IV/IV B. Tech. 1st Semester

Code	Subject	Category	Instruction Periods per week				Maximum Marks			Credits
			Theory	Tutorial	Lab	Total	Sessional	External	Total	
CHE 411	Open Elective – II	OE	3	1	-	4	40	60	100	3
CHE 412	Transport Phenomena	PC	4	1	-	5	40	60	100	4
CHE 413	Process Dynamics and Control	PC	4	1	-	5	40	60	100	4
CHE 414	Process Modeling and Simulation	PC	4	1	-	5	40	60	100	4
CHE 415	Elective – III	PE	4	1	-	5	40	60	100	4
CHE 416	Process Dynamics and Control Laboratory	PC	-	-	3	3	50	50	100	2
CHE 417	Process Modeling and Simulation Laboratory	PC	-	-	3	3	50	50	100	2
CHE 418	Seminar	PW	-	-	3	3	100	-	100	4
CHE 419	Industrial Training*	IT	-	-	-	-	-	100	100	2
	Total		**19**	**5**	**9**	**33**	**400**	**500**	**900**	**29**

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

IV/IV B. Tech. 2nd Semester

Code	Subject	Category	Instruction Periods per week				Maximum Marks			Credits
			Theory	Tutorial	Lab	Total	Sessional	External	Total	
CHE 421	Chemical Process Economics and Equipment Design	PC	4	1	-	5	40	60	100	4
CHE 422	Elective – IV	PE	4	1	-	5	40	60	100	4
CHE 423	Chemical Process Equipment Design Laboratory	PC	-	-	3	3	50	50	100	2
CHE 424	Project	PW	-	-	6	6	100	100	200	8
CHE 425	MOOCs	OE	-	-	-	-	100	-	100	2
	Total		**8**	**2**	**9**	**19**	**330**	**270**	**600**	**20**

ELECTIVE SUBJECTS:

Elective – III

CHE 415(A)	Petroleum Refinery Engineering
CHE 415(B)	Chemical Process Computations
CHE 415(C)	Nanotechnology
CHE 415(D)	Computational Fluid Dynamics
CHE 415(E)	Fundamentals of Biological Sciences

Elective - IV

CHE 422(A)	Reserviour Engineering
CHE 422(B)	Process Optimization
CHE 422(C)	Energy Engineering
CHE 422(D)	Industrial Management
CHE 422(E)	Biochemical Engineering

Open Elective - I

CHE 311(A)	Industrial Safety and Hazard Management
CHE 311(B)	Engineering Biology
CHE 311(C)	Fuel Cell Technology
CHE 311(D)	Design of Experiments

Open Elective - II

CHE 411(A)	Food Processing Technology
CHE 411(B)	Corrosion Engineering
CHE 411(C)	Computational Tools for Engineers
CHE 411(D)	Bioinformatics

TRANSPORT PHENOMENA

CHE 412 **Credits:4**
Instruction : 4Lectures& 1Tut. /Week 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 **12L + 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.

UNIT-II **12L + 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.

UNIT-III **12L + 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.

UNIT-IV **12L + 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 solids and 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.

UNIT-V **12L + 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 and definition of the transfer coefficients for high mass transfer rates.

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.

PROCESS DYNAMICS AND CONTROL

CHE 413 **Credits: 4**
Instruction: 4 Lectures&1Tut./Week Sessional Marks: 40
End Exam: 3 Hours End Exam Marks: 60

Prerequisites:
Engineering Mathematics

Course Objectives:
1 To know about linear chemical process problems and control configurations
2 To understand control strategies

Course Outcomes:
By the end of the course, the student will be able to:
1 Formulate and solve linear chemical processes
2 Develop block diagram and transfer function for a closed loop system.
3 Analyze stability of control systems
4 Analyze the response of processes for various controllers
5 Acquire the knowledge on advanced control strategies, controller tuning and control valves.

