Chemical Engineering - (4 Year B.Tech Programme) - COURSE CURRICULUM R-19 **Total Credits:160**

I Year Course structure

Semester - I

Code	Title of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE111	Engineering Mathematics – I	BS	3	0	0	1	6	10	40	60	100	3
CHE112	Engineering Physics	BS	3	0	0	1	4	8	40	60	100	3
CHE113	Engineering Chemistry	BS	3	0	0	1	4	8	40	60	100	3
CHE114	Introduction to Chemical Engineering	PC	3	0	0	1	4	8	40	60	100	3
CHE115	Engineering Drawing	ES	2	0	3	1	4	10	40	60	100	3.5
CHE116	Engineering Physics Lab	BS	0	0	3	0	1	4	50	50	100	1.5
CHE117	Engineering Chemistry Lab	BS	0	0	3	0	1	4	50	50	100	1.5
CHE118	Engineering Workshop	ES	0	0	3	0	1	4	50	50	100	1.5
CHE119	Human Values and Professional Ethics (Mandatory non-credit course)	MC	3	0	0	0	1	4	50	0	50	--
	Total		**17**	**0**	**12**	**5**	**26**	**60**	**400**	**450**	**850**	**20**

Semester - II

Code	Title of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE121	Engineering Mathematics – II	BS	3	0	0	1	6	10	40	60	100	3
CHE122	Communicative English	HS	3	0	0	1	4	8	40	60	100	3
CHE123	Physical and Analytical Chemistry	BS	3	0	0	1	5	9	40	60	100	3
CHE124	Basic Electrical and Electronics Engineering	ES	3	0	0	1	5	9	40	60	100	3
CHE125	Problem solving with C	ES	3	0	0	1	6	10	40	60	100	3
CHE126	English Language Lab	HS	0	0	3	0	1	4	50	50	100	1.5
CHE127	Problem solving with C Lab	ES	0	0	3	0	3	6	50	50	100	1.5
CHE128	Environmental Science (Mandatory non-credit course)	MC	3	0	0	0	1	4	50	0	50	--
	Total		**18**	**0**	**6**	**5**	**31**	**60**	**350**	**400**	**750**	**18**

II Year Course structure

Semester - I

Code	Name of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE211	Engineering Mathematics – III	BS	3	0	0	1	6	10	40	60	100	3
CHE212	Organic Chemistry	BS	3	0	0	1	5	9	40	60	100	3
CHE213	Basic Mechanical Engineering	ES	3	0	0	1	5	9	40	60	100	3
CHE214	Chemical Process Calculations	PC	3	0	0	1	6	10	40	60	100	3
CHE215	Mechanical Operations	PC	3	0	0	1	6	10	40	60	100	3
CHE216	Organic Chemistry Lab	BS	0	0	3	0	1	4	50	50	100	1.5
CHE217	Mechanical Operations Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**15**	**0**	**6**	5	30	**56**	**300**	**400**	**700**	**18**

Semester - II

Code	Name of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE221	Engineering Mathematics – IV	BS	3	0	0	1	6	10	40	60	100	3
CHE222	Biology for Engineers	BS	3	0	0	1	3	7	100	--	100	3
CHE223	Momentum Transfer	PC	3	0	0	1	6	10	40	60	100	3
CHE224	Chemical Engineering Thermodynamics – I	PC	3	0	0	1	5	9	40	60	100	3
CHE225	Numerical Methods for Chemical Engineers	PC	3	0	0	1	5	9	40	60	100	3
CHE226	Professional Elective - I	PE	3	0	0	1	3	7	40	60	100	3
CHE227	Momentum Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE228	Computational Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**18**	**0**	**6**	**6**	**30**	**60**	**400**	**400**	**800**	**21**

III Year Course structure

Semester - I												
Code	Name of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE311	Open Elective - I	OE	3	0	0	1	2	6	40	60	100	3
CHE312	Chemical Engineering Thermodynamics – II	PC	3	0	0	1	4	8	40	60	100	3
CHE313	Heat Transfer	PC	3	0	0	1	4	8	40	60	100	3
CHE314	Mass Transfer - I	PC	3	0	0	1	4	8	40	60	100	3
CHE315	Chemical Technology	PC	3	0	0	1	4	8	40	60	100	3
CHE316	Professional Elective – II	PE	3	0	0	1	3	7	40	60	100	3
CHE317	Quantitative and Verbal Aptitude – I	HS	0	0	3	1	3	7	100	0	100	1.5
CHE318	Heat Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE319	Chemical Technology Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**18**	**0**	**9**	**7**	**26**	**60**	**440**	**460**	**900**	**22.5**

Semester - II												
Code	Name of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE321	Open Elective - II	OE	3	0	0	1	2	6	40	60	100	3
CHE322	Mass Transfer – II	PC	3	0	0	1	4	8	40	60	100	3
CHE323	Chemical Reaction Engineering – I	PC	3	0	0	1	4	8	40	60	100	3
CHE324	Process Dynamics and Control	PC	3	0	0	1	4	8	40	60	100	3
CHE325	Professional Elective - III	PE	3	0	0	1	3	7	40	60	100	3
CHE326	Professional Elective – IV	PE	3	0	0	1	3	7	40	60	100	3
CHE327	Quantitative Aptitude – II & Soft Skills	HS	0	0	3	2	3	8	100	0	100	1.5
CHE328	Mass Transfer Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE329	Process Dynamics and Control Lab	PC	0	0	3	0	1	4	50	50	100	1.5
	Total		**18**	**0**	**9**	**8**	**25**	**60**	**440**	**460**	**900**	**22.5**

IV Year Course structure

Semester - I

Code	Name of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE411	Open Elective – III	OE	3	0	0	1	2	6	40	60	100	3
CHE412	Chemical Reaction Engineering – II	PC	3	0	0	1	5	9	40	60	100	3
CHE413	Transport Phenomena	PC	3	0	0	1	6	10	40	60	100	3
CHE414	Process Modeling and Simulation	PC	3	0	0	1	5	9	40	60	100	3
CHE415	Chemical Process Economics and Equipment Design	PC	3	0	0	1	6	10	40	60	100	3
CHE416	Chemical Reaction Engineering Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE417	Process Modeling and Simulation Lab	PC	0	0	3	0	1	4	50	50	100	1.5
CHE418	Project Phase – I	PR	0	0	3	0	3	6	100	-	100	2
CHE419	Summer Internship *	PR	0	0	0	0	1	1		100	100	1
	Total		**15**	**0**	**9**	**5**	**30**	**59**	**400**	**500**	**900**	**21**

*There is summer Internship (Industrial Training) at the end of III year II Semester for a minimum of three weeks during summer vacation.
Assessment for the same is made during IV year I semester.

