

Chemical Engineering Curriculum

E1 Sem1 Courses and Syllabus		
Course Code: MA1101	Course Name: Mathematics-I	No. of Credits: 4
Detailed Syllabus: UNIT-1: SEQUENCES AND SERIES: Sequences – series – Convergences and divergence – Ratio test – Comparison test – Integral test –cauchy's root test– Raabe's test –Absolute and conditional convergence. UNIT-2: Differential Calculus (Functions of several variables): Limit, Continuity and Differentiability of functions of several variables, Partial derivatives and their geometrical interpretation, Differentials, Derivatives of Composite and Implicit functions, Derivatives of higher order and their commutativity, Euler's theorem on homogeneous functions, Harmonic functions, Taylor's expansion of functions of several variables, Maxima and Minima of functions of several variables - Lagrange's method of multipliers. UNIT-3: Integral Calculus: Convergence of improper integrals, tests of convergence, Beta and Gamma functions - elementary properties, differentiation under integral sign, differentiation of integrals with variable limits - Leibnitz rule. Rectification, double and triple integrals, computations of surface and volumes, change of variables in double integrals. UNIT-4: Vector Calculus: Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, theorems of Green, Gauss and Stokes, orthogonal curvilinear coordinates.		
Course Code: CH1001	Course Name: Fluid Mechanics	No. of Credits: 4
Detailed Syllabus: Unit operations and unit processes, unit systems, dimension analysis, basic concepts, nature of fluids, hydrostatic equilibrium, applications of fluid statics. Fluid flow phenomena-Laminar flow, Shear rate, Shear stress, Rheological properties of fluids, Turbulence, Boundary layers. Basic equation of fluid flow –Mass balance in a flowing fluid; continuity, differential momentum balance; equations of motion, Macroscopic momentum balances, Mechanical energy equations Incompressible Flow in pipes and channels- shear stress and skin friction in pipes, laminar flow in pipes and channels, turbulent flow in pipes and channels, friction from changes in velocity or direction. Flow of compressible fluids- Definitions and basic equations, Processes of compressible flow, Isentropic flow through nozzles, adiabatic frictional flow, and isothermal frictional flow. Flow past immersed bodies, Drag and Drag coefficient, flow through beds of solids, motion of particles through fluids. Fluidization, Conditions for fluidization, Minimum fluidization velocity,		

Types of fluidization, Expansion of fluidized bed, Applications of fluidization. Continuous fluidization; slurry and pneumatic transport.

Transportation and Metering of fluids- Pipes, fittings and valves, pumps: positive displacement pumps, and centrifugal pumps. Fans, blowers, and compressors, Measurement of flowing fluids- full bore meters, insertion meters.

Text Books:

1. Introduction to Fluid Mechanics by Fox and Mc Donald – 8th Edition.

References:

1. Unit Operations of Chemical Engineering by W.L.McCabe, J.C.Smith & Peter Harriot, McGraw- Hill, 6th Edition, 2001.
2. Transport processes and unit operations by Christie J. Geankoplis, PHI.

Course Code: CH1002

Course Name: Chemical Process Calculations

No. of Credits: 4

Detailed Syllabus:

Basic concepts of Chemical process calculations – Dimensions, units and conversion, concepts on Temperature, Pressure and Concentration.

Material Balances – Introduction, Material Balances with and without chemical reactions, Recycle, Bypass, Purge and Industrial applications.

Energy Balances – Introduction, Energy balances with and without chemical reactions, enthalpy changes.

Basic Chemical Calculations - Ideal gas laws and its application. Dalton law, Raoult's law, Henry's laws, solubility and Distribution coefficient, Heats of Solutions

Humidity charts, their use and saturation.

Text Book:

1. “Basic Principles and Calculations in Chemical Engineering”, David M Himmelblau and James B Riggs, 7th Edition, PHI.

References

1. “Chemical process principles Part-I, Material and Energy Balance” by O. A. Hougen, K. M. Watson, John Wiley and Asia Publication.
2. “Stoichiometry” (S.I units): B. I. Bhatt & S. M. Vora, McGraw Hill Ltd, 3rd Edition.

Course Code: CY1101

Course Name: Engineering Chemistry-I

No. of Credits: 4

Detailed Syllabus:		
Course Code: CE1101	Course Name: Engineering Drawing	No. of Credits: 4
Detailed Syllabus: Introduction to IS code of drawing; Conics and Engineering Curves - ellipse, parabola, hyperbola, cycloid, trochoid, involute; Projection of lines - traces, true length; Solid objects - cube, prism, pyramid, cylinder, cone and sphere; Projection on Auxiliary planes; Isometric projection, isometric scale; Section of solids - true shape of section; Introduction of Development and Intersection of surfaces. Introduction to CAD tools - basics and use; Text Book - 1. Engineering Drawing and Graphics By K. Venugopal (New age International Publisher) Reference book- Engineering drawing by N. D Bhatt and V. M Panchal(Charotar Publisher)		
Course Code: CY1101	Course Name: Engineering Chemistry-I-Lab	No. of Credits: 2
Detailed Syllabus:		
Course Code: ME1102	Course Name: Engineering Drawing Lab	No. of Credits: 2

Detailed Syllabus:

Introduction to IS code of drawing;

Conics and Engineering Curves - ellipse, parabola, hyperbola, cycloid, trochoid, involute;

Projection of lines - traces, true length;

Solid objects - cube, prism, pyramid, cylinder, cone and sphere;

Projection on Auxiliary planes;

Isometric projection, isometric scale;

Section of solids - true shape of section;

Introduction of Development and Intersection of surfaces.

Introduction to CAD tools - basics and use;

Text Book - 1. Engineering Drawing and Graphics By K. Venugopal (New age International Publisher)

Reference book- Engineering drawing by N. D Bhatt and V. M Panchal(Charotar Publisher)

E1 Sem2 Courses and Syllabus**Course Code:****Course Name:** Introduction to
Computer Science**No. of Credits: 4****Detailed Syllabus:****Course Code:****Course Name:** Engineering Chemistry-
II**No. of Credits: 4****Detailed Syllabus:**