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

SYLLABUS

UNIT- I **12L + 3T**
Linear open loop systems: Simple first order and second order systems, physical examples of first and second order systems, response of first order systems in series, transportation lag

UNIT-II **12L + 3T**
Linear closed loop systems : The control systems, controllers , final control element, block diagram of chemical reactor control systems, closed loop transfer functions , transient response of simple control systems

UNIT-III **12L + 3T**
Stability: Stability, root locus, frequency response, control system design by frequency response, Bodediagram, Bode stability criteria

UNIT-IV **12L + 3T**

Analysis and design of feedback control systems: Concept of feedback control, types of feedback controllers, measuring devices, final control elements, dynamic behavior of feedback control process, block diagram and closed loop response, effect of proportional, integral and derivative control action on the response of a controlled process

UNIT-V **12L +**

3TAnalysis and design of control systems: Cascade control, feed forward control, ratio control

Introduction to process applications: Controller tunings, controller mechanisms, control valves

Text Books:

1 Donald R. Coughnowr, Steven E. LeBlanc*Process Systems Analysis and Control*, 3rdEd., McGraw-Hill Education India Pvt. Ltd., 2013.

References:

1 G.Stephanopoulos, *Chemical Process Control: An Introduction to Theory & Practice*, PHI, 1983

2 W. B.Bequette, *Process Control: Modelling, Design and Simulation*, Prentice Hall, 1998

3 D.Seborg, T.F. Edgar Duncan, A. Mellichamp, *Process Dynamics and Control*,3rd Ed., John Wiley &Sons, Inc, 2010

PROCESS MODELING AND SIMULATION

CHE 414 **Credits:4**

Instruction : 4 Lectures& 1Tut./Week 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 **12L+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.

UNIT –II **12L+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.

UNIT-III **12L+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.

UNIT-IV **12L+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.

UNIT-V **12L+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.

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.

PETROLEUM REFINERY ENGINEERING

CHE 415(A) **Credits: 4**

Instruction: 4 Lectures& 1Tut./ week Sessional marks: 40

End Exam: 3 Hours End Exam Marks: 60

Prerequisites:

Engineering chemistry and organic chemistry

Course Objectives:

1. To understand the scenario of petroleum refining and future prospects.
2. To understand the process technologies for the petroleum products.
3. To understand suitable processes for obtaining the desired petroleum cuts.

Course Outcomes:

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

1. Outline the formation of crude oil and its reserves
2. Acquire knowledge on pretreatment and fractionation of petroleum
3. Predict the suitable treatment techniques for the desired products
4. Classify various petroleum cracking operations
5. Identify different refinery value addition processes

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

SYLLABUS

UNIT-I **12L+3T**

Origin, formation and composition of petroleum: Origin, formation and composition of petroleum, Reserves and deposits of world, Petro Glimpses and petroleum industry in India, future prospects.

UNIT-II **12L+3T**

Petroleum processing data: Evaluation of petroleum, thermal properties of petroleum fractions, important products, properties and test methods.

Fractionation of petroleum: Dehydration and desalting of crudes, heating of crude pipe still heaters, atmospheric and vacuum distillation, blending of gasoline.

UNIT-III **12L+3T**

Treatment techniques: Fraction-impurities, treatment of gasoline, treatment of kerosene, treatment of lubes.

UNIT-II **12L+3T**

Cracking processes: Thermal cracking, Hydrocracking, Catalytic cracking and - Feed stocks - Catalysts - Process variables, Naphtha cracking, Coking, Visbreaking processes.

UNIT-V

Refining processes: **12L+3T**

Hydrogenation process, Catalytic reforming, Alkylation processes, Isomerization, Polymerization, Hydrotreating, Asphalt and air blown asphalt.

Textbooks:

1. B.K. BhaskaraRao, *Modern Petroleum Refining Processes*, 5th Edition, Oxford & IBHPublishing, 2011.
2. Nelson, W.L. *Petroleum refining Engineering*, 4th Edition, McGraw Hill, New York, 1969. (**UNIT IV & V)**

Reference Books:

1. Ram Prasad,*Petroleum Refining Technology*, 1stEdition, Khanna Publishers, 2002.
2. J.H. Gary and G.E.Handwerk,*Petroleum Refining Technology and Economics*, 4thEdition, Marcel Dekkar Inc., 2001.

