN-13: 978-9332549326.
2	J M Smith	Chemical Engineering Kinetics, McGraw Hill, 3e, 2014, ISBN-13: 978-9332902633.

Course Outcomes: Upon completion of this course, student will be able to:	
1	Formulate stoichiometric relations and kinetic rate expression for elementary and non-elementary reactions considering thermodynamic consistency.
2	Apply the principles of reaction kinetics, formulate rate equations and analyze the batch reactor data
3	Solve chemical reaction engineering problems applying material and energy balance equations to batch, semi-batch and continuous type reactors for different reaction systems.
4	Apply knowledge of RTD to diagnose non ideal reactors and selection of appropriate models to predict conversion from different reactors
5	Analyse and select reactor type to achieve a desired reactant conversion/ selectivity/ yield.

CHEMICAL REACTION ENGINEERING LAB

Experiments:	
1	Estimate order and rate constant for a reaction in a batch reactor-I (equi-molar and non-equimolar)
2	Estimate order & rate constant for a reaction in a batch reactor-II (non-equimolar)
3	Estimate the rate constant of a reaction at different temperatures in a batch reactor
4	Estimate order and rate constant for a reaction in a CSTR
5	Determine the order and rate constant for a reaction in a PFR
6	Study the effect of addition of reactant on conversion in a Semi-batch reactor
7	Estimate the rate constant of a saponification reaction in a packed bed reactor
8	RTD studies in a CSTR (pulse input)
9	RTD studies in a PFR-I (pulse input)
10	RTD studies in a PFR-II (step input)
11	Determine rate constant and order in a combined flow reactor (PFR + MFR)

PROCESS ENGINEERING ECONOMICS AND MANAGEMENT

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S5CH01	Semester	5

Course objectives:

1	Describe the relation between engineering and economics in process design development
2	Understand the cost and its components
3	Learn about interest and its significance in process economics and the ways to compare the same.
4	Know the significance of depreciation of assets and its relation with tax
5	Understand the financial statement and break even analysis

UNIT I

Introduction: Engineering Economics – An overview, relationship between engineering and economics, scope of engineering economics. **Process Design Development:** Economics in the overall plant, plant location and layout – Factors affecting plant design and layout, economics of Plant location and layout.

8 Hours

UNIT II

Estimating Component: Components of costs such as direct material cost, direct labour cost, fixed, Overheads, factory costs, administrative – Overheads, first cost, marginal cost, selling price, estimation for simple components.

8 Hours

UNIT III

Interest: Simple and compound interest, nominal and effective interest, continuous interest, interest formulae and their application, time value of money and numerical. Comparison Methods for Rate of Interest: Present worth, future worth & annual Equivalent method of comparison, revenue and cash dominated cash flow diagram.

8 Hours

UNIT IV

Depreciation: Depreciation – Introduction, causes of depreciation, Methods of Depreciation - Straight Line method, Unit of Production Method, Double Declining Balance Method. Numerical problems. Determination of break-even point, BEP in terms of quantity, sales value, and percentage of capacity, break even chart and numerical.

8 Hours

UNIT V	
Project Management: Introduction. Phases of Project Management. Guidelines for Network Construction Critical Path Method (CPM). Gantt Chart/Time Chart. PERT (Project Evaluation and Review Technique). Simple numerical	
8 Hours	

Text Books		
1	M.S. Peters and K. D. Timmerhaus	Plant Design and Economics for Chemical Engineers, 5e, McGraw Hill, 2017.
2	R Paneerselvam	Engineering Economics, Prentice Hall India Learning Private Limited, 2e, 2013.
Reference Books		
1	Sasmita Mishra	Engineering Economics and Costing, PHI Publishers, 2e, 2011.
2	V.V. Mahajani and S.M. Mokashi	Chemical Project Economics, Laxmi Publications Private Limited; 2e, 2016.
3	Pinto, P.K.	Project Management, Pearson Education, 3e, 2012 ISBN: 9780273767428

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Apply the knowledge of engineering economics for process design development
CO2	Estimate the cost and its components in economics
CO3	Distinguish between various types of interests and their significance in Engineering Economics.
CO4	Identify and comprehend the appropriate method of depreciation in industrial process
CO5	Infer on a macroscopic level the minute economics of process engineering design and plant technology.

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1			3										3		
	CO2										3			3		
	CO3				2									3		
	CO4		3											3		
	CO5	2										3		3		

ENVIRONMENTAL ENGINEERING LABORATORY

Contact Hours/ Week	0+0+2 (L+T+P)	Credits:	1.0
Total Lecture Hours	0	CIE Marks:	50
Total Practical Hours	26	SEE Marks:	50
Sub. Code	S5CHL01	Semester	5

Course objectives:	
1	Perform the experiments to determine water and waste water quality
2	Understand the water & waste water sampling, their quality standards

3	Estimate quality of water, waste water, Industrial water
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Experiments:	
1	Determine the alkalinity in a given sample of water
2	Determine the acidity in a given sample of water
3	Determine the salinity in a given sample of water
4	Determine the chloride in given sample of water.
5	Determine the quantity of dissolved oxygen present in the given sample of water.
6	Determine the amount of total solids, Dissolved solids, Suspended solids present in a given sample of water.
7	Determine the turbidity of the given sample of water.
8	Determine the electrical conductivity of the given sample.
9	Determine the chemical oxygen demand of the given sample
10	Find out Nitrate nitrogen present in the given sample.
11	Determining optimum coagulant dosage by Jar test
12	Determine the biological oxygen demand of the given sample.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Know about the equipment used to conduct the test procedures
CO2	Perform the experiments in the lab
CO3	Examine and Estimate water, waste water, air and soil Quality
CO4	Develop a report on the quality aspect of the environment
CO5	Compare the water quality standards with prescribed standards set by the local governments

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	2					3							3		
	CO2	2					3							3		
	CO3	2					3							3		
	CO4	2					3							3		
	CO5	2					3							3		

PLANT UTILITIES

Contact Hours/ Week	3+0+0 (L+T+P)	Credits:	3.0
Total Lecture Hours	39	CIE Marks:	50
Total Tutorial Hours	0	SEE Marks:	50
Sub. Code	S5CHPE11	Semester	5

Course objectives:	
1.	Select Various Methods For Water Softening And Purification.
2.	Explain Different Types of Steam Generators and Compressors along with their components.
3.	Select Refrigeration For Various Applications.

4.	Understand the concepts of energy efficiency and green chemistry for conservation of utilities.
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UNIT I	
Compressed Air: Types, construction and working: Reciprocating (Single and double), centrifugal and gear compressors, fans and blowers. Power requirement and performance calculations. Instrument Air	
Vacuum Systems: Basic Concepts of vacuum and pressure, Components of vacuum system like vacuum chamber, pumps, gauges, valves, seals, and many other subsidiary components, Vacuum generation and Piping.	
8 Hours	

UNIT II	
Steam And Power: Fire tube boilers and water tube boilers, examples, boiler mountings and accessories, boiler performance and its calculation	
Cogeneration power plants. Fuels: Types, Proximate and ultimate analysis, Calorific value and its calculation.	
8 Hours	

UNIT III	
Refrigeration And Cold Storage: Refrigeration cycles, Refrigerants and their characteristics, chilled water plant, Coefficient of performance, Power requirement and related calculations. Air Conditioning: Air-conditioning system and its, components Insulation: Types of insulation, Different types of insulating materials and their characteristics, Selection criteria for insulating materials.	
8 Hours	

UNIT IV	
Cooling Water: Principle, types and construction of cooling towers, related calculations, humidification and dehumidification chambers.	
Utility Piping: Colour codes for piping, Chilled Water Insulation Piping, Compressed Air Piping, Water Utility Piping, Cooling Coil Heat Transfer, Anti Fire Pipes and steam piping.	
8 Hours	

UNIT V	
Water and Its Treatment: Sources of water, hard and soft water, Requisites of industrial water and its uses, Methods of industrial water treatment: Chemical softening, Demineralization Resins used for water softening, reverse osmosis and membrane separation, Effects of impure boiler feed water & its treatment.	
8 Hours	

Text Books		
1	D. B. Dhone	Plant utilities, Nirali Prakashan, Pune, 2e, 2018
2	Sathiyamoorthy Manickkam	Chemical Plant Utilities, Lambert Academic Publishing; India, 2016, ISBN:9783659978289

Reference Books		
1	P. K. Nag	Power Plant Engineering, Tata Mc Graw Hill-2007, ISBN:9780070648159
2	B. K. Sarkar	Thermal Engineering, Tata Mc Graw Hill, 2001, ISBN:9780074633632
3	C. P. Arora	Refrigeration and Air conditioning, 3e, McGraw Hill Companies, 2006, ISBN:9789351340164
Course Outcomes: Upon completion of this course, student will be able to:		
CO1	Enlist the applications of utilities in chemical processes.	
CO2	Identify the equipment used for a utility, describe their construction and working.	
CO3	Apply thermodynamic principles involved in utility generation and perform the relevant calculations.	
CO4	Compare equipment based on their relative advantages and disadvantages.	
CO5	Evaluate equipment based on their performance and efficiency calculations.	