Course Code:MA1202	Course Name: Mathematics 2	No. of Credits: 4
Detailed Syllabus: UNIT –I Linear Algebra: Rank and inverse of a matrix. Eigenvalues and eigenvectors, Hermitian and skew Hermitian matrices. Numerical solution of system linear equations - Gauss, Gauss-Jordan elimination and Gauss-Seidel iteration methods. Vector spaces - linear dependence of vectors, basis, linear transformations.		
UNIT-II Vector Calculus: Scalar and vector fields, level surfaces, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, theorems of Green, Gauss and Stokes, orthogonal curvilinear coordinates.		
UNIT-III Numerical Analysis: Finite differences, Newton's forward and backward interpolation formulae, central difference interpolation formulae. Trapezoidal and Simpson's 1/3rd rule for numerical integration. Solution of polynomial and transcendental equations - bisection, Newton-Raphson and regula-falsi methods.		
UNIT-IV Complex analysis: Limit, Continuity, Differentiability and Analyticity of functions, Cauchy-Riemann equations, Line integrals in complex plane, Cauchy's integral theorem, Independence of paths, Existence of indefinite integral, Cauchy's integral formula, Derivatives of analytic functions, Taylor's series, Laurent's series, Zeros and singularities, Residue theorem, Evaluation of real integrals.		
Course Code:CH1003	Course Name: Basic Thermodynamics	No. of Credits: 4
Detailed Syllabus: Scope and limitations of thermo dynamics, definition and fundamental concepts, pressure, work, energy, heat. Equilibrium state and phase rule.		
Zeroth law of thermodynamics First law of Thermodynamics: General statement, thermodynamic state and state functions, Internal energy, Enthalpy. The steady-state steady-flow process, Mass and energy balances, equilibrium, the phase rule, the reversible process, constant-V and constant- P processes, heat capacity, isobaric, isochoric, isothermal, adiabatic and polytropic processes.		
Volumetric properties of pure substances : The PVT behavior of pure substances, virial equations, the ideal gas, the applications of the virial equations. Cubic equations of state, generalized correlations for gases, generalized correlations for liquids.		

Heat effects :

Sensible heat effects, Internal energy of ideal gases: Microscopic view, Latent heats of pure substances, heat effects of industrial reactions, heat effects of mixing processes. Standard heat of reaction, Standard heat of formation, Standard heat of combustion, temperature dependence of heat of reaction

Second law of Thermodynamics-Statement, Heat engines, thermodynamic temperatures scales, thermodynamic temperature and the ideal gas scale.

Entropy, Entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, entropy from the microscopic view point, calculation of ideal work and lost work.

Third law of Thermodynamics.

Power Cycles-Carnot cycle, Rankine cycle, Otto cycle, Diesel cycle

Refrigeration and liquefaction: The Carnot refrigerator, the vapor compression cycle, the comparison of refrigeration cycles, the choice of refrigerant, absorption refrigeration, the heat pump, liquefaction processes.

Text Books:

1. "Introduction to Chemical Engineering Thermodynamics" by J M Smith, H C Van Ness and M M Abbott, 6th Edition, TMH.

Course Code: CH1004

Course Name: Heat Transfer

No. of Credits: 4

Detailed Syllabus:

Introduction & Heat transfer by conduction:

Nature of heat flow, Heat transfer by conduction in Solids Fourier's law ,thermal conductivity, steady state conduction in plane wall & composite walls, compound resistances in series.

heat flow through a cylinder, conduction in spheres, thermal contact resistance, plane wall: variable conductivity

Unsteady state heat conduction Equation for one-dimensional conduction, Semi-infinite solid, finite solid

Heat Transfer to Fluids without Phase change:

Regimes of heat transfer in fluids, thermal boundary layer, heat transfer by forced convection in laminar flow,

Heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies and analogy between transfer of momentum and heat.

Natural convection -Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar flow heat transfer,

Free convection in enclosed spaces, mixed free & forced convection
Heat transfer to fluids with phase change -Heat transfer from condensing vapors, heat transfer to boiling liquids.

Heat exchange equipment :

General design of heat exchange equipment, heat exchangers, condensers, Boilers and Calandrias, extended surface equipment, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds, heat exchanger effectiveness (NTU method).

Evaporators - Evaporators, performance of tubular evaporators, capacity and economy, multiple effect evaporators, vapour recompression.

Radiation -Properties and definitions, black body radiation, real surfaces and the gray body,.

Absorption of radiation by opaque solids, radiation between surfaces, radiation shielding, radiation to semi transparent materials.

Text Books

1. Transport processes and Unit operations, Christie J. Geankoplis, PHI.

References:

1. Unit Operations of Chemical Engineering by W. L. McCabe, J. C. Smith & Peter Harriot, 6th Edition. McGraw-Hill

2. Process heat transfer by D. Q. Kern, McGraw-Hill.

3. Heat Transfer, 4th ed., J.P. Holman, McGraw-Hill, New York, 1976.

4. Heat Transfer by B. K. Dutta

Course Code: CH1011	Course Name: Fluid Mechanics Lab	No. of Credits: 2
Detailed Syllabus: Bernoulli's apparatus – verification of Bernoulli's Theorem. Friction Losses in pipe lines/equivalent length of different pipe fittings. Fluidized bed. Reynolds apparatus-Identification of laminar and turbulent flows Venturimeter- Determination of Venturi coefficient Calibration of Pitot tube, Measurement of point Velocity Calibration of Rotameter. Orifice meter- Determination of Orifice coefficient Packed Bed-Pressure drop variation Fluidized bed-Pressure drop variation and void fraction Characteristics of Centrifugal Pump.		
Course Code:	Course Name: Introduction to	No. of Credits: 2

	Computer Science Lab	
Detailed Syllabus:		
E1 Summer Semester		
Course Code:	Course Name: Soft skills	No. of Credits:
Detailed Syllabus:		
E2 Sem1 Courses and Syllabus		
Course Code: MA1202	Course Name: Transform calculus	No. of Credits:
Laplace Transform: Definition of Laplace Transform, linearity property, conditions for existence of Laplace Transform. First and second shifting properties, Laplace Transform of derivatives and integrals, unit step functions, Dirac delta-function, error function. Differentiation and integration of transforms, convolution theorem, inversion, periodic functions. Evaluation of integrals by Laplace Transform. Solution of initial and boundary value problems. Fourier Series : Periodic functions, Fourier series representation of a function, half range series, sine and cosine series, Fourier integral formula, Parseval's identity. Fourier Transform: Fourier Transform, Fourier sine and cosine transforms. Linearity, scaling, frequency shifting and time shifting properties. Self reciprocity of Fourier Transform, convolution theorem. Applications to boundary value problems. Brief Introduction of Z-Transform, Mellin transform and Wavelet Transform. Text Books: 1. Jain. R.K. Iyengar. S.R.K., Advanced Engineering Mathematics, 3rd Edition, Narosa. 2. Churchill. R.V. Brown. J.W., Fourier series and boundary value problems, Mc Graw. Hill. Reference Books: 1. E. Kreyszig Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons (1999) 2. H.Dym and H.P Mc Kean, Fourier series and integrals, Academic press, Newyork (1972)		
Course Code: CH2001	Course Name: Mechanical Unit Operations	No. of Credits: 4
Topics		
Introduction to unit operations and their role in Chemical Engineering industries;		

Properties, handling and mixing of particulate solids: Characterization of solid particles, properties of particulate masses, storage and mixing of solids, types of mixers, mixers for cohesive solids, mixers for free flowing solids.