Semester - II

Code	Name of the Course	Category	L	T	P	E	O	Total	Max. marks Sess.	Max. marks End. Exam	Total Marks	Credits
CHE421	Open Elective – IV	OE	3	0	0	1	2	6	40	60	100	3
CHE422	Professional Elective – V	PE	3	0	0	1	3	7	40	60	100	3
CHE423	Professional Elective – VI	PE	3	0	0	1	3	7	40	60	100	3
CHE424	Project Phase – II	PR	0	0	9	0	9	18	100	100	200	8
	Total		**9**	**0**	**9**	3	17	**38**	**220**	**280**	**500**	**17**

* Open Elective can be interdisciplinary/ emerging subjects/ MOOCs that will be decided by the department

R -2019 regulations – List of electives

CHE 226 Professional Elective - I	
CHE 226 (A)	Polymer Technology
CHE 226 (B)	Entrepreneur Engineering
CHE 226 (C)	Design Thinking
CHE 316 Professional Elective – II	
CHE 316 (A)	Industrial safety
CHE 316 (B)	Fertilizer Technology
CHE 316 (C)	Pharmaceutical Technology
CHE 325 Professional Elective – III	
CHE325 (A)	Industrial pollution and control
CHE325 (B)	Membrane technology
CHE325 (C)	Catalysis
CHE 326 Professional Elective – IV	
CHE326 (A)	Material Science and Engineering
CHE326 (B)	Petroleum refinery Engineering
CHE326 (C)	Energy engineering
CHE 422 Professional Elective – V	
CHE422 (A)	Petrochemicals
CHE422 (B)	Nanotechnology
CHE422 (C)	Industrial management
CHE 423 Professional Elective – VI	
CHE423 (A)	Biochemical engineering
CHE423 (B)	Process optimization
CHE423 (C)	Computational fluid dynamics
CHE 311 Open Elective - I	
CHE 311(A)	Food Processing Technology
CHE 311(B)	Engineering Biology
CHE 311(C)	Fuel Cell Technology
CHE 311(D)	Design of experiments
CHE 321 Open Elective - II	
CHE 321(A)	Fundamentals of Industrial Safety and Health
CHE 321(B)	Bioinformatics
CHE 321(C)	Corrosion Engineering
CHE 321(D)	Computational tool for Engineers
CHE 411 Open Elective – III	
CHE 421 Open Elective – IV	

Chemical Reaction Engineering – II

Course Code – Category: CHE 412 – PC

L	T	P	E	O	Credits: 3
3	0	0	1	4	Sessional Marks: 40

End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites: Chemical Reaction Engineering-I

Course Objectives:

1. To have an overview of temperature and pressure effects on chemical reactions
2. To analyse different non-ideal reactors
3. To interpret and design solid catalysed and fluid-fluid reactors

Course Outcomes:

By the end of the course, the student will be able to:

1. Analyze the temperature and pressure effects of chemical reactions
2. Distinguish between ideal and non-ideal reactors
3. Characterize the catalyst by knowing their properties
4. Design solid-catalyst reactors
5. Formulate the mechanisms for solid-fluid and fluid-fluid reactions

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L + 3T**

Temperature and Pressure Effects:

Heats of reaction and temperature – Equilibrium constants from thermodynamics – Equilibrium conversion – General graphical design procedure – Optimum temperature progression – Adiabatic operations.

Learning Outcomes:

At the end of this unit, student will be able to

- Compute temperature progression
- Calculate equilibrium constant and conversion

UNIT II **9L + 3T**

Non Ideal Flow:

Basics of non-ideal flow: C, E and F curves – Conversion in non-ideal flow reactors – Dispersion model – Tanks-in-series model.

Learning Outcomes:

At the end of this unit, student will be able to

- Determine conversion in non-ideal flow reactors
- Model the non-ideal flow by dispersion and tanks in series models

UNIT III **9L + 3T**

Heterogeneous Catalysis:

Physical adsorption – Chemisorption – Catalyst properties – Estimation of surface area, pore volume and porosity – Catalyst preparation – Catalyst poisons – Catalytic deactivation.

Learning Outcomes:

At the end of this unit, student will be able to

- Differentiate various adsorption isotherms
- Calculate the catalyst properties

UNIT IV **9L + 3T**

Solid Catalysed Reactions:

Rate equations – Pore diffusion combined with surface kinetics – Thiele modulus – Effectiveness factor – Performance equations for reactions containing porous catalyst particles – Experimental methods for finding rates – Determining controlling resistances.

Learning Outcomes:

At the end of this unit, student will be able to

- Estimate the Thiele modulus and effectiveness factor the particular reaction
- Calculate the catalyst required for various reactors

UNIT V **9L + 3T**

Non-Catalytic Systems:

Design of fluid-fluid reactors – Factors to consider in selecting a contractor – Various contractors and contacting patterns for G/L reactions. Design of fluid particle reactions – Progressive Conversion Model (PCM), Shrinking Core Model (SCM) – Comparison – Controlling mechanisms – Determination of rate controlling step.

Learning Outcomes:

At the end of this unit, student will be able to

- Predict the model equations for various fluid-fluid reactors
- Analyze the controlling mechanisms for fluid-particle reactions

Text Book:

1. Levenspiel O. *Chemical Reaction Engineering*, 3rd Edition, John Wiley & Sons.

Reference books:

1. J. M. Smith., *Chemical Engineering Kinetics*, 3rd edition.,Mc-Graw Hill, Inc.
2. H. Scott Fogler., *Elements of Chemical Reaction Engineering*, 5th edition., PHI Learning Private Ltd

TRANSPORT PHENOMENA

Course Code – Category: CHE 413 – PC

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**4**	**Sessional Marks: 40**

End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites: Engineering Mathematics, Momentum Transfer, Heat Transfer and Mass Transfer

Course Objectives:

1. To provide basic knowledge on laminar flow using shell balances in momentum, heat and mass transfer.
2. To familiarize with equation of change for non-isotheral systems.
3. To acquaint knowledge on velocity, temperature and concentration distributions in turbulent flow.

Course Outcomes:

By the end of the course, the student would be able to:

1. Determine the dependency of transport properties on pressure and temperature.
2. Identify the coordinates and develop velocity, temperature and concentration profiles in laminar flow.
3. Apply equations of change for non-isothermal systems for solving steady state problems.
4. Evaluate velocity distributions using time smoothed quantities.
5. Estimate the friction factors, heat transfer coefficients and mass transfer coefficients.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L + 3T**

Momentum transport: Viscosity and the mechanism of momentum transport, Newton's law of viscosity, Non-Newtonian fluids and pressure and temperature dependence of viscosity.