		POs											PSOs			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1	2	3											3		
	CO2	2	3											3		
	CO3	2	3											3		
	CO4	2	3											3		
	CO5	2	3											3		

CHEMICAL PROCESS INDUSTRIES

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S5CHPE12	Semester	5

Course objectives:	
1	Describe the role of a process engineer in chemical industry
2	Train students to identify different unit operations and unit processes in a given process flow diagram
3	Teach chemical processes with an emphasis on recent technological developments
4	Introduce process technologies, availability of raw materials, production trends, preparation of flow sheets, engineering problems of chemical processes
5	Train to troubleshoot various errors in process lines, vessels, and reactions in chemical processes

UNIT I
Carbohydrate and fermentation industries: Manufacture of Sucrose, starch and Starch derivatives. Manufacture of Ethyl Alcohol, Citric Acid, Acetic acid and beer by fermentation.
8 Hours

UNIT II	
Edible and essential Oils, soaps and detergents: Production and extraction of vegetable oils, Hydrogenation of oils, refining of oils, production of fatty acids, glycerine and soap, Production of detergents. Pulp and paper industries: Methods of pulping, Production of pulp, Production of paper.	
8 Hours	

UNIT III	
Chlor - Alkali Industries: Manufacture of soda ash, Caustic soda and Chlorine. Industrial gases: Manufacture of Carbon dioxide, Hydrogen, Oxygen and Nitrogen, Water gas, Producer gas. Cement Industries: Manufacture of cement.	
8 Hours	

UNIT IV	
Sulfur industry: Elemental sulphur mining and Manufacture of sulphur. Acids: Manufacture of sulphuric acid, Hydrochloric acid, Phosphoric Acid and Nitric acid Fertilizer industry: Manufacture of Ammonia, Urea, Calcium Phosphates, Ammonium Phosphates.	
8 Hours	

UNIT V	
Polymer and Rubber industries: Polyethylene, PVC and SBR, Viscose rayon, Nylon. Semiconductor Substrate manufacturing process: Manufacturing of Silicon Wafer, Silicon Carbide (SiC) wafer, Galium Nitride (GaN) wafer and Silicon on Insulator (SoI) wafer. Specialty Gases manufacturing process: Ultrahigh purity bulk gas manufacturing and Specialty process gas manufacturing.	
8 Hours	

Textbooks		
1	M Gopal Rao	Dryden: Outlines of Chemical Technology for 21st Century, EWP. 3e, 2010. ISBN: 9788185938790

Reference Books		
1	George T. Austin	Shreve's Chemical Process Industries, McGraw Hill Education, 5e, 2017, ISBN: 9781259029455.
2	G. N. Pandey	A Textbook of Chemical Technology Volume-II, 2e, 2018, Sangam Books Ltd. ISBN: 9780706986877
3	S Wolf	Microchip Manufacturing, Lattice Pr, USA, 2003. ISBN: 978-0961672188

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Explain the Production of Carbohydrate and fermentation industries
CO2	Outline the Production of soaps and detergents and pulp and paper manufacturing processes
CO3	Illustrate the Production of various inorganic products, industrial gases and

	cement
CO4	Identify Various types of fertilizers and their production methods and also to learn about various industrial acids and sulfur industry
CO5	Analyse the various Polymer and Rubber products and gain knowledge on various aspects of semiconductor manufacturing processes

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	3	2										3	3		
CO2	3	2										2	2		
CO3	3	2										2	2		
CO4	3	2										2	2		
CO5	3	2										2	2		

BIOENERGY ENGINEERING

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S5CHPE13	Semester	5

Course objectives:

1	Identify potential biomass feedstock including energy crops
2	Learn the importance of pre-treatment and use appropriate pre-treatment method.
3	Understand the existing and emerging biomass to energy technologies
4	Widen knowledge on concept of biorefinery and biomass utilization
5	Perform case studies on certain biofuels

UNIT I

Introduction to Biomass and its chemistry: World energy outlook, Biomass availability & potential, Traditional biomass and energy crops, Biomass characterization, Biomass composition, structure of wood, carbohydrate chemistry, Lignin.

8 Hours

UNIT II

Biomass Pre-processing and Pre-treatment: Importance of pretreatment, Types of pretreatments, Acid pretreatment, Alkaline pretreatment. Densification, Torrefaction, Hydrothermal Carbonization

8 Hours

UNIT III

Biomass Conversion Technologies: Biomass gasification, Biomass pyrolysis, Hydrothermal processing, Transesterification, Biochemical conversion, Bio methanation, Bioethanol production

8 Hours

UNIT IV	
Biofuel Utilization and Bio refinery Concept: Combustion, Co-firing, Fuel Cell Technology, Biomass Gasification Combined Cycle, Bio refinery Classification, Building Block Chemicals for bio refinery, Microbial fuel cell	
8 Hours	

UNIT V	
Case studies: Bio-ethanol from starch and other biomass, Biogas from water hyacinth, Biodiesel Jatropa and Gasoline production.	
8 Hours	

Text Books		
1	Mark Crocker	Thermochemical Conversion of Biomass to Liquid Fuels and Chemicals, 2010, RSC Publishing, ISBN:9781849730358.
2	Donald L. Klass	Biomass for Renewable Energy, Fuels and Chemicals ,1998, Academic Press, San Diego, CA. ISBN:9780124109506.

Reference Books		
1	Daizo Kunii and Octave Levenspiel	Fluidization Engineering, 2e. Butterworth- Heinemann series in Chemical Engineering, 2e. 1991, ISBN:0-409-90233-01.
2	Brigit Kamm, Patrick R. Gruber and Michael Kamm,	Biorefineries-Industrial Processes and Products: Status Quo and Future Directions, 2008, Vol. 1& 2. Wiley-VCH, Weinheim, Germany.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Describe the nature and principle of different biomass energy extraction systems.
CO2	Identify how to choose the suitable biomass fuels for different bio- energy applications
CO3	Recognize drivers and barriers for biofuel production
CO4	Develop sustainable biofuel production considering ecological and socio-economic criteria
CO5	Analyze the experimental data from literature through case studies

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	2	3					3					2			
CO2	2	3					3					2			
CO3	2	3					3					2			
CO4	2	3					3					2			
CO5	2	3					3					2			

FOOD ENGINEERING

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S5CHPE14	Semester	5

Course objectives:

1	Identify contaminants associated with food
2	Appreciate the significance of food additive
3	Understand food preservation and related engineering aspects
4	Appreciate the significance of packaging
5	Learn recent trends food preservation

UNIT I

Introduction to Food Engineering: Introduction: general aspects of food industry, world food demand and Indian scenario, **Physical properties of food materials:** Rheological models, Water activity, Fluid Flow in Food Processing: Liquid Transport Systems, Pipes for Processing Plants, Pumps for food plants; Numerical on fluid flow in food processing.

8 Hours

UNIT II

Food Processing and Preservation: Food deterioration – Causes, Aims and objectives of preservation and processing. **Food Contamination and Adulteration:** Types of adulterants and contaminants, Intentional adulterants, Metallic contamination, Incidental adulterants, Nature and effects, food laws and standards, Hazard analysis and critical control points or HACCP, Food Safety and Standards Authority of India (FSSAI) **Non Thermal Preservation:** Cold sterilization: Gamma irradiation; Microwave & Ohmic heating, Pulsed Electric Field, High Pressure Processing.

8 Hours

UNIT III

High-Temperature Preservation: Introduction to Thermal Processing; Pasteurisation; Commercial Sterilization Kinetics of Microbial Death; Thermal Death Time; Heat Transfer in Thermal Processing; Integrated F Value; Numericals; Batch & continuous Retorts for Thermal processing. **Low-Temperature Preservation:** Principles of low temperature preservation; freezing rate & freezing point; physical properties of frozen food; food quality during frozen storage; freezing equipment, plate freezer, blast freezer, fluidised bed freezer, scraped surface freezer; cryogenic and immersion freezing; prediction of freezing time using Plank's equation & Nagaoka's equation.