Transportation of solid particulate mass, belt, screw, apron conveyers, bucket elevators, pneumatic conveying.

Size reduction -Principles of comminution, computer simulation of milling operations, size reduction equipment-crushers, grinders, ultra fine grinders, cutting machines, Equipment operation. Laws of crushing: Kick's law, Bond's law, Rittinger's law

Screening; industrial screening equipments, capacity and effectiveness of screens; differential & cumulative analysis.

Filtration, cake filters, centrifugal filters, cyclone separators, electro-static precipitators.

Principles of cake filtration. Clarifying filters, liquid clarification, gas cleaning, principles of clarification.

Cross flow filtration, types of membranes, permeate flux for ultra-filtration, Concentration polarization, particle rejection of solutes, micro filtration .

Separations based on motion of particles through fluids, gravity settling processes and centrifugal settling processes, float and sink method, differential settling, coagulation, Flotation-separation of ores, flotation agents

Agitation and mixing of liquids:

Agitation of liquids, circulation velocities, power consumption in agitated vessels. Blending and mixing of liquids, suspension of solid particles, dispersion operations

Crystallization: crystal geometry, principles of crystallization equilibria and yields, nucleation, crystal growth, ΔL law, crystallization equipment including MSMPR crystallizers.

TEXT BOOK:

1. Unit Operations in Chemical Engineering by W.L. McCabe and J.C. Smith and Peter Harriott, Mc Graw Hill 7th ed. 2001.

REFERENCES:

1. Chemical engineers hand book, J.H. Perry, 7th ed. Mc Graw Hill

2. Introduction to Chemical Engineering by J.T.Banchero & W.L. Badger., TMH, 1997.

Course Code: CH2002

Course Name: Introduction to Reaction Engineering

No. of Credits: 4

Introduction and Overview of the subject, Classification of chemical reactions; single, multiple,

elementary and non-elementary homogeneous reactions; reaction rate, order and Molecularity; Collision theory and Transition-state theory, Arrhenius relation. Reaction Mechanisms

Interpretation of Batch reactor data :

Constant volume batch reactor; Integral analysis and differential Analysis of batch reactor data. Variable volume batch reactor.

Reversible and irreversible reactions. Autocatalytic reactions.

Introduction to Reactor design for homogeneous isothermal reactions

Ideal Batch reactor

Ideal CSTR reactor design

Ideal plug flow Reactor Design and

Design for single reactions:

Comparison of Ideal Reactors for single reaction. Reactors in series, Reactors of different types in series, Design of Recycle reactor, Optimum recycle ratio, Best reactor system setup for given conversion.

Design for Parallel reactions-Introduction to multiple reactions, Product distribution, quantitative treatment of product distribution-instantaneous yield, Overall yield, Selectivity, various contacting patterns.

Design for Series reactions –irreversible series first order reactions-yield, batch reactor,, plug flow reactor, mixed flow reactor,

Design for reactions with change in order.

Design considerations for Reversible reactions in series.

Design considerations for Series-Parallel reactions

Denbigh reactions

Temperature and pressure effects:

Equilibrium constant and effect of temperature on equilibrium conversion-exothermic and endothermic reactions, General graphical design procedure, Optimum temperature progression, Adiabatic operation and Non-adiabatic operation.

Exothermic reactions in Mixed flow reactor. Multiple reactions-product distribution, Choosing the right kind of reactor.

Text Books

1. "Chemical Reaction Engineering", by Octave Levenspiel, Wiley Eastern, 3rd ed., Tata McGraw Hill.

Reference:

1. "Elements of Chemical Reaction Engineering" by H S Fogler, 4th Edition, PHI.

Course Code: CH2003

Course Name: Chemical Engineering
Thermodynamics

No. of Credits:4

Thermodynamic properties of pure fluids -Property relations for homogeneous phases, Gibbs free energy, Residual properties, Two phase systems, Fugacity, Activity.

Fundamental property relations.

Solution Thermodynamics: Theory, Fundamental property relation, chemical potential as a criterion for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficient for pure species, fugacity and fugacity coefficient for species in solutions, generalized correlations for Fugacity coefficient, The ideal solutions, excess properties.

Solution Thermodynamics Applications: The liquid phase properties from VLE data, models for the excess Gibbs energy, property changes of mixing

VLE at low to moderate pressures-The nature of equilibrium, the phase rule, Duhems theorem, VLE: Qualitative behavior, the gamma /Phi formulation of VLE, Dew point and bubble point calculations, flash calculations, solute (1)/solvent (2) systems

Thermodynamic Properties and VLE from Equations of State- properties of fluids from the virial equations of state, properties of fluids from cubic equations of state, fluid properties from correlations of the Pitzer type,

VLE from cubic equations of state

Topics in Phase Equilibria- Equilibrium and stability, Liquid-Liquid Equilibrium (LLE), Vapor-Liquid-Liquid Equilibrium (VLLE), Solid-Liquid Equilibrium (SLE), Solid Vapor Equilibrium (SVE).

Chemical Reaction Equilibria: The reaction coordinate, application equilibrium criterion to chemical reactions, The standard Gibb's energy change and the equilibrium constant, effect of temperature on equilibrium constants, relation of equilibrium constants to composition, equilibrium conversion for single reactions, Phase rule and Duhem's theorem for reacting systems.

Introduction to Molecular Thermodynamics - Molecular Theory of Fluids, Second Virial Coefficients from Potential Functions, Internal Energy of Ideal Gases: Microscopic view, Thermodynamic Properties and Statistical Mechanics , Hydrogen Bonding and Charge-Transfer Complexing , Behaviour of Excess Properties , Molecular Basis for Mixture Behaviour, VLE by Molecular Simulation.

Text Books:

1. "Introduction to Chemical Engineering Thermodynamics" by J M Smith, H C Van Ness and M M Abbott, 6th Edition, TMH.

REFERENCE:

1. Chemical Engineering Thermodynamics, Pradeep Ahuja, PHI Learning Pvt. Ltd., New Delhi, 2009

2. A Text Book of Chemical Engineering Thermodynamics, K.V. Narayanan, PHI Learning Pvt. Ltd., New Delhi, 2001.

Course Code: CH1014

Course Name: Heat Transfer Lab

No. of Credits: 2

Experiment

Pool boiling apparatus -Determination of critical heat flux point for pool boiling of water.

