# SEMESTER – III

## NUMERICAL ANALYSIS AND PROGRAMMING (MA 3103)

Numerical computation and error, solution of algebraic and transcendental equations-Bisection method, Regula-Falsi method and Newton-Raphson method and their order of convergence. Iterative methods for system of non-linear equations. Linear system of equations: Gauss elimination method, Crout's method, Jacobi's method, Gauss-Seidel method. Computer programming of above methods.

Finite differences, difference operators and symbolic relations, difference of a polynomial, Interpolation ,error in interpolation, Newton's forward and backward formulae, Lagrange's interpolation formula, Newton general interpolation formula, Numerical differentiation, error in numerical differentiation. Numerical integration: Newton's cote's formula, Trapezoidal rule, Simpson 1/3 rule, Simpson 3/8 rule and their error estimation. Computer programming of above methods.

**Ordinary differential equations**: Taylor's series method, Euler's method, Euler's modified method, Runge-Kutta method, Boundary value problem-linear and non-linear equations. Computer programming of above methods.

## MATERIAL SCIENCE (A) (ML 3101)

1. Atomic Bonding:- Classification of Engineering Materials, Ionic, Covalent, Metallic and Vander Walls Bonding. Effect of types of Bonding on properties of materials.
2. Structure of Solids:- Crystalline Solids, Crystal System, Unit Cells, Space Lattice, Miller Notations, Structure in Metallic Elements, Ionic and Molecular Crystals, Imperfection in Crystals.
3. Introduction to Iron Carbon Diagram and Principles of Heat Treatment. Annealing, Normalizing, Hardening, Tempering, T-T-T Diagram etc. recovery, recrystallisation and grain growth. White Caste Iron, Grey, Spheroidal Graphite, Malleable Caste Iron, their properties and applications.
4. Brief Introduction to Polymer, Ceramics, Composite Materials and Their Application as Engineering Materials.

**MATHEMATICS – III (MA 3104)**

LAPLACE TRANSFORMATION :- Definition of Laplace transform and linearity and shifting property, Laplace transform of elementary functions, Inverse Laplace transform, Laplace transform of derivative and integration, convolution theorem, Solution of differential equation by Laplace transform, Unit Step function, Unit impulse function.

VECTOR CALCULUS :- Differentiation of vector function, gradient, divergence, curl and their geometrical or physical interpretation, Line, Surface and Volume integrals, Statement of Green's Theorem , divergence theorem and Stoke's theorem and their applications. Curvilinear co-ordinates.

FOURIER SERIES :- Fourier series, Dirichlet's conditions, Half Range series.

FOURIER TRANSFORM :- Definition of Fourier Transform, linearity, shifting, frequency theorem, Fourier transform of derivatives and Dirac-delta function, Inverse Fourier transform, Fourier Sine and Cosine transform, Solution of simple differential equation by Fourier transform method.

Z- TRANSFORMATION :- Definition, Z-transformation of standard sequences, linearity property, Shifting theorem, inverse of Z-transformations, Scaling property of Z-transformation, differentiation of Z-transformation, convolution of sequences, solution of difference equations by Z-transformation.

**CHEMICAL ENGINEERING THERMODYNAMICS-I (CL 3101)**

The First law and other Basic concepts: Internal Energy, Formulation of First Law of Thermodynamics, the Thermodynamic State and State Functions, Enthalpy, the Steady State low process, the Reversible Process, the Hear Capacity and Specific Heat,
Gas laws: Equation of states, Dalton's Law of partial pressure, Non Ideal Gases, Vanderwaal's Equation, Grahm's law of Diffusion.
Kinetic Theory of Gases: Boltzman Equation, Distribution of Molecular Velocities, Average speeds, Traslational energy of an Ideal Monatomic Gas, Heat capacity of Gases, Molecular Collisions, Derivation of the Equation of state of an ideal Gas, Kinetic Energy, Avagadro's hypothesis, Dalton's law of Partial pressure, the mean free path.
Pressure – Volume – Temperature Relationship of Fluids: The PVT behaviour of pure substances, Equation of State for gases, the Principle of Corresponding States, gas mixture, Mixture of ideal Gases, Dalton's law of additive pressure, Amagat's law of additive volume, the pseudo control point method.
Solution: Ideal Solution, Raoult's Law, Henery's Law, vapour pressure of ideal Solution, Elevation of Boiling point and Depression of Freezing point Heat of solution and Heat of Dilution.
Nuclear Energy: Radioactivity Interaction application of radioactivity in Industries,
Nuclear fission and Nuclear Fusion, Half life period.