CHEMICAL ENGINEERING COMPUTATIONS

CHE 415(B) **Credits :4**
Instruction: 4 Lectures & 1Tut. / Week Sessional Marks : 40
End Exams : 3 hr End Exams Marks : 60

Prerequisites
Fluid Mechanics, Heat Transfer, Mass Transfer

Course Objectives
1. To impart the application of computations in Chemical Engineering

Course Outcomes
By the end of this course, students will be able
1. To mathematically formulate the chemical process
2. To mathematically formulate chemical equilibria with two or more equations
3. To mathematically formulate reactions in chemical reactors with two or more equations
4. To simulate mass transfer equipment
5. To simulate transport processes in one dimension

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

SYLLABUS

UNIT-I **12L + 3T**
Introduction: Algebraic equations, Process Simulation, Differential Equations
Equation of State: Mathematical Formulation, solving equations of state using excel and MATLAB

UNIT-II **12L + 3T**
Vapor Liquid equilibria: Flash and phase separation, Isothermal flash- Development of equations, Thermodynamic parameters, Non ideal liquids- Test of thermodynamic models
Chemical Reaction Equilibria: Chemical equilibrium expression, Chemical equilibria with two or more equations, Example of hydrogen for fuel cells,

UNIT- III **12L + 3T**
Chemical Reactors: Mathematical formulation of reactor problems, Batch reactor, plug flow reactor, chemostat, Reactor problems with mole changes and variable density, Chemical reactors with mass transfer limitions

UNIT- IV **12L + 3T**

Simulation of Mass Transfer Equipment: Mathematical modeling of distillation with rigorous plate to plate methods, Packed bed adsorption, gas plant production separation,

UNIT -V **12L + 3T**

Transport Process in one dimension: Applications in Chemical Engineering- Mathematical formulations, heat transfer in slab, reaction and diffusion, flow of Newtonian and non Newtonian fluid in a pipe, Transient heat transfer, Linear Adsorption, Chromomatography.

Textbook

1. Bruce A. Finlayson, *Introduction to Chemical Engineering Computation*, John Wiley and Sons Inc., 1st edition, 2012.
2. Kenneth. J. Beers, Numerical Methods in Chemical Engineering, Cambridge Press, 2nd edition, 2007

References

1. C. D. Holland, *Fundamentals and Modelling of Separation Processes*, Prentice Hall Inc., New Jersey, 1975
2. Tarhan. M. Orhan, *Catalytic Reactor Design*, McGraw Hill, 1983
3. R. K. Sinnot,Coulson& Richardson, *Chemical Engineering Volume – 6: Chemical Engineering Design*, 3rd Edition, Butterworth – Heinemann Publication.

NANOTECHNOLOGY

CHE 415(C) **Credits:4**
Instruction : 4 Lectures& 1Tut/Week Sessional Marks : 40
End Exam : 3 Hours End Exam Marks: 60

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. Process Design different synthesis route 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

SYLLABUS

UNIT-I **12L+3T**

Basics and Scale of Nanotechnology: Introduction, Scientific revolutions, Time and length scale in structures, 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).

UNIT-II **12L+3T**

Nanomaterials: Classification based on dimensionality, Quantum Dots, Wells and Wires,Carbonbasednano materials (buckyballs, nanotubes, graphene)Metalbasednanomaterials (nanogold, nanosilver and metal oxides) Nanocomposites, Nanopolymers. Nanoglasses, Nano ceramics, Biologicalnanomaterials.

UNIT-III **12L+3T**

Nanotechnology to Nano Engineering: Introduction to nanotechnology, Process Technology in nanoengineering, 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

UNIT-IV **12L+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

UNIT-V **12L+3T**

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

Text Book:

1. Pradeep T., *A Textbook of Nanoscience and Nanotechnology*, Tata McGraw Hill Education Pvt. Ltd., 2012.(**UNIT-I &II**)
2. Said SalaheldeenElnashaie, FiroozehDanafar, 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.

COMPUTATIONAL FLUID DYNAMICS

CHE 415(D) **Credits:4**
Instruction : 4Lectures& 1Tut/Week 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. Familiarize with the relevance and identification of the governing equations.
2. Understand 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. Know the procedure to 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

SYLLABUS

UNIT-I **12L+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.

UNIT-II **12L+3T**
Discretization methods: Discretization concept, structure of discretization equation, Taylor series formulation, variational formulation, method of weighted residuals, control volume formulation.

UNIT-III **12L+3T**

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

UNIT-IV **12L+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.

UNIT-V **12L+3T**

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

Text Book:

1. Suhas V. Patankar, *Numerical Heat Transfer and Fluid Flow*, McGraw 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.

FUNDAMENTALS OF BIOLOGICAL SCIENCES

CHE 415(E) **Credits:4**

Instruction : 4 Lectures& 1Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

Course Objectives:

1. To provide a basic understanding of biological mechanisms of living organisms from the perspective of engineers.
2. To encourage engineering students to think about solving biological problems with engineering tools.