Natural convection apparatus- Determination of natural convective heat transfer coefficient for a vertical tube

Forced convection- Determination of forced convective heat transfer coefficient for air flowing through a pipe

Thermal conductivity Apparatus-Determination of thermal conductivity of a metal rod

Composite wall apparatus- Determination of total thermal resistance and thermal conductivity of composite wall

Shell And Tube Heat Exchanger- Determination of overall heat transfer coefficient

Emissivity measurement apparatus

Determination of Thermal conductivity of liquid

Course Code:

Course Name: Introduction to software tools Lab

No. of Credits: 2

Introduction to Matlab, Basics of Matlab:

creating and working with arrays of numbers

creating and printing simple plots

creating, saving and executing a script files

Loops, branches and control flows.

Creating and executing a function file, Working with anonymous functions and symbolic computation, importing and exporting Data, publishing Data.

Solving a linear system using Gaussian elimination

Finding Eigen values and Eigen vectors for a linear system

Curve fitting tool box

Least squares curve fitting

Finding the roots of algebraic equations

Solving an ordinary differential equations

Solving partial differential equations

Course Code:	Course Name: Environmental Science	No. of Credits: 4
Detailed Syllabus:		
E2 Sem2 Courses and Syllabus		
Course Code: CH2004	Course Name: Chemical Reaction Engineering	No. of Credits: 4
Detailed Syllabus:		
The tanks in series model- pulse response experiments and the RTD, chemical conversion. Earliness of mixing, segregation and RTD- self-mixing of a single fluid, mixing of two miscible fluids. catalysis and Catalytic reactors- catalysts, steps in a catalytic reactions, synthesizing a rate law, mechanism and rate limiting step. Heterogeneous reactions -Introduction to Solid catalyzed reactions- The rate equation for Surface Kinetics- Pore diffusion resistance combined with surface kinetics, Porous catalyst particles, Heat effects during reaction, Performance equations for reactors containing porous catalyst particles. Solid catalyzed reactions- Experimental methods for finding rates. Modeling and Design of Bio reactors and Fluidized Bed Reactors.		
Text Books		
1. "Chemical Reaction Engineering", Wiley Eastern, 3 rd ed., Tata McGraw Hill.		
Reference:		
1. "Elements of Chemical Reaction Engineering" by H S Fogler, 4 th Edition, PHI.		
Course Code: CH2005	Course Name: Mass Transfer Operations-I	No. of Credits: 4
Detailed Syllabus:		
Concepts of molecular diffusion and mass transfer coefficients. Molecular Diffusion in Fluids: Molecular Diffusion, Equation of Continuity, binary solutions, Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow, estimation of diffusivity of gases and liquids. Diffusion in Solids, Fick's Diffusion, Unsteady State Diffusion, types of Solid Diffusion. Mass Transfer Coefficients and various theories, Heat and Mass Transfer Analogies. Inter phase Mass Transfer: Concept of Equilibrium, Diffusion between Phases, Material Balances in steady state co-current and counter current stage processes, Stages, Cascades,		

Kremser – Brown equations.

Equipments for Gas Liquid Operations – their applications, types of packing.

Drying: rate of drying for batch and continuous dryers.

Humidification and Dehumidification: design of cooling towers

Absorption And Stripping: Absorption equilibrium, ideal and non ideal solutions selection of a solvent for absorption, one component transferred: material balances. Determination of number of Plates, HETP, HTU, NTU determination.

Text books:

1. Separation Process Principles”, J Seader and E J Henry.

Reference:

1. Mass transfer operations by R.E. Treybal, 3rd ed. Mc Graw Hill..
2. Diffusion: mass transfer in fluid system by E. L. Cussler.
3. Transport processes and unit operations by Christie J. Geankoplis
4. Principles of mass transfer and separation processes, B.K. Dutta, PHI, India

Course Code:CH2006

Course Name: Chemical Technology

No. of Credits: 4

Detailed Syllabus:

Scope of CPT in process industries, introduction of CPT with reference to Indian resources, industries, trade and export potentials, small scale industries and rural development etc.; preparation of process flow diagrams and process and instrumentation diagrams and major process symbols.

Chlor-Alkali Industries- Phosphorus Industries- Potassium Industries- Nitrogen Industries- Sulphur And Sulphuric Acid- Soap And Detergents- Sugar And Starch Industries- Fermentation Industries-Pulp And Paper Industries- Plastic Industries- Petroleum Processing- Rubber Materials of construction including special materials with reference to the above process industries.

Text Books:

1. Dryden's outlines of Chemical Technology, edited by M.Gopal Rao and M.Sittig,
3rd

Edition.		
Course Code: CH2007	Course Name: Instrumentation and Process Control	No. of Credits: 4
Detailed Syllabus: Instrumentation: Characteristics Of Measurement System- Pressure Measurement- Temperature Measurement - Flow Measurement- Measurement- Instruments For Analysis Process Control: Introduction to process dynamics and control. Response of First Order Systems. Physical examples of first order systems Response of first order systems in series, Higher order systems: Second order and transportation lag Control systems Controllers and final control elements, Block diagram of a chemical reactor control system, closed loop transfer functions, Transient response of simple control systems, Stability, Root locus, Transient response from root locus, Application of root locus to control systems Introduction to frequency response, Control systems design by frequency response. Advanced control strategies, Cascade control, Feed forward control, ratio control, Smith predictor, dead time compensation, internal model control. Controller tuning and process identification. Control valves. Text Books: 1. Patranabis D. – Principles of Industrial Instrumentation – 2nd Edition – Tata McGraw Hill Publishing Company, New Delhi (1999) 2. Industrial instrumentation by Donald P. Eckman, Wiley eastern. 3. Chemical process control by G. Stephanopolous, PHI,1998 4. Process systems analysis and control by D.R. Coughanowr, 2nd ed. Mc Graw Hill 5. Process Control by Wayne Bequette, PHI.		
Course Code: CH2011	Course Name: Mechanical Unit operations Lab	No. of Credits: 2
Jaw Crusher-Crushing Laws verification To determine surface area and shape factor of particle by permeability method ball mill Apparatus-Time of grinding for producing 80% product passing through given screen. Jaw Crusher-Determine working index Sieve Shaker-Determine effectiveness. Froath Flotation- To achieve beneficiation of a ore using froth flotation technique. Batch Sedimentation- To obtain batch sedimentation data and to calculate the minimum thickner area under given conditions Filtration- To determine the specific cake resistance and filter medium resistance of a slurry in		