8 Hours

UNIT IV

Food Additives: Introduction and need for food additives, Types of additives – antioxidants, chelating agents, colouring agents, curing agents, emulsions, flavors and flavor enhancers, flavor improvers, humectants and anti-caking agents, leavening agents, nutrient supplements, non-nutritive sweeteners, pH control agents. Preservatives: types and applications, Stabilizers and thickeners, other additives, Additives and food safety.

8 Hours

UNIT V

Extrusion Processes: Introduction to Extrusion, Basic Principles, Extrusion Systems, Cold Extrusion, Extrusion Cooking, Single Screw Extruders, Twin- Screw Extruders. 3D Printing of Food. **Packaging Concepts:** Introduction to packaging, food protection, product containment, commutation, convenience, mass transfer in packaging materials, and permeability of packaging material to fixed gases, innovations in food packaging, passive packaging, active packaging, intelligent packaging, food packaging and product shelf-life. Advances in aseptic processing and packaging, nutrition labeling.

8 Hours

Text Books

1	R. Paul Singh and Dennis R	Introduction to Food Engineering, Elsevier Science & Technology, 5th Edition, 2013, ISBN:9780123985309,
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Reference Books

1	G. Smith	Introduction to Food Process Engineering 2 nd Edition, 2009, Springer Press, ISBN 978-1-4419-7661-1
2	Subbulakshmi G. and Shobha A	Food Processing and Preservation, New Age International Pvt. Ltd. 2001, ISBN:8122412831

Course Outcomes: Upon completion of this course, student will be able to:

CO1	Identify process utilities and its significance in food industry.
CO2	Comprehend the significance of contamination and adulteration in food and processing
CO3	Analyze and select a suitable food preservation technique
CO4	Understand the need of food additives and its safety aspects
CO5	Discern different technological change and recent advancements involved in food processing and packaging.

	POs											PSOs				
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
COs	CO1		3										2			
	CO2	2												2		
	CO3			3									2			
	CO4							3					2			

	CO5					3					2			
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APTITUDE RELATED ANALYTICAL SKILLS

Contact Hours/ semester	0+0+2 (L+T+P)	Credit	1.0
Total Lecture Hours	0+0+26	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	ARAS	Semester	5

MODULES COVERED:

No.	Module covered	Duration (in hrs.)
1	Quantitative Aptitude	16
2	Verbal Reasoning	08
3	Logical Reasoning	08
4	Test taking strategies to crack recruiter tests	02
5	Post-Training Assessment along with a debrief	02
	Total Course Duration	36

Methodology: Instructor led–Concepts with guided question solving, assignments and homework assessments.

Detailed syllabus:

1. Quantitative Aptitude (with focus on questions from top recruiters)
Number System: Classification of numbers, Divisibility tests, Power cycles and remainders, Factors and multiples, Applications of HCF and LCM
Profit and Loss, Partnerships and Averages: Basic terminology in Profit and Loss, Partnerships, Averages and weighted averages, Mixtures and alligations.
Time and Work: Working with different efficiencies, Pipes and cisterns, Work equivalence, Division of wages.
Time, Speed and Distance: Basics of Time Speed and Distance, Relative Speed, Problems based on trains, Problems based on boats and streams, Problems based on Races.
Percentages, Simple and Compound Interest: Percentages as fractions and decimals, Percentage increase / decrease, Simple interest and compound interest, Relationship between simple and compound interest.
Permutation, Combination and Probability: Fundamental counting principle, Basics of permutation and combination, Computation of permutation, Circular permutation, Computation of combination Probability.
Logarithms, Progressions, Geometry and Quadratic Equations: Logarithms, Progressions – Arithmetic, Geometric and Harmonic, Geometry, Mensuration, Quadratic equations.
16 Hours

2. Verbal Reasoning (with focus on questions from top recruiters)		
Reading Comprehension: Eyespan, Speed reading techniques, Types of questions, Comprehension strategies. Sentence Correction: Subject-Verb Agreement, Parallelism, Modifiers, Pronoun Antecedent Agreement, Verb Time Sequence, Comparison, Determiners, Prepositions. Vocabulary: Etymology of words, Prefix and suffix, Memory techniques to remember words, Synonyms and antonyms, Analogy. Sentence Completion and Para Jumbles: Sentence completion – single blank and double blank questions, Parajumbles – Moving and anchored jumbles.		
8 Hours		
3. Logical Reasoning (with focus on questions from top recruiters)		
Coding and Decoding, Series, Analogy, Odd Man Out and Visual Reasoning: Coding and decoding, Number and alphabet series, Analogy, Odd man out, Visual Reasoning. Data Arrangements and Blood Relations: Linear, circular and distribution arrangements, Blood Relations. Data interpretation and Data Sufficiency: Tables, Pie Charts, Bar Graphs, Data Sufficiency. Clocks, Calendars, Direction sense and Cubes: Clocks, Calendars (Conventional and shortcut methods to find day of a date), Cubes, Direction Sense.		
8 Hours		
4. Test taking strategies - This module will focus on:		
Understanding patterns of tests (Adaptive, non adaptive, navigation – intra sectional, inter sectional) Best strategies to maximize scores and clear cut-offs Shortcut strategies on Quantitative Aptitude, Logical Reasoning as well as Verbal Ability to ace sections		
2 Hours		
5. Post Training Assessment with debrief		
An assessment that tests a student on all three sections of Aptitude, followed a detailed student-wise analysis based on: Cut-off: Percentile w.r.t the batch, Percentile w.r.t. the college Corrective measures to be taken to improve the score In class, there will be a debrief on how the test should have been taken by an ideal test taker to navigate through the difficulties and ace the cut-off.		
2 Hours		

Tests outside training schedule:		
An ideal aptitude training course is a mix of classroom learning / guided question solving, followed by self-practice. The ‘training duration’ focuses mainly on laying strong foundations on concepts and ability to solve questions on major aptitude topics. Significant amount of practice is also provided to students through online tests in the form of: Pre-Assessment test: Full-length practice tests, Company specific tests (patterns and question types of major recruiters should be given exposure to).		
2 Hours		

Reference Books:		
1	Face Wiley India	Aptipedia, Aptitude Encyclopedia, Wiley India Ltd. 2017, 2e, ISBN:978-8126569502
2	R S Agarwal	Quantitative Aptitude for Competitive Examinations, SChand Publishing ,2022, New Delhi, ISBN:978-9355012326
3	Nisht K Sinha	The Pearson Guide to Verbal Ability and Logical Reasoning for the CAT, 1e, Pearson Education, 2012, ISBN:978-8131774137

ENVIRONMENTAL STUDIES

Contact Hours/ week	2+0+0 (L+T+P)	Credits:	2.0
Total Lecture Hours	24	CIE Marks:	50
Total Tutorial Hours	0	SEE Marks:	50
Sub. Code	SHS05	Semester:	5

Course Objectives:

1	Describe problems of depletion of natural resources due to deforestation, mining agricultural practices, adverse environmental effects, pesticides, soil erosion,
2	Explain the different types of energy- renewable, non-renewable and energy conservation, the impact of environmental pollution on water quality, air quality, soil pollution and noise pollution.
3	Describe solid waste management- disposal, treatment of different types of solid waste including MSW, e-waste, biomedical waste, the societal impact of environmental issues- ozone layer depletion, GHG effects, water conservation and harvesting and environmental protection & Acts

UNIT I

Introduction: Components of Environment and their interactions. **Natural Resources:** Forest Resources-Deforestation, Causes of deforestation, Environmental effects of deforestation and solutions. Water resources, World's water reserves, Hydrological cycle. Land resources Land degradation. Soil erosion, Causes and prevention, Soil conservation and its types. Numerical problems on rainfall & runoff

6 Hours

UNIT II

Energy and resources: Types of Energy-Renewable, Non-renewable & sustainable energy & their advantages and disadvantages. Renewable energy sources- Solar energy, Wind energy, Tidal energy, Ocean thermal energy. Geothermal energy, Hydroelectric power, Biomass energy, Hydrogen energy, Thermal power-environmental impacts. Conservation of energy. Numerical problems on Solar energy, Wind power

6 Hours

UNIT III

Environmental pollution: Sources of pollution- Natural and anthropogenic sources. Pollutants - Classification & their effects on environment. Air Pollution -Composition of clean air, Sources of air pollution, Effect of air pollution on human health and climate. Water quality – Potable water, Wholesome water, Sources of water pollution Polluted water & Contaminated water. Common impurities in water (physical, chemical and bacteriological), Effects of impurities on human health. Soil Pollution – Sources, effects, and its control. Noise pollution- Sources of noise, Effects on human health & its control Numerical problems on pH, hardness of water, noise pollution.