Course Outcomes:

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

1. Classify various microorganisms
2. Identify different types of bacteria
3. Draw structures of different biomolecules
4. Identify DNA as a genetic material in the molecular basis of information transfer.
5. Classify different types of immune system of humans combating with pathogens

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

SYLLABUS

UNIT-I **12L+3T**

Importance of Biology and Classification of microorganisms: Fundamentaldifferences between science and engineering- comparing eye and camera, flying bird and aircraft. Major discoveries in biology from 18th century (Robert Brown and Julius Von Mayer).Classification of organisms based on Cellularity, Energy and carbon utilization, Ammonia excretion, Habitat. Molecular taxonomy- Five kingdom classification- Characteristics, Structure, Nutrition, Reproduction, Economic importance and pathogenicity.

UNIT-II **12L+3T**

Microbiology: Microbial taxonomy- Taxonomic ranks, concept of species and strains, Classification systems-phenetic, phylogenetic and molecular parameters. Concept of single celled organisms, Microscopy- optical microscopy, electron microscopy and their uses. Identification methods of bacteria -based on shape, arrangement of cells, gram staining, metabolic differences and biochemical characteristics, Ecological aspects of single celled organisms.

UNIT-III **12L+3T**

Biochemistry: Molecules of life, Structure, properties and functions of carbohydrates (Mono-, di- and polysaccharides), Proteins (Aminoacids-types; proteins Types, classification (Enzymes, Transporters, receptors, and structural elements) and hierarchy of structure), Nucleic acids (Nucleotides, DNA & RNA), Lipids (Simple lipids, compound lipids & derived lipids).

UNIT-IV **12L+3T**

Genetics: DNA as a genetic material, Hierarchy of DNA structure-from single to double helix to nucleosomes. Concept of genetic code- characteristics.Introduction to central dogma.Definition of gene in terms of complementation and recombination.Outlines of Mitosis and Meiosis and its significance.

UNIT-V: **12L+3T**

Immune System: Overview of the Immune System: Innate and adaptive immune system components, T-lympcytes, Antigen presenting cells, MHC molecules bind antigenic peptides, Immune dysfunction and its consequences

Text Book:

1. Thyagarajan S., Selvamurugan N., Rajesh M. P., Nazeer R. A., Richard Thilagaraj W, Barathi S., and Jaganathan M. K., *Biology for Engineers*, Tata McGraw-Hill, New Delhi, 2012.
2. Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne , *Kuby Immunology*, 7th Edition, 2013 (**UNIT-V**)

Reference Books:

1. Jeremy M. Berg, John L. Tymoczko and LubertStryer, *Biochemistry*, W.H. Freeman and Co. Ltd., 6th Ed., 2006.
2. Robert Weaver, *Molecular Biology*, MCGraw-Hill, 5th Edition, 2012.
3. B.D. Singh, *Fundamentals of Genetics*, Kalyani Publishers, 2004.

PROCESS DYNAMICS AND CONTROL LABORATORY

CHE 416 **Credits:2**
Instruction : 3Practical hours per week Sessional Marks : 50
End Exam : 3 Hours End Exam Marks: 50

Prerequisites:
Engineering Mathematics, Process dynamics and control

Course Objectives:
1. To impart knowledge on the determination of time constants of a process.
2. To enable the students in designing a controller.

Course Outcomes:
By the end of the course, the student will be able to:
1. Determine the response and time constants of various process
2. Acquire hands on experience on the operation of various Controllers

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				3	2		1	2	3

List of experiments
1. Response of mercury-in glass thermometer
2. Response of mercury-in glass thermometer with thermal well.
3. Response of manometer
4. Response of single tank liquid level system
5. Response of two tank non-interacting liquid level system
6. Response of two tank interacting liquid level system
7. Study of control valve coefficient.
8. Valve characteristics of a control valve
9. Response of pressure control trainer for sinusoidal input
10. Pressure control trainer
11. Temperature control trainer
12. Level control trainer

Prescribed Books:
1. Donald R. Coughnowr, Steven E. LeBlanc*Process Systems Analysis and Control*, 3rdEd., McGraw-Hill Education India Pvt. Ltd., 2013.
2. G. Stephanopoulas, *Chemical Process Control- An Introduction to Theory andPractice,*Prentice Hall of India Pvt. Ltd., New Delhi, 2008.
3. B. Wayne Bequette, *Process Control – Modeling Design and Simulation,* Prentice Hall, 1st edition, 2003.