plate and frame filter press Cyclone separator- To calculate separation efficiency of particles in a mixture using cyclone separator Stoke's law apparatus- To Verify Stoke's law.		
Course Code:	Course Name: Elective	No. of Credits: 4
Detailed Syllabus:		
Course Code: CH2012	Course Name: Chemical Reaction Engineering Lab	No. of Credits: 2
Detailed Syllabus:		
1. Packed Bed Reactor 2. Cascade CSTR 3. Isothermal CSTR 4. Isothermal PFR 5. coiled PFR 6. Adiabatic Batch Reactor 7. RTD of packed Bed reactor		
<u>E3 Sem1 Courses and Syllabus</u>		
Course Code: CH3002	Course Name: Mass Transfer Operations-II	No. of Credits: 4
Detailed Syllabus:		
Distillation – Flash Distillation, Simple Distillation, Batch distillation with and without reflux, Ponchon - Savarit and McCabe- Thiele analysis of binary distillation.		
Adsorption: types and nature of adsorption, isotherm, stage wise and continuous adsorption; fixed, fluidized and moving beds; ion-exchange.		
Liquid Extraction: triangular diagram;		
Leaching: single and multistage operation, equipment for leaching.		

Crystallization: Millers theory, yield calculations, crystallizers. Membrane processes: liquid & gas separation processes, microfiltration, ultra-filtration, nanofiltration, reverse osmosis.

Text books:

1. Separation Process Principles”, J Seader and E J Henry.

Reference:

1. Mass transfer operations by R.E. Treybal, 3rd ed. Mc Graw Hill..
2. Diffusion: mass transfer in fluid system by E. L. Cussler.
3. Transport processes and unit operations by Christie J. Geankoplis
4. Principles of mass transfer and separation processes, B.K. Dutta, PHI, India

Course Code: CH3003

Course Name: Process Equipment Design

No. of Credits: 4

Detailed Syllabus:

Introduction; development of flow diagrams from process description, material and energy balance, sizing of equipment, design preliminaries, design codes, MOC selection procedure, fabrication methods and testing methods.

Stresses in thin and thick walled shells, theories of failure, design of storage vessels. Design of pressure vessels, Design of shell and tube heat exchangers, Design of single effect evaporator, Design of distillation and absorption columns, Design of batch reactor, CSTR and PFR, Optimum pipe diameter.

Text Books:

1. Chemical Engineering: Vol.6, Coulson J.M. and Richardson J.F., Pergamon Press 1983

References:

1. Process Equipment Design, M.V. Joshi
2. Process Equipment Design-Vessel Design: Brownell L.E., Wiley Eastern Ltd.
3. Introduction to Chemical Equipment Design-Mechanical Aspects: Bhattacharya B.C., CBS Publishers.
4. Chemical Engineering Hand Book, Perry, 5th Ed.,

Course Code:CH3001

Course Name: Biochemical Engineering

No. of Credits: 4

Detailed Syllabus:

Introduction to biochemical process industries, industrial alcohols, antibiotics, acids, alcoholic beverages, enzymes, vitamins, single cell protein. Food processing and biological waste treatment. Interaction of chemical engineering principles with biological sciences.

Life processes, unit of living system, microbiology, reaction in living systems, biocatalysts, model reactions. Fermentation mechanisms and kinetics : kinetic models of microbial growth and product formation. Fermenter types; Modeling of batch and continuous fermentor. Bioreactor design, mixing phenomena in bioreactors. Sterilization of media and air, sterilization equipment, batch and continuous sterilize design.

Biochemical product recovery and separation. Membrane separation process: reverse osmosis, dialysis, ultrafiltration; Chromatographic methods: adsorption chromatography, gel filtration, affinity chromatography etc. Electro-kinetic separation: electro-dialysis, electrophoresis. Waste water treatment: activated sludge process, anaerobic digestion, trickling filter.

Text Books:

1. Biochemical engineering fundamentals by J.E.Bailey and D.F.Ollis, 2 ed,1986,McGraw Hill.

Course Code: CH3004

Course Name: Transport Phenomenon

No. of Credits: 4

Detailed Syllabus:

Viscosity and Mechanism of Momentum Transport-Velocity Distributions in Laminar Flow-Equation of change for Isothermal Systems-Velocity Distributions with more than One independent variable-Interphase

Transport in Isothermal Systems-Thermal Conductivity and Mechanism of Energy Transport-Temperature Distributions in solids and in Laminar Flow-Equations of change for

Non-Isothermal Systems-Temperature Distributions with more than One Independent Variable-Interphase transport in Non-Isothermal Systems-Diffusivity and the mechanism of mass transport-Concentration Distribution in solids and in Laminar Flow-Equation of change for multicomponent systems-Interphase Transport in multicomponent systems.

Text Books:

1. Bird R.B., Stewart W.E. and Light Foot E.N. Transport Phenomena – John Wiley International – 2nd Edition , New York, 2002.
2. Christie J. Geankoplis – Transport Processes and Unit Operations – 3rd Ed., Prentice Hall of India Pvt. Ltd., New Delhi, 1997.

Course Code: CH2017

Course Name: Instrumentation and process control Lab

No. of Credits: 2

Detailed Syllabus:

1. Temperature Measurement Apparatus
2. Pneumatic control trainer
3. Control valve characteristics
4. Multi process trainer
5. Temperature control trainer
6. Flapper-Nozzle system
7. Calibration of differential pressure transmitter
8. Calibration of thermocouple and resistance thermometer
9. Study of I/P and P/I converter
10. Pressure control trainer
11. Interacting and Non interacting system
12. Temperature control module
13. Process module

Course Code:**Course Name: Elective****No. of Credits: 4****Detailed Syllabus:****Course Code: CH3013****Course Name: Process Equipment
Design Lab****No. of Credits: 2****Detailed Syllabus:**

Introduction to various mechanical properties of materials to be used as material of construction, resistance of metals to corrosion under varying conditions of temperature and pressure etc. Application and use of various codes and standards in design.

Design of non-pressure storage vessel, tall vertical vessels, unfired pressure vessels with internal pressure, Design of unfired pressure vessels with external pressures, end closures, flat plates, domed ends, torispherical, ellipsoidal, hemispherical and conical ends.

Design of Pipe lines; Design and process design of a few equipments like heat exchangers, Evaporators, Distillation columns, Absorbers, Reactors and Dryers.

Mechanical design of selected process equipments such as heat exchangers, Evaporators, Distillation columns, Absorbers, Reactors and Dryers and Crystallizers; Use of softwares for design of equipments.