6 Hours

UNIT IV

Solid Waste Management: Refuse, Garbage, Rubbish, Ash, types of solid waste. Necessity of safe disposal, impacts on human health and environment. Classification of solid wastes- Quantity and composition of MSW, Collection of solid waste-methods. Disposal of solid waste-Sanitary land-fill. E-waste- Problems and solutions. Biomedical waste-Impacts on human health, storage, treatment methods and disposal. Numerical problems on moisture content, density & proportioning of land fill

5 Hours

UNIT V

Sustainable development: Issues on energy utilization, water conservation, concept of 3 R's, Rain water harvesting- methods. **Global environmental issues:** Population growth, Urbanization, Global warming, Acid rains, Ozone layer depletion & controlling measures. Environmental acts, Regulations, Role of state & central governments, Numerical problem on carbon foot print & rainwater harvesting.

5 Hours

Text Books

1	Joseph, B	Environmental Studies (2009), India: Tata McGraw-Hill. ISBN: 9781283922524
2	Tripathi, A. K	Environmental Studies (2016), India: Energy and Resources Institute. ISBN:9788179935828

References

1	Erach Bharucha	Environmental studies for Undergraduate Courses, 1st Edition, University Press, (2013)
2	Santhosh Kumar Garg	Environmental Science and Engineering Ecology and Environmental Studies, Khanna Publishers, (2015), ISBN-10:8174092188 ISBN-13:978-8174092182

Course Outcomes: Upon completion of this course, student will be able to:

CO1	Explain the importance of forestation, effects of deforestation, land degradation, adverse effects of mining on environment, using the principles of natural sciences compute the runoff from rainfall & estimates the conservation of water for beneficial use of humans.
CO2	Choose appropriate renewable energy sources by formulating, reviewing the literature, calculating the power potential of solar & wind energy and using the principles of natural sciences.
CO3	Explain the effects of pollution of air, water, soil & noise on humans and the environment, identify and analyze the pollution problems related to air, water, soil & noise and quantify pollution levels & draw valid inferences using the principles of engineering sciences
CO4	Describe Impact of solid waste on human health and environment, its safe disposal. Use population data & compute percapita solid waste generation, land area requirement for sanitary landfill

CO5	Appreciate the importance of sustainable development, current global environmental issues, present state & central governments protection acts, compute carbon footprint using data (vehicles/industries) & asses its impact on the environment.
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COs	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
1						2							2		
2						2							2		
3						2							2		
4						2							2		
5						2							2		

RESEARCH METHODOLOGY AND IP RIGHTS

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Lecture Hours	0	SEE Marks	50
Subject Code	RMIP	Semester	5

UNIT-I

Research Methodology: Objectives and motivation of research - Types of research - Research approaches - Significance of research - Research methods verses methodology- Research and scientific method - Importance of research methodology - Research process - Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations- Criteria of good research. **Defining the research problem:** Definition of research problem - Problem formulation - Necessity of defining the problem - Technique involved in defining a problem.

8 Hours

UNIT-II

Literature Survey and Data Collection: Importance of literature survey - Sources of information - Assessment of quality of journals and articles - Information through internet. Effective literature studies approach, analysis, plagiarism, and research ethics. Data - Preparing, Exploring, examining and displaying. Referencing methods

8 Hours

UNIT-III

Research Design and Analysis: Meaning of research design - Need of research design - Different research designs - Basic principles of experimental design - Developing a research plan - Design of experimental set-up - Use of standards and codes. Overview of Univariate / Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

9 Hours

UNIT-IV	
Intellectual Property Rights (IPR): Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.	
8 Hours	

UNIT-V	
Patent Rights (PR): Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. Licenses, Licensing of related patents, patent agents, Registration of patent agents.	
9 Hours	

Text Books		
1.	Prof. Kothari C. R.	Research methodology: Methods and techniques, New Age International, 5th Edition, 2023. ISBN:978-9389802559
2.	R. Ganesan	Research Methodology for Engineers, MJP Publishers, Chennai, 2011.

Reference Books:		
1.	Cooper Donald R, Schindler Pamela S and Sharma JK	Business Research Methods, Tata McGraw Hill Education, 11th Edition, 2012.
2.	Catherine J. Holland	Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, Entrepreneur Press, 2007.
3.	David Hunt, Long Nguyen, Matthew Rodgers	Patent searching: tools & techniques, Wiley, 2007.
4.	The Institute of Company Secretaries of India	Professional Programme Intellectual Property Rights, Law and practice, September 2013.
5.	Peter S. Menel Mark A. Lemley, Robert P. Merges	Intellectual Property in the New Technological-Vol. I Perspectives, 2021.
6.	Laura R. Ford	The Intellectual Property of Nations: Sociological and Historical Perspectives on a Modern Legal Institution Paperback-2021.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Describe the research process & formulate research problem
CO2	Perform literature review, manage data & practice research ethics
CO3	Practice basic principles of experimental design, use standard codes and carry out research analysis

CO4	Distinguish between types of innovation, describe patenting procedure, maintenance and role of IPR establishments
CO5	Identify the significance of patent rights, licensing, technology transfer & manage patenting system

MINI PROJECT

Contact Hours/ Week	0+0+4 (L+T+P)	Credits	2.0
Total Practical Hours	52	CIE Marks	50
Total Practical Hours	0	SEE Marks	50
Sub. Code	S5CHMP	Semester	5

Course Objectives:

1	Educate the students to identify unmet societal needs and train them to apply basic sciences and chemical engineering principles to solve them.
2	Guide the students to use latest research methods and modern engineering and design tools to provide valid conclusions.
3	Create awareness about importance of professional ethics and implications of the proposed solution.
4	Guide the students to function effectively as an individual or in a team to solve a problem.
5	Educate the students to effectively communicate the unmet need and their proposed solution.
6	Introduce the need for further knowledge and continuous development of competencies including innovation and entrepreneurship.

Guidelines:

The project can be taken by group of 4 students and mini project can be carried out in the dept. under a guide or outside the department/institute/ company under a guide from the dept. and co guide from the outside department/institute/ company.

Mini project is evaluated over 2 semesters (V & VI) and is evaluated at the end of each semester. With no credit in the V sem., Mini project is evaluated for 100 marks at the end of VI semester (50% CIE & 50% SEE).

Break-up of CIE marks for Mini Project

Project Report	20 marks
Project Presentation Skills	10 marks
Viva-Voce (Q&A Session)	10 marks
Guide Assessment	10 marks
TOTAL	50 marks

Break-up of SEE marks for Mini Project

Project Report, Presentation, Demonstration & Quality of Work	30 marks
Viva-Voce	20 marks
TOTAL	50 marks

Summary of Evaluation pattern – Mini Project Work

Exam Details	Max. Marks	Min. Marks
CIE	50 marks	20 marks
SEE	50 marks	20 marks
TOTAL	100 marks	40 marks

Course Outcomes: On completion of the course, the student will be able to	
1	Identify a problem from literature review and knowledge of chemical engineering technology.
2	Consolidate the literature review to identify issues/gaps and formulate the hypotheses.
3	Formulate objectives and prepare project schedule for the identified design methodology and budget analysis.
4	Conduct investigations and analyze, interpret and draw valid conclusions from experimental results.
5	Apply modern engineering tools like process modelling, simulation and optimization to the problem with an understanding of the constraints.
6	Apply basic concepts of science, engineering, design and economics to develop sustainable process engineering solutions or design process equipment.
7	Consider societal, health, safety, legal and cultural issues and concern for the environment while implementing the process solutions.
8	Display professional ethics in the conduction of experiments, data analysis and reporting.
9	Demonstrate effective written communication in the form of project report or research publication.
10	Engage in effective oral communication through power point presentation and project demonstration.
11	Function effectively as an individual or as a member or leader in a team, and in multidisciplinary settings to solve the given problem.