PROCESS MODELLING AND SIMULATION LABORATORY

CHE 417 **Credits:2**
Instruction : 3practical hours per week Sessional Marks : 50
End Exam : 3 Hours End Exam 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 flowsheet
10. Simulation of a flowsheet with recycle stream
11. Optimization of process parameters in a flowsheet
12. Unsteady state operation of a flowsheet

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.

SEMINAR

CHE 418 **Credits: 4**
Instruction: 3 practical hours/Week Sessional Marks: 100

Course Objectives:
1. To provide knowledge in preparing Technical Reports
2. To familiarize with the power point presentations
3. To enhance communication skills

Course Outcomes:
By the end of the course, the student will be able to:
1. Prepare Technical Reports
2. Develop Presentation and Communication Skills

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	2	2			1	3	3		2	2	3
	2	1	1	1	1	2			1	3	3		2	2	3

- Seminars are conducted in two phases to evaluate the knowledge, presentation skills of the student.
- For each presentation 50 marks are allotted to each student by the four evaluators.
- Marks have been awarded based on the performance of the student in terms of presentation skills, communication skills, knowledge on the topic.
- Finally all the marks obtained in the two phases are averaged to award total marks for the project

Industrial Training

CHE 419 **Credits: 2**

End Exam 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

CHEMICAL PROCESS ECONOMICS
AND EQUIPMENT DESIGN

CHE 421 **Credits: 4**
Instruction: 4 Lectures&1Tut./Week 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 equipment.
5 Design process equipment

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 **12L+3T**
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.

UNIT-II **12L+3T**
Value of money and depreciation: Types of interest- discrete and continuous, equations for economic studies, annuities - relation between ordinary annuity and the periodic payments,

value of a bond, types and various methods of calculating depreciations, depreciation accounting.

UNIT-III **12L+3T**

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.

UNIT-IV **12L+3T**

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

UNIT-V **12L+3T**

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

Text Books:

1 M. S. Peters &K.D.Timmerhaus, *Plant design and Economics for Chemical Engineers,* 4th edition, McGraw 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.

RESERVOIR ENGINEERING

CHE 422(A) **Credits:4**
Instruction: 4 Lectures& 1Tut. / Week Sessional Marks : 40
End Exams : 3 hr End Exams Marks : 60

Prerequisites
Chemical Process Calculations, Fluid Mechanics, Chemical Technology, Mass Transfer

Course Objectives
1. To impart knowledge on basic terminology of Reservoir Engineering
2. To impart knowledge of salient features of an oil reservoir
3. To give the basic material balance of the reservoir resources
4. To make aware of importance of pressurizing an oil reservoir
5. To give an in-depth understanding of enhanced oil recovery methods

Course Outcomes
By the end of this course, students will be able
1. To understand the terms and denotations of an Oil Reservoir
2. To know the features and identifications of an Oil Reservoir
3. To perform material balances of the reservoir resources
4. To understand the need for maintaining pressure in an oil reservoir
5. To understand the different levels of enhanced oil recovery methods

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

SYLLABUS

UNIT-I **12L +3T**
Introduction to Reservoir Engineering: Basic Principles and Definitions – Porosity, Fluid saturation, Permeability, Flow through Layered Beds, Flow through Series Beds, Klinkenberg effect, Effective Permeability, Relative Permeability - Calculating Relative Permeability Data, Phase Behavior.

UNIT-II **12L + 3T**
Features of Reservoir: Reservoir Driving Mechanisms, Basic Equation and Tools, Volatile Oil Reservoirs, Identification of Volatile Oil Reservoirs, Ultimate Recovery, Predicting Reservoir Behavior, Rock Compressibility, Reservoir Heterogeneity.

UNIT-III **12L + 3T**

Material Balance of Oil Reservoirs: General Material Balance Equations, Reservoir Drive Mechanisms – Solution Gas, Gas cap, Natural Water, Compaction, Pore Compressibility Phenomena.