Text Books:

1. Peters Max. S., Timmerhaus Klaus D. and Ronald E West “Plant Design and Economics for Chemical Engineers”. 2003 5th Edition McGraw Hill.
2. Coulson, J. M. and Richardson J. F. “Chemical Engineering”, vol. 6 Pergamon Press. (1989).
3. Brownel and Young, “Process Equipment Design”. Wiley (1968).

Reference Books:

1. Indian and American Codes Used in Designing of equipments (TEMA and IS Codes)

E3 Sem2 Courses and Syllabus**Course Code:**CH3006**Course Name:** Plant Design and Economics**No. of Credits:** 4

Process selection, synthesis and analysis (Aspects of process design, pre-project objectives, project classification, hierarchical approach to process design)

Engineering Economics (Elements of project cost, cost information, total capital investment and total capital cost, time value of money, depreciation, interest, project financing, measures of process profitability, simplified model for economic analysis of process design)

Short-cut Procedure for Equipment Design and Economic Decision Making (Basic design of absorber, distillation columns, cost model for distillation column, sizing and costing of equipment, Guthrie's correlation, distillation column sequencing, energy integration of distillation columns, case study for economic decision making for an absorber)

Preliminary Process Design (Batch versus continuous processes, comparative analysis, input information)

Input-Output Structure of Flowsheet (Hierarchy of decisions for Input-Output structure, overall material balance, stream costs, process alternatives)

Recycle Structure of Flowsheet (Hierarchy of decision for the recycle structure, materials and energy balance for recycle structure, equilibrium limitations, modifications of reactor design for recycle, equipment costs associated with recycle, overall economic potential of process with recycle)

Separation Systems (General structure of the separation system, location of vapor and liquid recovery system in the process, sequencing of non-integrated distillation columns for minimum vapor load, sequencing of columns with more than 2 products, thermal coupling of columns, azeotropic distillation, residue curve maps, azeotropic systems at total and minimum reflux,

distillation with entrainer)

Heat Exchanger Networking (Composite curves, heat recovery pinch, threshold problems, problem table algorithm, process constraints, number of exchanger units, heat exchanger area target, capital and total cost target, pinch design method, design of threshold problems, stream splitting, design for multiple pinches)

Cost Diagrams and Quick Screening of Process Alternatives (Concept of cost diagram, quick assessment of cost distribution with design heuristics, cost allocation procedures, lumped cost diagram, cost allocate diagram for stream flows, screening of process alternatives with cost diagrams)

Course Code:CH3005

Course Name: Process Modeling and Simulation

No. of Credits: 4

Detailed Syllabus:

Parameter Estimation:

Parameter estimation techniques in theoretical as well as numerical models.

Models:

Models, need of models and their classification, models based on transport phenomena principles, alternate classification of models, population balance, stochastic, and empirical models, unit models.

Models of Heat Transfer Equipment:

Development of detailed mathematical models of evaporators, use of Newton-Raphson method for solving evaporator problems.

Models of Separation Processes:

Separation of multicomponents mixtures by use of a single equilibrium stage, flash calculation under isothermal and adiabatic conditions.

Tridigonal formulation of component-material balances and equilibrium relationships for distillation, absorption and extraction of multicomponents.

Thiele and Geddes method plus θ - method and Kb method, models of absorbers , strippers and extractors.

Models of Reactors:

Classification of fixed bed reactor models, one dimensional and two dimensional fixed bed reactor models, fluidized bed reactor models, bioreactor models.

Numerical Methods:

Classification of partial differential equations (PDE's), solution of PDEs by Finite difference techniques, method of weighted residuals.

Orthogonal collocation to solve PDEs with their application to chemical engineering systems models.

Course Code:CH2015

Course Name: Mass Transfer
Operations Lab

No. of Credits: 2

Detailed Syllabus:

1. To study the performance of a bench top cooling tower
2. The drying curve of a solid under constant drying conditions
3. Separation of two miscible liquids in a sieve plate distillation column
4. Liquid liquid equilibria
5. Rate of evaporation and concentration profile
6. packed bed distillation column
7. Simple distillation
8. Steam Distillation.

Course Code:

Course Name: Elective

No. of Credits: 4

Detailed Syllabus:

Course Code:

Course Name: Project

No. of Credits: 8

Detailed Syllabus:

Course Code:CH3015	Course Name: Process Modeling and Simulation Lab	No. of Credits: 2
Detailed Syllabus: General Unit operations: Mixer, Flow splitter; Flash column; pipe line and pipe pressure drop; multistage extractor; Decanter; Pump; Single and multistage compressors-Solids handling unit operations: Crusher, Screen, Cyclone, Rotary drum filter, centrifuge, crystallizer -Heat Exchangers: Simple heater, Shell and Tube Heat Exchanger-Distillation Columns: Batch, Binary & multi-component; single and multiple columns; Extractive and azeotropic distillation columns-Absorption Column: Absorption, Stripping-Reactors: Yield based, Stoichiometric and equilibrium reactors: Batch, CSTR, PFR with generalized kinetics Physical property estimations: Molar volume using equations of state; Fugacity coefficient; Activity coefficient; VLE (K – values); Enthalpy, Free energy; Vapor pressure; Thermal conductivity; Surface tension; Viscosity; Diffusion coefficient- Simulation of a flow sheet: Mass and Energy balances; Handling user specifications on output streams; User specified unit modules-Costing and economic analysis: Project capital cost estimation; Plant operating cost estimation; Profitability analysis Along with this Students are made to learn with FLUENT also.		
E3 Summer Semester		
Course Code: CH3301	Course Name: Summer internship	No. of Credits: 6
<u>E4 Sem1 and Sem2 Courses are Electives and Projects</u>		
Course Code:CE4700	Course Name: Project – I	No. of Credits: 8
Course Code:	Course Name: Elective–I	No. of Credits: 4
Detailed Syllabus:		

Course Code:	Course Name: Elective-II	No. of Credits: 4
Detailed Syllabus:		
Course Code:	Course Name: Elective-III	No. of Credits: 4
Detailed Syllabus:		
Course Code:	Course Name: Project-II	No. of Credits: 8
List of Electives will be offered during E4Sem1 and Sem2		
Course Code: CH 4201	Elective1: Energy Conservation in Process Industries	No. of Credits: 4
Detailed Syllabus:		
Concepts of energy accounting, energy auditing and their applications. Energy management principles and their scope. Second law analysis - concepts of energy, entropy generation and lost work. Application of the principle to steady flow process, non-flow process and other irreversible processes involving momentum, heat and mass transfer. Energy conservation measures through process optimization, product improvement and technology up-gradations - heat pump, co-generation. Pipeline network and heat exchanger network analysis. Principles of thermo-economics and its application.		
Course Code: CH4202	Elective2: Polymer Engineering	No. of Credits: 4
Detailed Syllabus:		
Basic concept of polymer and polymer chemistry. Classification of polymers. Mechanism and		

kinetics of polymerization. Polymerization reaction engineering: emulsion polymerization, dispersion polymerization etc.