	POs											PSOs				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	
COs	CO1		3											3		
	CO2			3						2				3		
	CO3			3	3									3		
	CO4					3						3			3	
	CO5	3		2									3			3
	CO6						3							3		
	CO7							3						3		
	CO8									3		2		3		
	CO9									3		2		3		
	CO10								3					3		
	CO11		3											3		

AICTE ACTIVITY POINTS

Contact Hours/ Week:	0+0+0 (L+T+P)	Credits	0
Total Lecture Hours:	0+0+40 hours	CIE Marks	100
Total Tutorial Hours:	0	SEE Marks	0
Sub. Code:	AAP	Semester	5

VI Semester

PROCESS DYNAMICS AND CONTROL

Contact Hours/ Week	3+0+2 (L+T+P)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Practical Hours	26	SEE Marks	50
Sub. Code	S6CHI01	Semester	6

Course Objectives:

1.	Learn the concepts of first order systems and its response for various types of input.
2.	Conceptualize the importance of interacting and non-interacting systems
3.	Know the importance of various controllers and final control elements.
4.	Understand the concepts of open loop system and closed loop system.
5.	Describe the various criteria involved in stability of a system and performing the stability test.

UNIT I

First-order systems: Transfer function, transient response, forcing functions, step response, impulse response, ramp response, sinusoidal response. **Examples of first-order systems:** Liquid level, liquid-level process with constant-flow outlet, mixing process, heating process; Linearization. Conceptual numerical.

8 Hours

UNIT II

First-order systems in series: Non-interacting system, several non-interacting systems in series; interacting system. **Second-order systems:** Manometer, Damped vibrator, Transfer function, step response, terms used to describe an under-damped system, impulse response, sinusoidal response; Transportation lag.

8 Hours

UNIT III

Control system: Components of a control system, development of block diagram.

Controllers and final control elements: Control valve and controller mechanisms, ideal transfer function of control valve, Proportional control, on/off control, PI, PD, and PID control actions.

8 Hours

UNIT IV

Closed-loop transfer functions: Overall transfer function for single-loop and multi-loop control systems. **Transient response of simple control systems:** Proportional control for set point and load changes, PI control for load and set point changes, Proportional control of system with measurement lag.

8 Hours

UNIT V

Stability: Concept, criterion, and characteristic equation; Routh test for stability. Frequency response: Substitution rule, Bode diagrams. **Advanced control techniques:** Cascade, feed-forward and ratio controls. **Controller tuning techniques:** Ziegler-Nicholas method and Cohen-Coon method.

8 Hours

Text Books

1	Coughanowr, D. R. and LeBlanc, S. E	Process Systems Analysis and Control, McGraw Hill, New York, 3e, 2009. ISBN: 9780073397894
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Reference Books

1	Seborg, D. E., Edgar, T. F., Mellichamp, D. A. and Doyle, F. J	Process Dynamics and Control, Wiley India Pvt Ltd, New Delhi, 3e, 2011. ISBN: 9788126541263
2	Svrcek, W. Y., Mahoney, D. P. and Young, B. R.	A Real-Time Approach to Process Control, John Wiley & Sons Ltd, Chichester, 3e, 2014. ISBN:9781119993889.

Course Outcomes: Upon completion of this course, student will be able to:

CO1	Interpret the response of various first order systems.
CO2	Solve various problems associated with various first order systems in series
CO3	Choose suitable controllers and final control element for any process control operations
CO4	Address the use of closed loop systems in controlling any processes using P, PI, PD and PID controllers
CO5	Analyze the stability of the control system using Routh Array and Root Locus techniques

PROCESS DYNAMICS AND CONTROL LABORATORY

Experiments:

1	Determine the response to a step input of a thermometer and find the time constant
2	Determine the response to a step input of a thermometer and find the time constant
3	Study the dynamics and compare theoretical response with actual response for a Step forcing function in a two tank non-interacting system.
4	Study the dynamics and compare theoretical response with actual response for a step forcing function in a two tank interacting system.
5	Study the dynamics and compare theoretical response with actual response for a step input to a single tank system.
6	Determine the response to step input of a pressure system
7	Study the performance of ON-OFF/P/PI/PD/PID controllers on flow process
8	Study the performance of ON-OFF / P / PI / PD / PID controllers on Pressure process
9	Study the performance of ON-OFF/P/PI/PD/PID controllers on pH process

10	Study the characteristics of thermocouple with and without compensation
11	Study the temperature characteristics of AD-590 transducer
12	Study the characteristics of resistance temperature detector
13	Study the characteristics of thermistor

COs	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
1	3													3	
2	2	3												3	
3	2	2												2	
4	2										2			2	
5	2										2				

SEPARATION PROCESSES

Contact Hours/ Week	3+2+0 (L+T+P)	Credits	4.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	26	SEE Marks	50
Sub. Code	S6CH01	Semester	6

Course Objectives:	
1.	Develop familiarity with the basic principles of extraction, absorption, adsorption, crystallization and novel separation processes to enable selection of appropriate recovery process.
2.	Introduce the fundamentals of molecular diffusion and convective diffusion in the context of extraction, absorption, adsorption, crystallization and novel separation processes.
3.	Describe the mass transfer principles, material and energy balance to solve problems related to extraction, absorption, adsorption, crystallization and novel separation processes.
4.	Choose appropriate recovery process and perform basic design of the mass transfer equipment involved.
5.	Demonstrate the knowledge and need for sustainable operations including extraction, absorption, adsorption, crystallization and novel separation processes in the context of environment and economics

UNIT I

Absorption: Gas solubility in liquids at equilibrium, ideal and non-ideal liquid solutions, choice of solvent for absorption, design of isothermal absorption towers, overall transfer units, desorption, design of Packed tower absorber.

8+6 Hours

UNIT II	
Extraction: Equilibria, Equilateral-triangular coordinates, partially soluble system, Operations: single stage operation, multistage cross-current operation, multistage counter-current operation, insoluble systems: single stage operation, multistage cross-current operation. Extraction Equipment: mixer-settler, rotating disc contactor, pulsed column extractor. Leaching: Phase and equilibrium diagram, single stage contact, multistage cross current and countercurrent operation. Leaching equipment.	
13+10 Hours	

UNIT III	
Adsorption: Types of adsorption, equilibria, hysteresis, adsorption isotherms, operation: single stage operation, multistage cross-current operation, multistage counter-current operation, Adsorption Equipment: fluidised beds, moving bed adsorber.	
8+5 Hours	

UNIT IV	
Crystallization: Classification of crystals, invariant crystal, principles of crystallization – purity of product, equilibria and yield, enthalpy balance, supersaturation, nucleation, crystal growth, crystallizers: agitated tank crystallizer, Swenson-walker crystallizer, vacuum crystallizer and draft tube baffle crystallizer.	
7+5 Hours	

UNIT V	
Novel Separation Processes: Membrane separation process; solid and liquid membranes; reverse osmosis; electro dialysis; their applications.	
4 Hours	

Text Books		
1	R. E. Treybal	Mass Transfer Operation. Mc Graw Hill. NY; 3e, 2017, ISBN: 9781259029158
2	K. V. Narayanan and B. Lakshmikutty	Mass Transfer-Theory and Applications. CBS Publishers, NewDelhi, 2e, 2023, ISBN:9789354666094

Reference Books		
1	N. Anantharaman and K. M. M. S. Begum	Mass Transfer: Theory and practice. PHI Learning Private Limited, 2013, ISBN: 9788120341692
2	J. M. Coulson and J. F. Richardson	Chemical Engineering. Vol I/Vol II, Elsevier India, 7th Edition, 2017, ISBN: 9780081010990
3	W. McCabe and J. M. Smith	Unit Operations in Chemical Engineering. McGraw Hill; 7e, 2017, ISBN: 9788184959635
4	C. J. Geankopolis	Transport Processes and Unit Operations. Prentice Hall of India, New Delhi; Fourth Edition, 2013, ISBN:9781292026022

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Solve problems in absorption and perform basic design of absorption columns by applying the basic concepts of thermodynamic equilibrium and operating lines, analyze and communicate the solutions
CO2	Develop extraction and leaching processes by applying the fundamental concepts of thermodynamic equilibrium and operating lines, analyze and communicate the solutions
CO3	Solve problems in adsorption and perform basic design of adsorbers by applying the concepts of thermodynamic equilibrium and kinetic curves, analyze and communicate the solutions
CO4	Develop crystallization processes by applying the fundamental concepts of thermodynamic equilibrium and operating lines, analyze and communicate the solutions
CO5	Solve problems in novel membrane separation processes by applying mass transfer concepts of, analyze and communicate the solutions

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

MEMBRANE TECHNOLOGY

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S6CHPE21	Semester	6

Course objectives:	
1	Learn the principles of membrane technology and engineering aspects of membrane separation processes, including pervaporation, reverse osmosis, ultrafiltration, microfiltration, and dialysis.
2	Develop skills in applying transport models for the calculation of membrane permeability, flux, and the extent of separation for various membrane separation systems.
3	Calculate membrane process performance and analyze membrane separation characteristics.
4	Select membrane processes for solving separation problems in various applications.
5	Describe the main polymeric materials used for membrane synthesis.