Velocity distributions in laminar flow: Shell momentum balances boundary conditions, flow of a falling film, flow through a circular tube and flow through an annulus.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the viscosity of fluids at a given temperature and pressure conditions
- Perform shell momentum balance calculations for laminar flow steady-state problems

UNIT II **9L + 3T**

The equations of change for isothermal systems: The equations of continuity, motion and mechanical energy in rectangular and curvilinear coordinates, use of the equations of change to set up steady flow problems and dimensional analysis of the equations of change.

Velocity distributions in turbulent flow: Fluctuations and time-smoothed quantities, time-smoothing of the equations of change for an incompressible fluid and semi empirical expressions for the Reynolds stresses.

Learning Outcomes:

At the end of this unit, student will be able to

- Use the equations of continuity and bulk equations to solve steady-state flow problems
- Represent the time smoothed equations of change for an incompressible fluid

UNIT III **9L + 3T**

Energy transport: Thermal conductivity and the mechanism of energy transport, Fourier's law of heat conduction and temperature and pressure dependence of thermal conductivity in gases and liquids.

Temperature distributions in solids and in laminar flow: Shell energy balances boundary conditions, heat conduction with an electrical heat source, heat conduction with a viscous heat source, heat conduction through composite walls, forced convection and free convection.

Learning Outcomes:

At the end of this unit, student will be able to

- Predict the thermal conductivity of gases and liquids using empirical equations
- Execute the shell energy balance calculations to find temperature distribution in solids and laminar flow fluids

UNIT IV **9L + 3T**

Mass transport: Diffusivity and mechanism of mass transport, Definitions of concentrations, velocities and mass fluxes, Fick's law of diffusion and temperature and pressure dependence of mass diffusivity.

Concentration distribution in laminar flow: Shell mass balances – boundary conditions, diffusion through a stagnant gas film, diffusion with heterogeneous chemical reaction, mass transfer with chemical reaction, diffusion with homogeneous chemical reaction and diffusion into a falling liquid film.

The equations of change for multi component systems: The equations of continuity for a binary mixture.

Learning Outcomes:

At the end of this unit, student will be able to

- Assess the temperature and pressure dependence of mass diffusivity
- Derive the concentration profile for steady-state laminar flow problems

UNIT V **9L + 3T**

Interphase transport in isothermal systems: Definition of friction factors, friction factors for flow in tubes and for flow around spheres. Definition of the heat transfer coefficient, heat transfer coefficients for forced convection in tubes and around submerged objects and heat transfer coefficients for free convection. Definition of binary mass transfer coefficients in one phase, correlations of binary mass transfer coefficients in one phase at low mass-transfer rates, definition of binary mass-transfer coefficients in two phases at low mass-transfer rates

Learning Outcomes:

At the end of this unit, student will be able to

- Determine friction factor and heat transfer coefficients for flow in tubes and for flow around submerged objects
- Define mass transfer coefficient for one and two phases for binary compounds.

Text Book:

1. R. Byron Bird, Warren E. Steward and Edwin N. Lightfoot, *Transport Phenomena*, 1st edition, John Wiley and Sons Inc., New York, 1960.

Reference Books:

1. Geankoplis, C.J. *Transport Processes and UNIT Operations*, PHI, New Delhi, 3rd edition, 1997.
2. V. Kumaran, *Transport processes*, course module available at http://chemeng.iisc.ac.in/kumaran/courses.html.
3. Sunil Kumar Thamida, Transport Phenomena: Chemical Processes, Stadium press India Pvt Ltd., 2016.

PROCESS MODELLING AND SIMULATION

Course Code – Category: CHE 414 – PC

L	T	P	E	O		Credits: 3
3	0	0	1	4		Sessional Marks: 40

End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites: Process Control, Heat transfer, Mass transfer, Chemical reaction engineering, Fluid Mechanics

Course Objectives:

1. To use the fundamental laws in developing model equations.
2. To understand various chemical engineering systems.
3. To develop mathematical models for solving process problems.
4. To gain skills by proper usage of simulators for modelling chemical processes.

Course Outcomes:

By the end of the course the student will be able to:

1. Apply the fundamental laws to develop a mathematical model for simple flow systems.
2. Formulate mathematical models for various types of reactors
3. Develop a mathematical model for various Mass transfer equipment.
4. Solve the mathematical models using numerical methods.
5. Simulate mathematical models for various operations.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9L + 3T**

Introduction: Use and scope of mathematical modeling, Principles of model formulation, Role and importance of steady-state and dynamic simulation, Degree-of-freedom analysis, Selection of design variables, Model simulation.

Fundamental laws: Equations of continuity, energy, momentum, and state, Transport properties, Equilibrium and chemical kinetics, Review of thermodynamic correlations for the estimation of physical properties like phase equilibria, bubble and dew points.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply fundamental laws to develop model
- Formulate the models for different processes

UNIT II **9L + 3T**

Mathematical modeling-I: Chemical processes-Gravity flow tank, Two heated tanks, Gas phase pressurized CSTR, Non-isothermal CSTR, Series of isothermal, constant hold up CSTRs, CSTRs with variable hold-ups.

Learning Outcomes:

At the end of this unit, student will be able to

- Develop models for rate based equipments

UNIT III **9L + 3T**

Mathematical modeling-II: Modeling of Single component vaporizer, Multicomponent flash drum, pH systems, Batch reactor, Reactor with mass transfer, Ideal binary distillation and Batch distillation with holdup.

Learning Outcomes:

At the end of this unit, student will be able to

- Develop models for equilibrium based equipments

UNIT IV **9L + 3T**

Methods for solving non-linear equations: Interval Halving method, Newton-Raphson method, False Position method, Wegstein method. Numerical integration of ordinary differential equations: Euler Algorithm and Runge-Kutta (Fourth-Order) methods.

General Concepts of Simulation for Process Design: Introduction, modular approaches to process simulation- sequential modular approach, simultaneous modular approach, equation solving approach, tearing.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply numerical techniques to solve equations
- Solve set of equations

UNIT V **9L + 3T**

Simulation examples: Gravity flow tank, Three CSTRs in series with constant hold-up, Three CSTR’s in series with variable hold-up. Simulation of Non-isothermal CSTR, Batch reactor and Binary distillation column.