Reactors for polymerization: analysis of polymerization reactions, Reactor design applied to polymer system, Average molecular weight of polymer in different reactor, Control of molecular weight.

Rheology of polymeric system. Unit operations in polymer industries. Polymer processing: moulding, calendaring, extrusion etc.

Course Code: CH4203

Elective3: Renewable Energy

No. of Credits: 4

Detailed Syllabus:

Sources Of Energy- Solar Energy- Wind Energy- Hydrogen Energy- Other Sources

Text Books :

1. Sukhatme S.P - Solar Energy - Thermal Collection and Storage - Tata McGraw Hill.

Reference:

1. Rai, G. D. - Non-conventional Energy Sources, Khanna Publishers.
2. El Wakil – Power Plant Technology, Tata McGraw Hill, New York.
3. S. C. Arora and S. Domkundwar – A course in Power Plant Engineering, Dhanpat Rai and Sons, New Delhi,

Course Code: CH 6201

Elective4: Optimization Techniques in Process Design

No. of Credits: 4

Detailed Syllabus:

Introduction to optimization and its scope in chemical processes. Analytical methods: Objective function, single variable optimization, multivariable optimization without and with constraints.

Linear programming: graphical, algebraic, simplex methods, duality. Numerical search methods: one dimensional search, unrestricted, exhaustive search methods, interpolation methods. Multidimensional search methods without and with constraints. Variational methods and their applications.

Text Books:

1. Optimization of chemical processes by T.F.Edgar and Himmelblau DM.Mc- Graw. Hill.2001.

Course Code: CH6204

Elective 5: Advanced Mathematical Techniques in Chemical Engineering

No. of Credits: 4

Detailed Syllabus:

Models in chemical engineering; vector and tensor spaces; metric, norm and inner products; orthonormalization; matrices, operators and transformations; eigen values and eigen vectors;

Fredholm alternative, Rayleigh quotient and its application to chemical engineering systems; self adjoint and non-self adjoint systems; partial differential equations and their applications in chemical engineering; Sturm-Liouville theory; separation of variables and Fourier transformations; application of Greens function for solution of ODE and PDEs in chemical engineering; numerical techniques for solution of ODE and PDEs; linear stability and limit cycles; bifurcation theory; secondary bifurcation and chaos.

Introduction to numerical methods. Linear algebraic equations. Eigen values and eigenvectors of matrices. Nonlinear algebraic equations. Function evaluation and regression techniques. Numerical methods of solving ordinary differential equations - initial and boundary value problems. Numerical solutions of partial differential equations. Basic modeling principles and development of models in chemical engineering. Simulation techniques. Dynamic and steady state simulators.

Text Books:

S. Pushpavanam, Mathematical Methods in Chemical Engineering, Printice-Hall of India, New Delhi, 2001.

Course Code: CH6207

Elective 6: Industrial Pollution Control

No. of Credits: 4

Detailed Syllabus:

Engineering, ethics and environment. Ecological systems and pollution. Fundamental definitions of pollution parameters - air and water quality criteria, Standards and legislation EIA, EIS and EMP. Air and water pollution management through waste minimization.

Industrial air pollution management : air pollution meteorology (Generation, transportation and dispersion of air pollutants). Outlines of industrial air pollution control. Selection, design and performance analysis of air pollution control equipment : gravity settling chambers, air cyclones, ESPs, filters and wet scrubbers.

Industrial water pollution management: Wastewater treatment processes; Pre-treatment, primary and secondary treatment processes. Advanced wastewater treatment processes. Design of sedimentation tanks and biological treatment processes.

Text Books:

1. Environmental pollution and control engineering, Rao C. S. – Wiley Eastern Limited, India..
2. Pollution control in process industries by S.P. Mahajan TMH.,1985.

Course Code:CH6208

Elective 7: Novel Separation Processes

No. of Credits: 4

Detailed Syllabus:

CH 6208 Novel Separation Processes

Rate governed processes: definitions and terminologies; Membrane separation processes, preparation and characterization of membranes. Principles of reverse osmosis, nanofiltration,

ultrafiltration, microfiltration.

Osmotic controlled filtration, gel layer controlled filtration; Detailed design and modeling: film theory, similarity solution, integral method; Design of membrane/process modules; Basic principles and modeling of dialysis;

Electric field enhanced separation processes : zeta potential, electric double layer; Basic modeling of electric field enhanced filtration. Liquid membrane and its modeling. Basic design of gas separation and pervaporation

Course Code: CH6209

Elective 8: Petroleum Refinery Engineering

No. of Credits: 4

Detailed Syllabus:

Origin of petroleum crude oil. Evaluation of crude oil evaluation and characterization of crude oil : TBP and other distillation tests. Petroleum products, their properties, specification and testing , different properties like flash point, fire point, smoke point, aniline point, carbon residue, kinematic viscosity, pour point, freezing point etc.

Use of crude book data. Petroleum refinery distillation , pre-fractionation and atmospheric distillation of crude. Process design for atmospheric distillation. Stabilization of naphtha. Vacuum distillation of RCO. Reforming of naphtha.

Other secondary processes like Vis-breaking, Furfural/Phenol/NMP extraction, Solvent dewaxing, propane deasphalting. Delayed coking process. FCC unit. Hydrotreatment processes in refining: hydro-desulfurisation, hydrofinishing, Hydrocracking. Production of lube oil base stock, isomerization and alkylation.

Text Books:

1. Petroleum refining Engineering ; WL Nelson Mc Graw Hill company, 4th addition.
2. Modern Petroleum Refining Processes, 4th ed., B.K.bhaskara Rao, Oxford & IBH Publishing,2002.

Course Code:CH6210

Elective 9:Petrochemical Technology

No. of Credits: 4

Detailed Syllabus:

Survey of petrochemical industry; Availability of different feed stocks; Production, purification and separation of feed stocks; Chemicals from methane; Production and utilization of synthesis gas, oxo reactions, etc.; Production of and chemicals from acetylene; Naphtha cracking;

Chemicals from C₂, C₃, C₄ and higher carbon compounds; Polymers properties, production and utilization; Catalytic reforming of naphtha and isolation of aromatics; Chemicals from aromatics; Synthetic fibres, detergents, rubbers and plastics; Petroleum coke;

Elements of design of steam reformer, naphtha cracker, catalytic reformer, etc.