UNIT I

Introduction: Separation process, Introduction to membrane processes, definition of a membrane, classifications membrane processes. **Preparation of Synthetic membranes:** Types of Membrane materials, preparation of Synthetic membranes, phase inversion membranes, preparation technique for immersion precipitation, and preparation technique for composite membranes.

8 Hours

UNIT II

Characterization of membranes: Introduction, membrane characterization, characterization of porous membranes, characterization of non-porous membranes. Transport in membranes: introduction, driving forces, non-equilibrium thermodynamics, transport through porous, non-porous, and ion exchange membranes.

8 Hours

UNIT III

Membrane Processes: Introduction, osmosis, pressure driven membrane processes: Introduction, microfiltration, membranes for microfiltration, industrial applications, Ultrafiltration: membranes for ultrafiltration, industrial applications, Reverse Osmosis and Nanofiltration: membranes for Reverse Osmosis and Nanofiltration, industrial applications, Electrically Driven processes: Introduction, Electrodialysis, Process parameters, membranes for electrodialysis, applications, Membrane electrolysis, Bipolar membranes, Fuel Cells.

8 Hours

UNIT IV

Concentration driven membrane processes: gas separation: gas separation in porous and non-porous membranes, membranes for gas separation, applications, pervaporation, membranes for pervaporation, applications, dialysis: membranes for dialysis, applications, liquid membranes: aspects, liquid membrane development, choice of the organic solvent and carrier, applications, introduction to membrane reactors.

8 Hours

UNIT V

Polarization phenomenon and fouling: Introduction to concentration polarization, turbulence promoters, pressure drop, gel layer model, osmotic pressure model, boundary layer resistance model, concentration polarization in diffusive membrane separations and electro dialysis, membrane fouling, methods to reduce fouling, compaction. Module and process design: Introduction, plate and frame module, spiral wound module, tubular module, capillary module, hollow fiber module, comparison of module configurations.

8 Hours

Text Books		
1	M. H. V. Mulder	Membrane Separations, Springer Publications, 2e, 2007, ISBN: 9780792342489
2	P. C. Wanket	Rate-Controlled Separations, Elsevier Applied Science, London, 1e, 1994, ISBN: 9783527313167

Reference Books		
1	S. P. Nunes, K.V. Peinemann	Membrane Technology in the Chemical Industry, Wiley-VCH, 2e, 2006, ISBN: 9783527313167
2	J. G. Crespo, K.W. Bodekes	Membrane Processes in Separation and Purification, Kluwer Academic Publications, 1999, 4th Edition, 1994, ISBN: 978-0792329299
3	K. Nath	Membrane Separation Processes, PHI Pvt. Ltd., New Delhi, 1e, 2016, ISBN: 978-8120352919.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Understand the principles and materials properties for different membrane separation processes.
CO2	Identify the best membrane modules and manufacturing process for different applications.
CO3	Identify and design the suitable membrane separation technique for intended problem.
CO4	Calculate mean flux, selectivity and membrane area for the different membrane processes.
CO5	Calculate how concentration and eventually temperature polarization influence the solute transport for the different membrane processes phenomenon and fouling.

	POs											PSOs				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	
CO1	3											3				
CO2	3											2				
CO3	3		2									2				
CO4	3	2										3				
CO5	3	2										3				

WASTE WATER TREATMENT METHODS

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S6CHPE22	Semester	6

Course objectives: This course will enable students to:	
1	Understand the characteristics of water and wastewater.
2	Learn the physical, chemical and biological methods to treat wastewater.
3	Explain the various advanced wastewater treatment methods.
4	Know the various sludge treatment and disposal methods.

5	Study the performance of waste water treatment methods for different industries.
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UNIT I	
Wastewater management: Introduction, legislation, regulations, and government agencies. Wastewater Characteristics: Physical characteristics: colour, odour, temperature, turbidity, total solids. Chemical characteristics: inorganic and organic characteristics and their determination. Biological Characteristics: Classification of microorganisms, pathogenic organisms, Toxicity, Estimation of BOD, COD.	
8 Hours	

UNIT II	
Pretreatment: Equalization, Neutralization, Grease and Oil Removal, Toxic Substances. Primary Treatment: Screens, Grit Chambers, Comminutors, Gravity Sedimentation, coagulation and flocculation: types of coagulants, coagulant aids, coagulation theory, optimum dose of coagulant.	
8 Hours	

UNIT III	
Secondary Treatment: Biological process for wastewater treatment. Suspended and attached growth processes - Aerobic and Anaerobic. Activated Sludge Process, Trickling filters, Rotating Biological Contactors; Lagoons. Tertiary (Advanced) Treatment: Nutrient (N and P) removal; Chemical treatment processes; Advanced oxidation processes; Adsorption and Ion-exchange; Membrane processes.	
8 Hours	

UNIT IV	
Sludge Processing: Objectives, Concentration: Thickening and Flotation, Stabilization (Anaerobic Digestion, Aerobic Digestion, High Lime Treatment), Sludge Dewatering: Centrifugation, Vacuum Filtration, Pressure Filtration, Belt-Press Filters, Sand Beds, Sludge Disposal: Incineration, Sanitary Landfills, Beneficial Reuse of Biosolids.	
8 Hours	

UNIT V	
Wastewater Treatment in specific industries: Sugar, Dairy, Distillery, Textile, Pharmaceutical and Petrochemical industries.	
8 Hours	

Textbooks		
1	Mark J. Hammer, Mark J. Hammer, Jr.,	Water and Wastewater Technology, PHI Learning Private Ltd., New Delhi, 7e, 2012. ISBN: 9780135114049
2	Patwardhan, A.D	Industrial Waste Water Treatment, PHI learning, 2e, 2017, ISBN: 978-81- 203-3350-5

Reference Books		
1	Metcalf & Eddy	Wastewater Engineering Treatment and Reuse, McGraw Hill Education Private Ltd. New York, 2014, 5e, ISBN: 7-302-05857-1.
2	Eckenfelder, W. W.	Industrial Water Pollution Control, McGraw-Hill, 2001, 1e, ISBN: 9780070393646.
3	Don W. Green; Robert H. Perry	Perry's Chemical Engineers' Handbook, McGraw-Hill education, New York, 2008, 8e, ISBN: 9780071422949.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Illustrate the importance of water quality standards and analyze the basic characteristics of wastewater.
CO2	Apply the comprehensive knowledge of treating wastewater based on its characteristics.
CO3	Describe the various advanced wastewater treatment technologies to enhance water quality.
CO4	Identify the different methods for treating and disposing the sludge.
CO5	Identify, evaluate and propose solutions for treating wastewater for different industries.

COs	POs											PSOs				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	
1						3							3			
2						3							3			
3						3							3			
4						3							3			
5						3							3			

PETROCHEMICALS

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S6CHPE23	Semester	6

Course objectives:	
1	Illustrate the history, developments and importance of petrochemical industries along with major unit processes involved
2	Explain the manufacturing process and applications of certain Important petrochemicals produced from methane and ethylene
3	Outline the major unit operations and processes in processes involving production of petrochemicals from propane and propylene
4	Analyze engineering problems in petrochemical production from C4 olefins
5	Elaborate the production process of important petrochemicals from benzene, toluene and xylene

UNIT I

Overview of petrochemical industries: Definition of petrochemicals, overall view of petrochemicals, History of petrochemical industries, Feed stocks for petrochemical industries (Natural gas, Crude oil, Coal, oil shale, Tar sand and gas hydrates, synthesis gas), Production of hydrocarbon intermediates: Fluidized bed catalytic cracking, catalytic reforming, steam cracking, hydrocracking, hydrodealkylation.

8 Hours

UNIT II

Petrochemicals from Methane, Synthesis gas and Ethylene: Chemicals based on direct reactions of methane: Carbon Disulfide, Hydrogen Cyanide, Chloromethanes (reactions involved and uses), Chemicals based on reaction of synthesis gas: Ammonia, Methyl alcohol (The ICI low-pressure process), Formaldehyde (The Haldor Topsoe and Nippon Kasei process), Oxo Aldehydes and Alcohols, Ethylene Glycols (reactions involved, and uses) Petrochemicals based on Ethylene : Oxidation of Ethylene (The Scientific Design Co. Ethylene Oxide process), Derivatives of Ethylene Oxide (Ethylene glycols and Ethanol amines -reactions and uses), Chlorination of Ethylene, Vinyl Chloride(The European Vinyls Corporation process).