Learning Outcomes:

At the end of this unit, student will be able to

- Solve models using numerical techniques
- Develop algorithms for different model equations

Textbooks:

1. W. L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2nd Ed., McGraw Hill India Pvt. Ltd., 2014.
2. Raghu Raman ,Chemical Process Computations, Elsevier Applied Science Publishers Ltd., New York, 1985 (**UNIT-IV**)

Reference Books:

1. Upreti, Simant R. Process Modeling and Simulation for Chemical Engineers: Theory and Practice. John Wiley & Sons, 2017.
2. Verma, Ashok Kumar. Process Modelling and Simulation in Chemical, Biochemical and Environmental Engineering. CRC Press, 2014.
3. H. Scott Fogler, Elements of Chemical Reaction Engineering, 3rd Ed., Prentice Hall of India, 2004.
4. Ian T. Cameron and K. Hangos, Process Modelling and Model Analysis, 1st edition, Academic press, 2001

CHEMICAL PROCESS ECONOMICS AND EQUIPMENT DESIGN

Course Code – Category: CHE 415 – PC

L	**T**	**P**	**E**	**O**		**Credits:3**
3	**1**	**0**	**0**	**4**		Sessional Marks: 40

End Exam: 3 Hours — End Exam Marks: 60

Prerequisites: Heat Transfer, Mass Transfer

Course Objectives:

1. To familiarize process development and general design considerations.
2. To provide the knowledge on mechanical design of equipments.
3. To familiarize the design of heat and mass transfer equipments.
4. To provide the knowledge of various equations used for cost analysis of process plant

Course Outcomes:

By the end of the course, the student would be able to

1. Outline the general design considerations for design / expansion of the process.
2. Estimate the time value of money and depreciation
3. Compute the cost of an equipment and process plant
4. Evaluate mechanical design of pressure vessels
5. Design process equipment like Heat exchangers and Distillation columns

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT I **9 L+ 3 T**

General process design considerations: Procedure for project design, design information from the literature survey, flow diagrams, preliminary design, comparison of different processes, firm process design, equipment design and specialization, scale up in design, safety factors specifications, health and safety hazards, fire and explosion hazards, personnel safety, loss prevention, plant location and layout.

Learning Outcomes:

At the end of this unit, student will be able to

- Explain the stages of process design development
- Summarize general design consideration during the project development

UNIT II **9 L+ 3 T**

Time Value of money and depreciation: Types of interest- discrete and continuous, equations for economic studies, annuities - relation between ordinary annuity and the periodic payments, Depreciation definition and types; Methods of calculating depreciations – Straight Line Method, Declining Balance Method, Sum of Years Digits Method and Sinking Fund Method

Learning Outcomes:

At the end of this unit, student will be able to

- Predict the interest involved in investment cost of a project
- Calculate the depreciation involved in the project cost

UNIT III **9 L+ 3 T**

Cost estimation and Profitability: Basic relationship in accounting, balance sheet and income statement, various ratios to study the balance sheet and income statements, break even chart, cost indices, capacity factors, cost estimation of an equipment and process plant, alternate investments and replacements for profitability evaluation.

Learning Outcomes:

At the end of this unit, student will be able to

- Estimate the equipment cost and product cost using cost indices and other methods
- Determine the profitability of a project using profitability analysis

UNITIV **9L+ 3 T**

Mechanical design of process equipment: Pressure vessel shell, closures, nozzles, flanges, supports, storage vessels, tall vertical column, Reactor.

Learning Outcomes:

At the end of this unit, student will be able to

- Predict the thickness of the plate required for the pressure vessel under the given conditions
- Choose suitable components like headers, flanges, supports etc. for the pressure vessel

UNITV **9 L+ 3 T**

Process equipment design: Design of Heat exchanger, evaporator, distillation column, absorption column.

Learning Outcomes:

At the end of this unit, student will be able to

- Implement area calculations for heat exchange equipment including evaporators
- Perform process design calculations for mass transfer equipment like distillation column

Text Books:

1 M. S. Peters & K. D. Timmerhaus, *Plant design and Economics for Chemical Engineers,* 4th edition, Mc Graw Hills Publishing Company, 1991.

2 M. V. Joshi, *Process Equipment Design*, 3rd Edition, MacMillan India Ltd 1981(**UNIT-II**)

References:

1. Hebert E. Schweyer, *Process Engineering Economics*, McGraw Hill Books company 1955.
2. J.M.Coulson & J.F.Richardon, *Chemical Engineering Volume-VI (An introduction to Chemical Engineering Design*
3. J.R.Backhurst & J.H.Harker , *Process-Plant-Design*, Heieman Education London.

CHEMICAL REACTION ENGINEERING LABORATORY

CHE 416 **Credits: 1.5**

Instruction: 3 Practical hours /week Sessional Marks: 50

End Exam: 3 Hours End Exam Marks: 50

Prerequisites: Chemical Reaction Engineering

Course Objectives:

1. To impart knowledge on the determination of the kinetics of a chemical reaction
2. To enable the students to understand the principles involved in designing of chemical reactors

Course Outcomes:

By the end of the course, the student will be able to

1. Determine the kinetics of a chemical reaction in various reactors
2. Acquire hands on experience on the operation of various ideal and non-ideal reactors

CO – PO – PSO Matrix:

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

List of Experiments:

1. Determination of the order of a reaction and rate constant using a batch reactor by analyzing the data by different methods.
2. Determination of the activation energy of a reaction using a batch reactor.
3. Determination of the effect of residence time on conversion and estimation of the rate constant using a CSTR.
4. Determination of the effect of residence time on conversion and estimation of the rate constant using a PFR.
5. Determination of RTD and Dispersion number in a Tubular reactor using a tracer.
6. Mass transfer with chemical reaction (solid-liquid system) - Determination of Mass Transfer Co-efficient.
7. Determination of RTD and the dispersion number for a packed-bed using a tracer
8. Langmuir Adsorption Isotherm: Determination of surface area of activated charcoal.
9. Performance of a PFR followed by a CSTR
10. Performance of a CSTR followed by a PFR.
11. Performance of two CSTRs in series.
12. Determination of M-M kinetics for an enzyme catalyzed reaction.

Prescribed Books:

1. Octave Levenspiel, *Chemical Reaction Engineering*, 3rd edition, 1999, John Wiley
2. J. M. Smith., *Chemical Engineering Kinetics*, 3rd edition., McGraw-Hill, Inc.
3. H. Scott Fogler., *Elements of Chemical Reaction Engineering*, 5th edition, PHI Learning Private Ltd.