UNIT-IV **12L + 3T**

Pressure Maintenance in Reservoirs: Pressure Maintenance by Gas Injection, Condensing Gas Drive, Predicting Performance by Gas Injection, Injected Gas Drive Index, Pressure Maintenance by Water Injection, Predicting Performance by Water Injection, Index of Injected Water Drive, Control of The Gas Cap, Typical Water Injection Pressure Maintenance Operations.

UNIT-V **12L + 3T**

Enhanced Oil Recovery: Methods - Fluid Injection (Immiscible or Miscible Fluid Injection), Thermal Oil Recovery, Carbon Capture and Sequestration.

Textbook

1. Frank. W. Cole, *Reservoir Engineering Manual*, Gulf Publishing Company, Houston, Texas, Second Edition, 1989.

References

1. Ahmed, T,*Reservoir Engineering Handbook*, 3rd Edition, Elsevier, 2006.
2. Slip Slider, H.C. *Worldwide Practical Petroleum Reservoir Engineering Method*, PennWell Publishing Company, 1983.
3. Gianluigichierici, *Principles of Petroleum Reservoir Engineering*, Elsevier, 1994.
4. Dake. L. P., *Fundamentals of Reservoir Engineering*, Seventeenth Impression, Elsevier Science B. V., 1998

Web Resources

1. http://nptel.ac.in/courses/103105110/m3l16.pdf
2. https://www.class-central.com/tag/reservoir%20engineering

PROCESS OPTIMIZATION

CHE 422(B) **Credits:4**
Instruction : 4 Lectures& 1Tut/Week 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

SYLLABUS

UNIT-I **12L+ 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, Optimization of a manufacturing problem with a stepwise procedure, 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

UNIT-II **12L+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.

UNIT-III **12L+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.

UNIT-IV **12L+3T**

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

UNIT-V **12L+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.

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,* 3rdEd., 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,* 2ndEd., 2006.
5. Joshi, Mohan C., and Kannan M. Moudgalya. *Optimization: theory and practice.* Alpha Science Int'l Ltd., 2004.

ENERGY ENGINEERING

CHE 422(C) **Credits: 4**
Instruction: 4 Lectures& 1Tut/Week Sessional Marks: 40
End Exam: 3 Hours End Exam Marks: 60

Prerequisites:
Chemical Technology, Engineering chemistry.

Course Objectives:
To provideknowledge to conventional and non-conventional energy resources and their applications, concept of fuel cells, nuclear energy, energy storage and conservation.

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

1. Explain the various conventional and non-conventional energy resources available, production and use.
2. Identify the scenario of oil and gases, characteristics and applications.
3. Discuss the sustainability in application of non-conventional energy resources
4. Elucidate the concept of fuel cells, biofuels and nuclear energy with future applications.
5. Substantiate the Energy Storage, Distribution and conservation methodology for sustainability.

CO – PO – PSO Matrix:

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

SYLLABUS

UNIT-I **12L+ 3T**
Introduction: Conventional energy resources, the present scenario, scope for future development.
Coal:Origin, occurrence and reserves, classification, ranking, analysis and testing, coal carbonization, manufacture of coke, coal gasification, coal liquefaction.

UNIT-II **12L+ 3T**
Oil and Gases: Origin and formation of petroleum and gases, reserves and deposits of world, Indian Petroleum Industry, Fractionation of petroleum.Fuels derived from oil and gases, Characteristics, production methods and uses.

UNIT-III **12L+ 3T**

Non-conventional energy sources: Solar energy, solar radiation, principles of heating and cooling, photo voltaic cells. Wind energy, hydrogen energy, geothermal and ocean thermal energy.

UNIT-IV **12L+ 3T**

Bio Fuels: Introduction, Bio mass conversion technologies, Wet processes, dry processes, Bio-gas generation, Factorsaffecting bio-digestion, Classification of biogas plants, Production methods, characteristics, uses of biodiesel,bio-ethanol, Second generation biofuel feed stocks.
Fuel Cells: Working principle, Types,Advantages, Current and Future Applications.
Nuclear Energy: Nuclear fuel processing, nuclear reactions and nuclear reactors.

UNIT-V **12L+ 3T**

Energy Storage and Distribution: Mechanical Energy Storage, Hydroelectric Storage, Compressed Air Storage and Energy Storage via Flywheels,Electric Storage, Chemical Storageand Thermal Energy Storage.
Energy Conservation: Conservation methods in process industries, Theoretical analysis, practical limitations, equipment for energy saving / recovery.