8 Hours

UNIT III

Petrochemicals from Propane and Propylene: Chemicals based on propane: Oxidation of Propane, Chlorination of Propane, Dehydrogenation of Propane, Nitration of Propane (reactions and uses). **Chemicals based on propylene:** Ammoxidation of Propylene (Montedison- UOP acrylonitrile process), Propylene oxide, Hydroformylation of Propylene: The Oxo Reaction (process description with flowsheet), Oxidation of Propylene (Acrolein, Acrylic Acid), Propylene Oxide, Oxyacylation of Propylene, Chlorination of Propylene, Hydration of Propylene.

8 Hours

UNIT IV

Petrochemicals from C4 Olefins: Chemicals from n-butane: Oxidation and isomerization of butane, The Monsanto process for producing maleic anhydride from butane, Isomerization, naphtha-based chemicals. **Chemicals from n-Butenes:** Oxidation of Butenes, hydration of Butenes, Oligomerization of Butenes (reactions and uses). **Chemicals from Isobutylene:** Oxidation of Isobutylene, Epoxidation of Isobutylene, Addition of Alcohols to Isobutylene, Hydration of Isobutylene, Carbonylation of Isobutylene.

8 Hours

UNIT V

Chemicals Based on Benzene, Toluene, and Xylenes: Review of technologies available for production of Benzene, Toluene, Xylene and Cumene UOP's EBone process manufacturing of Ethylbenzene, UOP QMax™ process for Cumene production, Production of Linear Alkyl Benzene Sulfonate for Detergents. **Reactions and Chemicals of Benzene:** Alkylation of Benzene, Chlorination of Benzene, Nitration of Benzene, Oxidation of Benzene, Hydrogenation of Benzene.

8 Hours

Textbooks		
1	B. K. Bhaskara Rao	A Text on Petrochemicals, 2004, Khanna Publishers, 5e, 2004, ISBN: 9788174090444
2	Frank (Xin X.) Zhu, James A. Johnson, David W. Ablin, and Gregory A. Ernst	Efficient petrochemical processes, John Wiley & Sons, Inc., 1e, 2020, ISBN: 9781119487869
3	Sami Pattar	Chemistry of petrochemical processes, Gulf Publishing Company, Houston, Texas, 2e, 2000, ISBN:9780080501086.

Reference Books		
1	Sarkar G. N	Advanced Petrochemicals, Khanna Publishers, 1e, 2002, ISBN: 978-8174090966.
2	Donald L. Burdick and William L. Leffler	Petrochemicals, in nontechnical language, Pennwell corporation, 4e, 2010, ISBN: 9781593702168
3	Uttam Ray Chaudhuri	Fundamentals of petroleum and petrochemical engineering, CRC Press, 1e, 2011, ISBN: 9781439851609.

Course Outcomes: Upon completion of this course, student will be able to:	
CO1	Illustrate the knowledge of history of petrochemical industries, sources for petrochemical production and unit processes for petrochemical production.
CO2	Elaborate the production process and applications of various chemicals produced from Methane, synthesis gas and ethylene
CO3	Explain the production process and applications of various chemicals produced from propane and propylene
CO4	Identify the engineering problems in the production process and applications of various chemicals produced from C4 olefins and
CO5	Explain the production process and applications of various chemicals produced from Benzene, Toluene and Xylenes

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1	2	2										2			
CO2	2	2										2			
CO3	2	2										2			
CO4	2	2										2			
CO5	2	2										2			

HETEROGENEOUS REACTION SYSTEM

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	S6CHPE24	Semester	6

Course objectives:	
1	Analyze the various contacting pattern for two phase system and predict the rate equation for heterogeneous reactions.
2	Analyze the best kinetic regimes for mass transfer and reaction for a given reaction and predict the rate equation.
3	Predict the rate controlling step for the fluid - particle reactions
4	Classify catalysts and predict physical properties of catalyst, surface area, void volume, solid density pore volume distribution
5	Understand the nature and mechanism of catalytic reactions

UNIT I

Heterogeneous Reactions: Introduction, Rate Equation for heterogeneous reactions, concept of rate controlling steps, Contacting Patterns for two phase systems. Derivations and problems, **Catalysis:** Introduction, Mechanism Types, Properties of Catalyst (Interfacial area, Physical Adsorption), Preparation, Promoters and Inhibitors, Poisoning of Catalysts, Surface area measurement, Measurement of void volume and solid density. Problems.

8 Hours

UNIT II

Deactivation catalyst: Types, Mechanism, Rate equation for main reaction and deactivation. Problems. Determining the Rate for Independent Deactivation, Batch-Solids+ Batch-Fluid. Batch-Solids+ Mixed Constant Flow of Fluid, Batch-Solids+ Mixed Changing Flow of Fluid (to keep CA fixed). Batch- Solids+ Plug Constant Flow of Fluid, Batch-Solids+Plug Changing Flow of Fluid (to keep CA fixed).

8 Hours

UNIT III

Solid Catalysed Reactions: Characteristics of catalysed reaction, Mechanism, Pore diffusion resistance combined with surface kinetics, Single cylindrical pore +first order reaction, Effectiveness factor, Porous catalyst particles, Heat effects during reaction, Performance equation for reactors containing porous catalyst particles, Experimental methods for finding rates Problems.

8 Hours

UNIT IV

Kinetics of Fluid-Fluid Reactions: Rate equation for straight mass transfer, Rate for mass transfer and reaction, liquid film enhancement factor, Instantaneous reaction with low CB, special case of negligible gas phase resistance, Instantaneous reaction with high CB and its rate, Fast reaction with low CB and its rate, Fast reaction with high CB and its rate, Intermediate with respect to mass transfer, Slow reaction w.r.t. mass transfer and its rate, Infinitely slow reaction and its rate, Hatta no., Use of solubility data to determine kinetic regime, Problems.

8 Hours

UNIT V

Kinetics of Fluid-Particle Reactions: Selection of kinetic model, Progressive conversion model, Shrinking core model (SCM), SCM for spherical. **Particles of unchanging sizes:** Diffusion through gas film controls, Diffusion through ash layer controls, Chemical reaction controls, **Rate of reaction for shrinking spherical particles:** Chemical reaction controls, Diffusion through gas film controls, Combination of resistances. Problems.

8 Hours

Text Books

1	Octave Levenspiel	Chemical Reaction Engineering, Wiley Publisher, 3e, 2006, ISBN-10:8126510005.
2	J.M. Smith	Chemical Engineering Kinetics, McGraw Hill, 3e, 2013, ISBN-13:978-9332902633
3	G. F. Froment & K. B Bischoff	Chemical Reactor Analysis and Design, McGraw Hill, 3e, 1981, ISBN:978-0070665743

Reference Books

1	Fogler H Scott.	Elements of chemical Reaction Engineering, Pearson Education India, 4e, 2015, ISBN-13:978-9332549326
2	S. Suresh, S. Sundaramoorthy	Green Chemical Engineering: An Introduction to Catalysis, Kinetics, and Chemical Processes, CRC Press, 1e, 2015, ISBN-13:978-1-4665-5885-1

Course Outcomes: Upon completion of this course, student will be able to:

CO1	Analyse and apply rate laws of heterogeneous reactions to demonstrate the knowledge of the nature and mechanism of catalytic reactions and properties of catalyst.
CO2	Explain why and how catalysts deactivate and how catalyst deactivation can be postponed or prevented
CO3	Solve problems of mass transfer with reaction in solid catalyzed reactions
CO4	Identify and analyse the best kinetic regimes for mass transfer and reaction for a given fluid-fluid system and predict the rate equation.
CO5	Predict the rate controlling step to solve problems on fluid-particle reactions

COs	POs											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
1	3	2	2	2	2	2	1				3	3	
2	3	2	3	2	2	3	1				3	3	
3	3	3	3	2	2	3	1				3	3	
4	3	3	3	2	2	3	1				3	3	
5	3	2	3	2	2	3	1				3	3	

SOFT SKILLS (ADDITIONAL COURSE OFFERED BY SIT)

Contact Hours/ Week	0+2+0 (L+T+P)	Credits	0
Total Lecture Hours	0+24+0	CIE Marks	100
Total Tutorial Hours	0	SEE Marks	0
Sub. Code	S6NCCM	Semester	6