PROCESS MODELLING AND SIMULATION LABORATORY

CHE 417 **Credits: 1.5**

Instruction: 3 Practical hours/week Sessional Marks: 50

End Exam: 3 hrs End Exams Marks: 50

Prerequisites:

Engineering Mathematics, Process Modelling and Simulation

Course Objectives:

1. To impart knowledge on simulation packages and tools.
2. To enable the student to have hand on experience on various simulation tools.

Course Outcomes:

By the end of the course, the student will be able to:

1. Represent the process in terms of mathematical equations.
2. Acquire hands on experience on simulation packages and tools.

CO – PO – PSO Matrix:

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

List of experiments

1. Estimation of thermodynamic properties
2. Vapour liquid Equilibria
3. Simulation of a pump
4. Simulation of a heat exchanger
5. Simulation of an evaporator
6. Simulation of an absorber
7. Simulation of distillation column
8. Simulation of a reactor
9. Simulation of a flow sheet
10. Simulation of a flow sheet with recycle stream
11. Optimization of process parameters in a flow sheet
12. Unsteady state operation of a flow sheet

The experiments can be performed in any software / tool to have hands on experience.

Prescribed Books:

1. Bruce A. Finlayson, *Introduction to Chemical Engineering Computation*, John Wiley and Sons Inc., 1st edition, 2012.
2. W. L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2nd Ed., McGraw Hill India Pvt. Ltd., 2014.
3. A. K. Jana, *Chemical Process Modelling and Computer Simulation*, PHI, 2nd edition, 2011.

PROJECT PHASE – I

CHE 418 **Credits: 2**

Instruction: 3 Practical hours/week Sessional Marks: 100

End Exam: 0 hrs End Exams Marks: 00

Course Objectives:

To prepare students to conduct, design and analyze the problems of Chemical Engineering through experimental or theoretical studies and represent in the form of technical report.

Course Outcomes:

By the end of the course, the student would be able to

1. Identify the gap between the needs of society and available technology through literature survey
2. Formulate and analyze the objectives of their study

CO – PO – PSO Matrix:

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

Project Identification Strategies Projects are classified into three categories

- Theoretical design projects
- Experimental projects
- Simulation projects

The project work should consist of a comprehensive design of a chemical plant in the form of a report with the following chapters.

1. Introduction
2. Physical and chemical properties and uses
3. Literature survey for different processes
4. Selection of the process
5. Material and energy balances
6. Specific equipment design (Process as well as mechanical design with drawings)
7. General equipment specifications
8. Plant location and layout
9. Materials of construction
10. Health and safety factors
11. Preliminary cost estimation
12. Bibliography

Project Evaluation:

The student projects have been evaluated by three internal evaluators and also by the project guide. The project is divided into six parts as follows

- Introduction of the project
- Process description with flow sheet
- Material and Energy balances
- Design of specific equipment
- Plan location, layout and economics
- Over all project

Project seminars are conducted in six phases to evaluate the progress of project work carried. For each presentation 50 marks are allotted to each student by the four evaluators (guide 20M and each examiner 10M). Marks have been awarded based on the performance of the student in terms of presentation skills, communication skills, knowledge on the project, finally all the marks obtained in the six phases are averaged to award total marks for the project

SUMMER INTERNSHIP

CHE 419 **Credits: 1**

Instruction: 0 Practical hours/week Sessional Marks: 00

End Exam: 0 hrs End Exams Marks: 100

Course Objective:

To gain an insight of various unit operations and processes in a chemical industry.

Course Outcomes:

By the end of the course, the student would be able to

1. Practically analyze various unit operations and processes in a chemical industry.
2. Prepare a technical report

CO – PO – PSO Matrix:

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

- ❖ Assesment for the industrial training is made through external examiner during IV year I Sem

ELECTIVE - V

PETROCHEMICALS

Course Code – Category: CHE 422 (A)– PE

L	T	P	E	O		Credits: 3
3	0	0	1	3		Sessional Marks: 40

End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites: Organic Chemistry

Course Objectives:

1. To make a thorough understanding of the availability of petroleum feed stocks for petrochemicals.
2. To understand the methods to produce various petrochemicals fromC_2, C_3, C_4 and higher carbon atoms.
3. To methodolically furnish the conversion of petroleum feedstocks to chemicals and intermediates.

Course Outcomes:

By the end of the course, the student will be able to

1. Understand petrochemical industry feedstocks, various chemicals produced from methane.
2. Describe the production of different chemicals from C_2 carbon atoms
3. Outline the production of different chemicals from C_3, C_4 and higher carbon atoms and production of various polymers.
4. Acquire the knowledge on production of petroleum aromatics
5. Describe the production of different intermediate chemicals, synthetic fibres, rubber and synthetic detergents.

CO – PO – PSO Matrix:

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

UNIT I **9L + 3T**

Petrochemical Industry-Feed Stocks: Petrochemical industry in India, feed stocks for petrochemicals. Chemicals from methane: Introduction, production of methanol, formaldehyde, PTFE.

Learning Outcomes:

At the end of this unit, student will be able to

- Draw and identify various unit operations and processes for C1 compounds

UNIT II **9L + 3T**

Chemicals From C2 Carbon Atoms: Ethylene production, vinyl chloride monomer, vinyl acetate monomer, ethylene oxide, ethylene glycol, acetylene, acetaldehyde from Acetylene.

Learning Outcomes:

At the end of this unit, student will be able to

- Draw and identify various unit operations and processes for C2 compounds

UNIT III **9L + 3T**

Chemicals From C3,C4 and Higher Carbon Atoms: Isopropyl alcohol, acrylonitrile, acrylic acid, phenol, bisphenol-A, iso and n-butanol, methacrylic acid, malic anhydride.

Polymers of Olefins: Polymer structure, methods of polymerization, high density polyethylene (HDPE), low density polyethylene (LDPE), polypropylene, polyvinylchloride.

Learning Outcomes:

At the end of this unit, student will be able to

- Draw and identify various unit operations and processes for C3, C4 and polymer compounds

UNIT IV **9L + 3T**

Petroleum Aromatics: Aniline, styrene, benzoic acid, caprolactum, terephthalic acid, phthalic anhydride.

Learning Outcomes:

At the end of this unit, student will be able to

- Draw and identify various unit operations and processes for aromatic compounds

UNIT V **9L + 3T**

Synthetic Fibres and Rubber: Production techniques of synthetic fibres, production of polyester, nylon-6,6, nylon- 6, acrylic fibers. Synthetic rubber: butyl rubber, synthesis of polyurethane.