Text Books:

1. B.K. Bhaskar Rao, "A Text on Petrochemicals " 2nd Edition, Khanna publishers, 1996.

Course Code: CH6211**Elective10: Multiphase Flow****No. of Credits: 4****Detailed Syllabus:**

Fundamental concepts of multiphase : gas - liquid, gas - solid, liquid – liquid and liquid - solid systems. Particle, drop and bubble dynamics. Application of continuity, momentum and energy equations.

Hydrodynamic characteristics : holdup, slip, pressure drop and rise/drop velocities.

Mass and energy transfer with and without simultaneous chemical reactions. Application to trickle beds, bubble and slurry reactors, cyclones, fluidized beds etc.

Text Books:

1. A. Gianetto and P.L. Selveston (Eds.) : 'Multiphase Chemical Reactors', Hemisphere Publishing Corporation, N.Y., 1986.
2. G.W. Wallis 'One dimensional two - phase flow', McGraw - Hill, N.Y. 1969.

Course Code: CH6212**Elective11: Fluidization Engineering****No. of Credits: 4****Detailed Syllabus:**

Momentum theorem, equations of change, ideal flow, Euler's equations of motion. Velocity potential, rotational and irrotational flow; Navier-Stokes equation, Poiseuille flow, creep flow and Couette flow. Boundary layer theory: integral momentum analysis. Turbulent boundary layer: turbulence and mixing. Universal velocity profile. Stability analysis of laminar flow, Orr-Sommerfield solution, transition to turbulence, detailed modeling of turbulent flow.

Laminar and turbulent flow of non-Newtonian fluid. Rheological characteristics, consistency measurement, viscometric flow, pipe and annular flow, pipeline design equations.

The phenomena of fluidization and its industrial application. Characteristics of particles. Principle of fluidization and mapping of various regimes. Two phase theory of fluidization. Bubbles in fluidized bed. Entrainment and Elutriation. Fast fluidized bed. Mixing, segregation and gas dispersion.

Heat and mass transfer in fluidized bed. Solid-liquid fluidized bed and three phase fluidized bed. Design of fluidized bed reactors.

Text Books:

1. Fluidization Engineering by Kunii and Levenspiel, 2nd Edition.

Course Code: CH6212**Elective12: Project Engineering and Management****No. of Credits: 4**

Detailed Syllabus:

Origin of chemical project; Feasibility studies; Techno-economic report; Plant location and site selection; Capital cost estimation; Working capital estimation; Profitability indices, Discounted cash flow, Cost-benefit analysis, Sensitivity analysis; Process development, Process Selection, Process Design, Utilities, Scale up; Optimization; Project Construction, Project scheduling, Network analyses; Project report; Plant and Equipment specification.

Text Book:

1. Projects by Prasanna Chandra, 7th Edition, Tata Mc Graw Hill., 2009.

Course Code: CH 6213

Elective13:Hazard Analysis and Risk Management in Chemical Industry

No. of Credits: 4

Detailed Syllabus:

Process plants : continuous and batch plants. Procedure for systematic study of plants. Plant and equipment start up and shut downs, operations at steady state. Emergency response strategy for plants and equipment. Plant test runs and rating calculations for various equipment.

Plant systems for utilities and auxiliary services. Handling of plant effluent. Safe commissioning of plants. Definition, Aspects of engineering safety; safety systems , General principles of industrial safety, Notified dangerous operation, Chemical hazards. Storage of dangerous materials; vapor cloud explosions; Flammability characteristics of liquids and vapours. control of toxic chemicals; runaway reactions;

Hazards due to fire, explosions, toxicity, relief system; risk and hazard management, emergency shutdown systems; human element in the design of safety, Safety in relation to economic and operational aspects. Engineering control of chemical plant hazards. Industrial plant layout.

HAZAN and HAZOP. Plant and equipment reliability analysis. Case studies plant accidents.

Text Books:

1. P. C. Nicholas, " Safety management practices for hazard waste materials", Dekker, 1996.
2. F. P. Lees, "Loss Prevention in Process Industries", Vol.1 and 2, Butterworth, 1983.
3. W. E. Baker, "Explosion Hazards and Evaluation", Elsevier, Amsterdam, 1983.
4. O. P. Kharbanda, and E.A. Stallworthy, "Management of Disasters and How to Prevent Them", Grower, 1986.
5. H.H. Fawcett and W.S. Wood, "Safety and Accident Prevention in Chemical Operations",
2nd edition John Wiley and sons, New York, 1982.

Course Code: CH6214

Elective14: Computational Fluid Dynamics

No. of Credits: 4

Detailed Syllabus:

Basic Concepts of Fluid Flow: Philosophy of computational fluid dynamics, conservation principles of mass, energy, and momentum, simplified flow models such as incompressible,

inviscid, potential and creeping flows, classification of flows.

Turbulence and its Modelling: Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model, The $k-\epsilon$ model, Reynolds stress equation models, Algebraic stress equation models.

Grid Generation: Structured and unstructured grids, choice of grid, general transformation of equations, some modern developments in grid generation in solving the engineering problems. Finite Difference Method: Discretization of ordinary and partial differential equations, approximation of first, second and mixed derivatives, implementation of boundary conditions, discretization errors, applications to the engineering problems.

Finite Volume Method: Discretisation methods, approximations of surface integrals and volume integrals, interpolation and differentiation practices, implementation of boundary conditions, applications to the engineering problems.

Introduction, one-dimensional steady state diffusion, two-dimensional diffusion problems, three-dimensional diffusion problems. The Finite Volume Method for Unsteady Flows and Implementation of Boundary Conditions: One-dimensional unsteady heat conduction.

Text Books:

1. Anderson Jr J. D., "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill. 1995.
2. Muralidhar K. and Sundararajan T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House. 2003.
3. H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics: the finite volume method, Longman scientific & technical publishers, 2007
4. Ferziger J. H. and Peric M., "Computational Methods for Fluid Dynamics", 3rd Ed., Springer. 2002.
5. Ranade V. V, "Computation Flow Modeling for Chemical Reactor Engineering", Academic Press. 2002.

Course Code: CH6216

Elective15: Nuclear Technology

No. of Credits: 4

Detailed Syllabus:

Course Introduction and overview of Nuclear Engineering, Basic Nuclear Physics and Radiation Interactions Radiation and Biological Effects, Medical Applications, Food Preservation & Agriculture Applications with radiation Other Radioisotope Applications, Tracing, Dating, Sterilization, Radiation Chemistry, Global Energy Supply and Demand Fission Reactors, Safety,

Licensing, Fuel Cycle, Advanced Applications of Nuclear Technology, Neutron Radiography,
Gemstone Coloring, Nuclear Batteries