Text Books:

1. S. Rao, B. B. Parulekar,*Energy Technology*, 3rd Ed., Khanna Publishers, 1994. **(UNIT-I &V)**
2. G. D. Rai,*Non-Conventional energy sources*, 18thEd.,Khanna Publisher, 2017.**(UNIT-III)**
3. S. Sarkar,*Fuels and Combustion*, Universities Press, 3rdEd., 2009.**(UNIT-IV)**
4. Nelson. W. L,*Petroleum refining Engineering*, 4thEd.,McGraw Hill, New York, 1969.**(UNIT-II)**

Reference books:

1. S.B.Pandy,*Conventional Energy Technology*, Tata McGraw Hill.
2. S. Srinivasan,*FuelCells: From Fundamentals to Applications*, Springer, 2006 .
3. O. P. Gupta,*Fundamentals of Nuclear power reactors*, Khanna Publishers, New Delhi, 1983.
4. Harker and Backhusst,*Fuels and energy,* Academic press, London 1981.

INDUSTRIAL MANAGEMENT

CHE 422(D) **Credits:4**
Instruction : 4 Lectures /Week Sessional Marks : 40
End Exam : 3 Hours End Exam Marks: 60

Course Objectives

1. To familiarize the students with the concepts of Management.
2. To relate the concepts of management with industrial organizations.
3. To explain the factors affecting productivity and how productivity can be increased in anIndustrial undertaking.

Course Outcomes:

By the end of the course, the 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

SYLLABUS

UNIT-I **12L+ 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.

UNIT-II **12L+ 3T**

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

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

UNIT-III **12L+ 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.

UNIT-IV **12L+ 3T**

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

UNIT-V **12L+ 3T**

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

Text Books

1. P.C. Tripathi, P.N.Reddy, *Principles of Management*, 4thEdition, Tata McGraw Hill Companies, New Delhi ,2008.**(UNITI & 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.

BIOCHEMICAL ENGINEERING

CHE 422(E) **Credits:4**

Instruction : 4 Lectures& 1Tut/Week Sessional Marks : 40

End Exam : 3 Hours End Exam Marks: 60

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 theproduction 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

SYLLABUS

UNIT-I **12L+3T**

Introductionto 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

UNIT-II **12L+3T**

Introduction to enzymes: Classification, kinetics of enzyme catalyzed reactions, derivation of MichaelisMenten 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

UNIT-III **12L+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

UNIT-IV **12L + 3T**

Transport phenomenonacross the cell: Active, passive and facilitated diffusion, gas liquid mass transfer in cellular systems, determination of $k_L$avalues

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

UNIT-V **12L + 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.

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
3. J.M. Lee, *Biochemical engineering,* Prentice Hall, Englewood Clifts, 1992.

CHEMICAL PROCESS EQUIPMENT DESIGN LABORATORY
(Open book practical examination)

CHE 423 **Credits: 2**
Instruction: 3 practical hours/Week Sessional Marks: 50
End Exam: 3 Hours End Exam Marks: 50

Prerequisites:
Heat Transfer, Mass Transfer, and chemical Reaction Engineering.

Course Objectives:
To provide the knowledge on design of different equipments.

Course Outcomes:
By the end of the course, the student would be able to
1 Design heat transfer equipment
2 Design reactor and mass transfer equipment

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					2	2		1	2	3
	2	3	3	3	3					2	2		1	2	3

The following equipments are to be designed in detail:

1. Double pipe heat exchanger
2. Double pipe heat exchanger in series-parallel arrangements
3. 1-2 Shell and Tube heat exchanger
4. 2-4 Shell and Tube heat exchanger
5. Condenser and reboiler
6. Multiple effect feed forward evaporator
7. Multiple effect feed backward evaporator
8. Fractionating column-Plate and packed columns
9. Packed bed absorber
10. Continuous tubular reactor (homogeneous and heterogeneous)

Two equipment designs can be performed in simulation software to have hands on experience

Prescribed Books:

1. Donald Q Kern, *Process Heat Transfer,* McGrawHill International Book Company, 1983.
2. Robert ETreybal, *Mass Transfer Operations*, 3rd Edition, McGraw Hill International Book Company, 1980

PROJECT WORK

CHE 424 **Credits: 8**

Instruction: 6 practical hours/Week 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

1. Identify the gap between the needs of society and available technology through literature survey
2. Formulate and analyze the objectives of their study
3. 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