Plastics: Phenol formaldehyde resins, urea formaldehyde resins, polycarbonates.

Synthetic detergents: Classification of detergents, general manufacture of sulphonates, keryl benzene sulphonate (Surf).

Learning Outcomes:

At the end of this unit, student will be able to

- Draw and identify various unit operations and processes for synthetic fibers, rubbers and plastics

TEXT BOOK:

1. B.K.BhaskaraRao, *A Text book on Petrochemicals*, 3rd Edition, Khanna Publishers, New Delhi.

REFERENCE BOOKS:

1. A.Chanvel and G. Lefebvre, *Petrochemical processes*, Vol.2, 2nd Edition, Gulf publishing company.
2. George T. Austin, *Shreve's chemical process industries*, 5th edition, McGraw Hill Publishers.
3. GopalaRao, M. and Marshall Sitting,*Dryden's out lines of chemical Technology*,3rd edition, East West Press Pvt.Ltd.

ELECTIVE - V
NANOTECHNOLOGY

Course Code – Category: CHE 422 (B)– PE

L	**T**	**P**	**E**	**O**	**Credits: 3**
3	**0**	**0**	**1**	**3**	**Sessional Marks: 40**

End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites:

Course Objectives:

1. To provide a basic understanding of nanotechnology and its importance towards chemical engineering

Course Outcomes:

By the end of the course, the student will be able to:

1. Understand the basics of nanotechnology
2. Classify different classes of nanomaterials
3. Apply nanotechnology to chemical and its related industries
4. Identify different synthesis routes of nanomaterials
5. Apply chemical reaction engineering concepts for production of different nanomaterials

CO – PO – PSO Matrix:

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

UNIT I **9L + 3T**

Basics and Scale of Nanotechnology: Introduction, Scientific revolutions, Definition of a nanosystem, Dimensionality and size dependent phenomena, Surface to volume ratio -Fraction of surface atoms, Surface energy and surface stress, surface defects, Properties at nanoscale (optical, mechanical, electronic and magnetic).

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the nanomaterial
- Influence the various properties of the nanomaterial with respect to size.

UNIT II **9L + 3T**

Nanomaterials: Classification based on dimensionality, Quantum Dots, Wells and Wires, Carbonbasednano materials (bucky balls, nanotubes, graphene) Metal based nanomaterials (nanogold, nanosilver and metal oxides) Nanocomposites, Nanopolymers, Nano ceramics, Biological nanomaterials.

Learning Outcomes:

At the end of this unit, student will be able to

- Recognize the category of nanomaterial in terms of dimensions
- Identify the category for the various applications

UNIT III **9L + 3T**

Nanotechnology to Nano Engineering: Introduction to nanotechnology, Process Technology in nano engineering, Chemical engineering and new materials, Application of nanotechnology to different fields: Nanotechnology in Biotechnology, Nanotechnology in Petroleum Industries, Nanotechnology in Material Science, Nanotechnology in Environmental Science, Nanotechnology in the Energy Sector, Nanotechnology in Other Specific Fields

Learning Outcomes:

At the end of this unit, student will be able to

- Differentiate engineering and technology
- Utilize various nano-materials in various fields

UNIT IV **9L + 3T**

Nanostructured materials synthesis, Concepts and design: Synthesis Technologies and Challenges, Top down methods, Bottom-up Methods, Routine Tests for Characterization of Nanostructures, particle characterization, Chemical Analysis, Thermal analysis

Learning Outcomes:

At the end of this unit, student will be able to

- Synthesize nanomaterials in different approaches
- Characterize nanomaterials

UNIT V **9L + 3T**

Nanostructured materials manufacturing: Kinetic approach of the reaction, Chemical reactors for manufacturing nanomaterials, Health safety and Environment issues.

Learning Outcomes:

At the end of this unit, student will be able to

- Analyze the kinetic approaches of various nano-reactors
- Identify the safety aspects of using naomaterials.

Text Book:

1. Pradeep T., *A Textbook of Nanoscience and Nanotechnology*, Tata McGraw Hill Education Pvt. Ltd., 2012. (**UNIT-I & II**)
2. Said Salaheldeen Elnashaie, Firoozeh Danafar, Hassan Hashemipour Rafsanjani, *Nanotechnology for Chemical Engineers*, Springer, 2015. (**UNIT-III to V**)

Reference Books:

1. Hari Singh Nalwa, *Nanostructured Materials and Nanotechnology*, Academic Press, 2002.
2. Nabok A., *Organic and Inorganic Nanostructures*, Artech House, 2005.
3. Dupas C., Houdy P., Lahmani M., *Nanoscience: Nanotechnologies and Nanophysics*, Springer-Verlag Berlin Heidelberg, 2007.

ELECTIVE - V
INDUSTRIAL MANAGEMENT

Course Code – Category: CHE 422 (C)– PE

L	T	P	E	O	
3	**0**	**0**	**1**	**3**	**Credits: 3**
					Sessional Marks: 40

End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites: NIL

Course Objectives:

- To familiarize the students with the concepts of Management.
- To relate the concepts of management with industrial organizations.
- To explain the factors affecting productivity and how productivity can be increased in an Industrial undertaking.

Course Outcomes:

By the end of the course, student will be able to

1. Understand the concepts of Management.
2. Gain basic understanding of management and to relate the concepts of management with industrial organizations and manage organizations efficiently.
3. Have the basic knowledge of production management and make decisions proficiently.
4. Have the knowledge in maintaining better human relations in the organizations.

CO – PO – PSO Matrix:

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

UNIT I **9L + 3T**

Management: Functions of management –Planning, Organizing, Staffing, Directing Controlling and Coordinating, Levels of management, Role of Manager, Skills of manager, –F.W. Taylor's scientific management and Henry Fayol's principles of management.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the roles of a manager
- Understand the principles of management

UNIT II **9L + 3T**

Organization: Meaning of Organization, Principles of organization, Departmentalization, Organization structure (in brief),

Communication: Importance, purpose and forms of communication. Barriers to communication.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the organization structure and flow of organization
- Importance of communication

UNIT III **9L + 3T**

Forms of business organizations: Salient features of Sole proprietorship, Partnership, Joint Stock Company, Private limited company and Public limited company, Government enterprises and Co-operative societies.

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the different forms of businesses

UNIT IV **9L + 3T**

Production operations management: Production planning and control, Plant location and factors affecting plant location, Plant layout and types of layout (in brief).

Learning Outcomes:

At the end of this unit, student will be able to

- Identify the various operations in a plant
- Describe the factor affecting plant location

UNIT V **9L + 3T**

Human Resources Management: Basic functions of human resource management. Manpower planning, Recruitment, Selection, Training and Development, Placement, Compensation and Performance appraisal.