OPEN ELECTIVE COURSE – I (COURSE OFFERED BY SIT)

Contact Hours/ Week	3+0+0 (L+T+P)	Credits	3.0
Total Lecture Hours	39+0+0	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	OE6X	Semester	6

MAJOR PROJECT PHASE I

Contact Hours/ Week	0+0+4 (L+T+P)	Credits	2.0
Total Lecture Hours	0+0+48	CIE Marks	100
Total Tutorial Hours	0	SEE Marks	0
Sub. Code	S6CHMP	Semester	6

Course objectives:	
1	Train the students to identify societal and industrial unmet needs needing chemical engineering solutions.
2	Introduce research methods including design of experiments and data analysis to provide valid conclusions after conducting investigations.
3	Guide students to develop process engineering solutions or design process equipment to the selected problem/unmet need.
4	Acquaint students to societal, health, safety, finance and legal issues in addition to responsibility to the professional engineering practice.
5	Teach modern engineering tools including process modelling, simulation and optimization to solve the selected problem.
6	Exemplify ethical behavior in the context of conduction of experiments, data analysis and reporting
7	Train to function effectively as an individual, and as a member or leader in a team, and in multidisciplinary settings to solve problems within the area of expertise
8	Give directions to students to evaluate and critically assess results and be able to document and present one's own work
9	Illustrate the need for life-long learning including innovation and entrepreneurship

Course Outline:

Students must identify an industrially or societally relevant problem and solve using chemical engineering principles and economics. This must be done in consultation with faculty of the department or a practicing chemical engineer from the industry. The students are advised to take up projects that can be performed using the facilities and infrastructure of the department and the institute. However, students are encouraged to think “out of the box” and take up challenging projects. If the projects are innovative and potentially has high impact, then the department would consider approving on a case by case basis. The department also

encourages students to take up projects towards developing a “technology” or a “product”. SIT’s technology incubation centre will facilitate any subsequent commercialization. The major project can be performed by a team of 3 to 4 students. One or more faculty of the department can advise the project and can be performed within the department or in an Industry or a Research Institute. A co-guide from the Industry or Research Institute is also allowed.

The major project is evaluated over two semesters (VII and VIII). It carries 2 credits in the VII semester and is evaluated for 100 marks (100% CIE only). In the VIII semester, it carries 13 credits and evaluated for 100 marks [50% CIE & 50% SEE].

The project can be taken by group of 4 students and major project can be carried out in the dept. under a guide or outside the department in institute/ company with a guide from the dept. and co guide from the institute/ company.

Scheme of Evaluation (CIE):

Project presentation (seminar) highlighting literature review, problem statement, hypothesis, objectives feasibility of the project (Phase 1)	10 marks
Project report (hard copy of the presentation slides)	20 marks
Assessment of the project by the guide and co-guide (if any)	25 marks
Project presentation highlighting objectives & progress of project (Phase 2)	30 marks
Viva Voce – by Internal Examiners	15 marks
TOTAL	100 marks

Reference books:

1	Lazic, Z.R	Design of Experiments in Chemical Engineering; A Practical Guide, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2004, ISBN: 3-527-31142-4
2	Piemonte, V., De Falco, M., Basile, A	Sustainable Development in Chemical Engineering: Innovative Technologies, Wiley, West Sussex, United Kingdom, 2013, ISBN:978-1-119-95352-4
3	Kakava, N.	Technopreneurship: Conceptualized, Lap Lambert Academic Publishing GmbH KG, Germany, 2012, ISBN:9783659240270
4	Leong, E.C., Heah, C.L-H., Ong, K.K.W.	Guide to Research Projects for Engineering Students: Planning, Writing and Presenting. CRC Press, 2015, ISBN:9781482238778

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

1	Identify a problem from literature review and knowledge of chemical engineering technology.
2	Consolidate the literature review to identify issues/gaps and formulate the hypotheses.
3	Formulate objectives and prepare project schedule for the identified design methodology and budget analysis.
4	Conduct investigations and analyze, interpret and draw valid conclusions from experimental results.

5	Apply modern engineering tools like process modelling, simulation and optimization to the problem with an understanding of the constraints.
6	Apply basic concepts of science, engineering, design and economics to develop sustainable process engineering solutions or design process equipment.
7	Consider societal, health, safety, legal and cultural issues and concern for the environment while implementing the process solutions.
8	Display professional ethics in the conduction of experiments, data analysis and reporting.
9	Demonstrate effective written communication in the form of project report or research publication.
10	Engage in effective oral communication through power point presentation and project demonstration.
11	Function effectively as an individual or as a member or leader in a team, and in multidisciplinary settings to solve the given problem.

	POs											PSOs			
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
CO1		3											3		
CO2			3							2			3		
CO3			3	3									3		
CO4					3						3			3	
CO5	3		2									3			3
CO6						3							3		
CO7							3						3		
CO8									3		2		3		
CO9									3		2		3		
CO10								3					3		
CO11		3											3		

INDIAN KNOWLEDGE SYSTEM

Contact Hours/ Week	1+0+0 (L+T+P)	Credits	0
Total Lecture Hours	13	CIE Marks	50
Total Tutorial Hours	0	SEE Marks	50
Sub. Code	SHS07	Semester	6

Course objectives:	
1	Rejuvenate and mainstream Indian Knowledge Systems by integrating it into the fabric of education research ecosystem
2	Bridge the gap between Traditional Indian Knowledge Systems and contemporary knowledge systems
3	Make a tangible difference to the contemporary world by mainstreaming Indian Knowledge Systems

UNIT I	
<p>Introduction to Indian Knowledge Systems (IKS) Overview: Need of IKS, Importance of ancient knowledge. Defining IKS, History of IKS, Indian philosophical systems- Development and unique features, Yoga-darsana, Number system in India-Historical evidence, salient features of Indian number system, the concept of zero and its importance</p> <p>Reference book- 1 : 1.1; 1.2; 1.5; 3.1; 3.3.2; 6.1; 6.2; 6.2.1</p>	
5 Hours	

UNIT II	
<p>Fundamental concepts in Science in IKS: Framework and classification. The knowledge triangle. Prameya – A Vaisesikan approach to physical reality. Dravyas – the constituents of physical reality. Attributes – the properties of substances. Unique aspects of Indian Mathematics. Great Mathematicians and their contributions. Arithmetic. Square of a number. Unique aspects of Indian astronomy. Elements of Indian calendar. Pancanga – the Indian calendar system.</p> <p>Reference book- 1: 7.1; 7.2; 7.2.1; 7.2.2; 8.1; 8.2; 8.3; 8.3.1; 9.1; 9.4; 9.6.</p>	
5 Hours	

UNIT III	
<p>Humanities and Social sciences in IKS. Ayurveda-Definition of health, Tri-dosas - Relationship to health, yoga way of life –relevance to health and wellness, Indian approach to psychology, The tri-guna system, The body- mind-intellect – consciousness complex, consciousness- the true nature of an individual, Arthasastra- Governance and administration, the Kautilyan state</p> <p>Reference book- 1: 13.1; 13.2;13.4;13.5; 13.6; 13.7; 13.8;14.1;14.2</p>	
5 Hours	

Reference Books		
1	B Mahadevan Vinayak Rajat Bhat	Introduction to Indian Knowledge System- concepts and applications, Nagendra Pavana R N, 2022, PHI Learning Private Ltd, ISBN-978-93- 91818-21-0
2	Amit Jha	Traditional Knowledge System in India, 2009, Atlantic Publishers and Distributors, (P) Ltd.,ISBN-13: 978-8126912230
3	Kapil Kapoor, Avadesh Kumar Singh	Knowledge Traditions and Practices of India, Vol. 1, 2005, DK Print World (P) Ltd., ISBN 81-246-0334
4	Suggested Web Links	https://www.youtube.com/watch?v=LZP1StpYEPM

Course Outcomes: On completion of the course, the student will be able to	
1	Analyse the continuous unbroken knowledge traditions of Bhārata since time immemorial
2	Provide holistic solutions by combining traditional wisdom with modern knowledge
3	Recognize the relevance of traditional knowledge in different engineering domains

AICTE ACTIVITY POINTS

Contact Hours/ Week:	0+0+0 (L+T+P)	Credits	0
Total Lecture Hours:	0+0+0	CIE Marks	50
Total Practical Hours:	40	SEE Marks	50
Sub. Code:	AAP	Semester	6