Learning Outcomes:

At the end of this unit, student will be able to

- Understand the functioning of HR management

Text books:

1. P.C. Tripathi, P.N.Reddy, Principles of Management, 4thEdition, Tata McGraw Hill Companies, New Delhi ,2008. (UNIT I & II)
2. A.R. AryaSri, Managerial Economics and Financial Analysis, TMH Publications, NewDelhi, 2014. (UNIT III)
3. S.C. Sharma and Banga T. R., Industrial Organization & Engineering Economics, khanna Publications, Delhi-6,2006. (UNIT IV & V)

Reference Books:

1. O.P. Khanna, Industrial Engineering and Management, Dhanpat Raj and Sons.

ELECTIVE - VI

BIOCHEMICAL ENGINEERING

Course Code – Category: CHE 423 (A)– PE

L	T	P	E	O	
3	**0**	**0**	**1**	**3**	**Credits: 3**
					Sessional Marks: 40

End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites: Chemical Reaction Engineering – I

Course Objectives:

1. To enhance interdisciplinary skills
2. To understand basic concept of life sciences
3. To have knowledge on different bioreactors and their design
4. To have knowledge on production of different bioproducts and their analytical procedures

Course Outcomes:

By the end of the course, the student will be able to:

1. Distinguish various microorganisms and biomolecules
2. Classify different enzymes and its kinetics
3. Design various bioreactors
4. Model various transport phenomena mechanisms
5. Describe the production of biomolecules and its quantification

CO – PO – PSO Matrix:

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

UNIT I **9L + 3T**

Introduction to biochemical engineering: Comparison of chemical and biochemical processes, industrially important microbial strains used for different bio products

Chemicals of life: Carbohydrates, proteins, lipids, nucleic acids, their classification and biological functions

Biology of microbes: Protist kingdom, classification and structure of different cells

Learning Outcomes:

At the end of this unit, student will be able to

- Classify the biomolecules and their biological functions
- Classify the types of microbial cells

UNIT II **9L + 3T**

Introduction to enzymes: Classification, kinetics of enzyme catalyzed reactions, derivation of Michaelis Menten equation for single substrate, determination of M.M parameters, enzyme inhibition – types, immobilization of enzymes, methods, immobilized enzyme kinetics, applications of immobilized enzymes and soluble enzymes

Learning Outcomes:

At the end of this unit, student will be able to

- Find the rate expressions for enzymatic reactions
- Identify the type of enzyme inhibition
- Apply the type of immobilization techniques for enzymes

UNIT III **9L + 3T**

Kinetics of cell growth: Growth phases, yield coefficient, Monod growth kinetics, ideal bioreactors – batch –mixed flow and plug flow reactors, chemostat with recycle and their analyses

Learning Outcomes:

At the end of this unit, student will be able to

- Apply Monod growth kinetics for continuous production of biomass
- Apply various bioreactors for manufacture of different bioproducts

UNIT IV **9L + 3T**

Transport phenomenon across the cell: Active, passive and facilitated diffusion, gas liquid mass transfer in cellular systems, determination of k_La values

Sterilization: Media and air, methods of continuous sterilization of media

Learning Outcomes:

At the end of this unit, student will be able to

- Determine the mass transfer coefficients in cellular systems
- Apply the sterilization techniques for media

UNIT V **9L + 3T**

Downstream processing: Special reference to membrane separation and chromatographic techniques like Gas chromatography, thin layer and paper chromatography, HPLC, affinity, gel, adsorption and ion exchange chromatography.

Important industrial bio products: ethanol – penicillin – citric acid – acetic acid, effluent treatment, production of biogas.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply the downstream processing techniques for the purification of bioproducts
- Produce the various microbial products

Text Book:

1. M. L. Shuler and F. Kargi, *Bioprocess Engineering: Basic Concepts,* 2nd edition, Prentice Hall India, New Delhi, 2003

Reference Books:

1. J. E. Bailey and D. F. Ollis, *Biochemical Engineering Fundamentals,* 2nd edition, McGraw-Hill Publishers, Newyork, 1986
2. D.G. Rao, *Biochemical engineering,* Tata McGraw-Hill Publishers, New Delhi
    1. J.M. Lee, *Biochemical engineering,* Prentice Hall, Englewood Clifts, 1992.

ELECTIVE - VI

PROCESS OPTIMIZATION

Course Code – Category: CHE 423 (B) – PE

L	T	P	E	O	
3	0	0	1	3	

Credits: 3
Sessional Marks: 40
End Exam: 3 Hours **End Exam Marks: 60**

Prerequistes:
Engineering Mathematics

Course Objectives:
1. To learn problem formulation of optimization.
2. To realize the numerical methods of un-constrained optimization
3. To learn linear programming and its applications
4. To know the applications of numerical optimization in chemical engineering principles

Course Outcomes:
By the end of the course, the student will be able to:
1. Apply the knowledge of optimization to formulate the problems
2. Apply different methods of optimization and to suggest a technique for specific problem with a single variable
3. Apply different methods of optimization and to suggest a technique for specific problem with multivariable
4. Apply of simplex method for linear optimization problems
5. Understand how optimization can be used to solve the industrial problems of relevance to the chemical industry

CO – PO – PSO Matrix:

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

UNIT I **9L + 3T**

Nature and organization of optimization problems: Introduction to optimization scope and hierarchy of optimization, examples of applications of optimization, essential features of optimization problems, general procedure for solving optimization problems, obstacles of optimization.

Basic Concepts of Optimization: constraints in optimization, examples and formulation of constrained optimization problems. Basic concepts of optimization: Continuity of functions, unimodal versus Multimodel functions. Convex and Concave functions, Convex region, Necessary and sufficient conditions for an extremum of an unconstrained function

Learning Outcomes:

At the end of this unit, student will be able to

- Formulate an optimization problem
- Compute optimum solutions

UNIT II **9L + 3T**

Optimization of unconstrained single variable functions: one-dimensional search: Numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of unidimensional search Quadratic interpolation, Cubic interpolation. Applications of one- dimensional search methods to chemical engineering problems.

Learning Outcomes:

At the end of this unit, student will be able to

- Determine the optimum points for single variable unconstrained problem

UNIT III **9L + 3T**

Unconstrained multivariable optimization: Random search methods, grid search, uni-variate search, multivariable Newton's method, Steepest descent method, Conjugate search directions, Conjugate gradient method, Powell's method.

Learning Outcomes:

At the end of this unit, student will be able to

- Calculate the optimum points for multivariable unconstrained problem

UNIT IV **9L + 3T**

Linear programming and applications: Basic concepts in linear programming, Degenerate LP's – graphical solution, natural occurrence of linear constraints, standard LP form. Simplex method and applications. Simplex method to solve LP problems, duality principle and converting a LP to dual LP. Introduction to Genetic Algorithms (Qualitative Treatment only)

Learning Outcomes:

At the end of this unit, student will be able to

- Solve constrained optimization problem

UNIT V **9L + 3T**

Optimization of UNIT operations: Optimal pipe diameter, minimum work of compression, Economic operation of a fixed bed filter, optimizing recovery of waste heat, optimization of multiple effect evaporator, optimization of flow rates in Liquid- Liquid extraction column, Determination of optimal reflux ratio for staged distillation column, Optimal residence time for maximum yield in an ideal isotherm batch reactor, Chemostat.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply optimization techniques to solve chemical engineering problems

Text Books:

1. T.F. Edgar and D.M. Himmelblau, L.S. Lasdon, *Optimization of Chemical Processes*, McGraw-Hill, New York, 2001.
2. Kalyan Moy Deb, *Optimization for Engineering Design*, PHI Pvt. Ltd., New Delhi, 2000 Codes/Books **(UNIT-III)**

Reference Books:

1. S. S. Rao, *Engineering Optimization: Theory and Practice,* 3rd Ed., John Wiley & Sons, 2009.
2. Dutta, Suman. *Optimization in Chemical Engineering*. Cambridge University Press, 2016.
3. Rangaiah, GadePandu. *Multi-objective optimization: techniques and applications in chemical engineering.* Vol. 1. World Scientific, 2009.
4. Nocedal, Jorge, and Stephen J. Wright. *Numerical optimization*, 2nd Ed., 2006.
5. Joshi, Mohan C., and Kannan M. Moudgalya. *Optimization: theory and practice.* Alpha Science Int'l Ltd., 2004.

ELECTIVE - VI

COMPUTATIONAL FLUID DYNAMICS

Course Code – Category: CHE 423 (C)– PE

L	T	P	E	O	
3	0	0	1	3	

Credits: 3
Sessional Marks: 40
End Exam: 3 Hours **End Exam Marks: 60**

Prerequisites:
Engineering Mathematics, Momentum Transfer and Heat Transfer.

Course Objectives:

1. To develop a general method of prediction for momentum, heat and mass transfer.
2. To familiarize with different methods of prediction.

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

1. Identify the governing equations.
2. Apply the various discretization methods
3. Apply the numerical methods to solve physical process that are governed mathematical equations containing only diffusion type.
4. Apply the numerical methods to solve physical process that are governed mathematical equations containing both diffusion and convection type.
5. Estimate the pressure and velocity corrections for calculation of flow field

CO – PO – PSO Matrix:

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

UNIT I **9L + 3T**

Mathematical description of physical phenomena: Conservation of chemical species, energy equation, momentum equation, time average equations for turbulent flow, the turbulence kinetic energy equation, general differential equation.

Learning Outcomes:

At the end of this unit, student will be able to

- Formulate mathematical equations from basic conservation principles

UNIT II **9L + 3T**

Discretization methods: Discretization concept, structure of discretization equation, Taylor series formulation, variational formulation, method of weighted residuals, control volume formulation.

Learning Outcomes:

At the end of this unit, student will be able to

- Describe discretization techniques and apply to equations

UNIT III **9L + 3T**

Steady and unsteady state molecular phenomena: Steady one dimensional equation – basic equation, grid spacing, non-linearity, source term linearization, boundary conditions and solution. Unsteady one dimensional equation – general discretization equation, explicit, Crank-Nicolson, Fully implicit schemes and equations.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply techniques to steady and unsteady state equations

UNIT IV **9L + 3T**

Steady and unsteady state molecular and convection phenomena: Upwind scheme, exact solution, exponential scheme, hybrid scheme, power law scheme, generalized formulation and consequences of various schemes.

Learning Outcomes:

At the end of this unit, student will be able to

- Apply techniques to molecular and convective models

UNIT V **9L + 3T**

Calculation of flow field: The momentum equations, the pressure and velocity corrections, the pressure correction equation, SIMPLE algorithm, SIMPLER algorithm.

Learning Outcomes:

At the end of this unit, student will be able to

- Solve the pressure and velocity equations

Text Book:

1. Suhas V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Mc Graw Hill Book Company, New York, 1980.

Reference Books:

1. Anil W. Date, *Introduction to Computational Fluid Dynamics*, Cambridge University press, 2005.
2. Muralidhar K. and Sundararajan T., *Computational Fluid Flow and Heat Transfer*, Narosa Publishing House, 2003.

PROJECT PHASE - II

Course Code – Category: CHE 424– PR

L	T	P	E	O	Credits: 8
0	0	9	0	9	Sessional Marks: 100

End Exam: 3 Hours **End Exam Marks: 100**

Course Objectives:

To prepare students to conduct, design and analyze the problems of Chemical Engineering through experimental or theoretical studies and represent in the form of technical report.

Course Outcomes:

By the end of the course, the student would be able to

3. Identify the gap between the needs of society and available technology through literature survey
4. Formulate and analyze the objectives of their study
5. Aggregate research in the form of a written report

CO – PO – PSO Matrix:

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

Project Identification Strategies Projects are classified into three categories

- Theoretical design projects
- Experimental projects
- Simulation projects

The project work should consist of a comprehensive design of a chemical plant in the form of a report with the following chapters.

1. Introduction
2. Physical and chemical properties and uses
3. Literature survey for different processes
4. Selection of the process
5. Material and energy balances
6. Specific equipment design (Process as well as mechanical design with drawings)
7. General equipment specifications
8. Plant location and layout
9. Materials of construction

10. Health and safety factors
11. Preliminary cost estimation
12. Bibliography

Project Evaluation:

The student projects have been evaluated by three internal evaluators and also by the project guide. The project is divided into six parts as follows

- Introduction of the project
- Process description with flow sheet
- Material and Energy balances
- Design of specific equipment
- Plan location, layout and economics
- Over all project

Project seminars are conducted in six phases to evaluate the progress of project work carried. For each presentation 50 marks are allotted to each student by the four evaluators (guide 20M and each examiner 10M). Marks have been awarded based on the performance of the student in terms of presentation skills, communication skills, knowledge on the project, finally all the marks obtained in the six phases are averaged to award total marks for the project