## FLUID MECHANICS FOR CHEMICAL ENGINEERING (CL 3102)

1. Introduction: Fluid continuum. Density, Specific weight, viscosity, Newtonian and Non-Newtonian Fluids, Kinematic viscosity, variation of viscosity with temperature and pressure, surface tension, capillary action, vapor pressure, properties of gases, Isothermal process, isentropic, adiabatic process. Incompressible and compressible fluids.
2. Fluid statics: Pressure at a point, variation of static pressure, piezometric head, Absolute and gauge pressure.
3. Pressure measurement: Mechanical pressure gauge, manometers simple, differential, micro & inclined.
4. Kinematic of fluid motion: Classification of flow-steady and unsteady flow, one, two and three dimensional flow, laminar & Turbulent flow, stream line, path, Line and streak line, Indtroduction of stream function and velocity potential, Laplaces equation for irrotational flow.
5. Dynamic of fluid flow: Concepts of system and control volume, The equation of continuity and motion, The Euler Equation of motion, Bernoullies equation pitot tube, venturimeter orificemeter Entrance Cone, Coefficient of Discharge, factors influencing coefficient of Discharge water flow through an open channel Air Anemometer. Rotameters and flow meters.
6. Use of Rayleigh's method, Buckingham pie ($\pi$) theorem, Dynamic similarity, Geometric similarity & Kinemetic similarity. Dimensionless groups and their physical significance: Reynolds Number, Fyoude Number, Euler Number, Mach number & Weber Number. Velocity Distribution in laminar flow for parallel and circular tubes, Hagen posiseul Equation.
7. Inter phase Transport in isothermal systems: Definition of Friction Factor, Friction Factor for flow in Tubes, Pressure drop required for a given flow rate. Flow rate for a given pressure drop f-Re-plot. Definition for Drag Coefficient for flow around spheres, $C_pVSR_e$. Plot Determination of Diameter of falling sphere. Friction factors for packed beds-Ergun Equation.
8. Pumps & Blowers- Centrifugal and reciprocating pumps

## HEAT TRANSFER-I (CL 3103)

1. Introduction and Concepts: of Conduction, convection and Radiation, Combined Heat Transfer Mechanism.
2. One Dimensional Heat Conduction Equation, Three Dimensional Heat Conduction Equation & Boundary Conditions.
3. One-Dimensional, steady-state Heat Conduction for Slabs, Cylinders, Spheres, Composite Media, Critical Thickness, Fined Rectangular Surfaces and Temperature Dependent KCTO,
4. Transient Heat Conduction: Lumped system Analysis, Semi-infinite solid, Transient heat Conduction in a Slab-Analytical Solution.
5. Flow over a Body, Flow inside a Duct, Concept of Turbulence, Equation of motion, Equation of Energy and Boundary layer Equations.

6. Forced Convection for flow inside Ducts: Hydro dynamically and Thermally Developed Laminar Flow, Turbulent Flow inside Ducts, Heat Transfer in Liquid metals. Analogies Between Heat and momentum Transfer in Turbulent Flow.
7. Forced Convection for flow over Bodies: Heat Transfer Coefficient for flow over Flat plate, Flow across a Single Circular Cylinder, Flow across Non-Circular Cylinder, Flow across Tube Bundles.
8. Free Convection: Dimensionless Parameters for Free Convection, Correlation for Free Convection on a Vertical plate, Free Convection on a Horizontal plate, Free Convection on a long cylinder, Mechanism of Free Convection in Enclosed Spaces. Combined Free and forced convection.

# SEMESTER – IV

## MATHEMATICS – IV (MA 4105)

SPECIAL FUNCTIONS :- Series solution of differential equations, Bessel and Legendre's equations and their series solution, elementary properties of Bessel's function and Legendre's polynomial.

COMPLEX VARIABLE:- Analytic function, Cauchy- Riemann equation. Complex Integration, Cauchy's theorem and Cauchy Integral formula. Taylor and Laurent's expansion. Poles and Residue, Residue theorem. Conformal transformation, Bilinear and Schwartz's transformations. .

PARATIAL DIFFERENTIAL EQUATION :- Formulation of partial differential equation, Linear and non-linear partial differential equations of the first order, Lagrange's method and Charpit's method. Higher order Partial Linear differential equations with constant coefficients. Method of separation of variables. Equation of vibrating strings, heat flow, Laplace's two dimensional equation and simple problems.

## PROBABILITY AND STATISTICS (MA 4106)

Probability: classical and axiomatic definitions, addition law, conditional probability, multiplication law, total probability, Baye's theorem and independence of events.
Random variables: Discrete and continuous random variables, probability mass, probability density and commutative distribution functions. Mathematical expectation, variance, moment and moment generating function, Chebyshev 's inequality.

Regression Analysis: Linear regression, principle of least square, non-linear regression, correlation, coefficient of correlation, Rank correlation.

Distributions: Binomial, Hypergeometric, Geometric, Poisson and Normal distributions.

Sampling Distribution: Population samples, sampling distribution, estimate for population mean and variance, point of estimation, confidence interval for mean and variance of normal population, Testing of hypothesis, the critical and acceptance region, two type of errors, Chi-square, t-student and F distributions.

Analysis of Variance: completely randomize design and randomized block design,
Quality control, control charts(X-chart, R-chart, P-chart and C-chart).

## INDUSTRIAL CHEMICAL CALCULATION (CL 4104)

1. Stoichiometric and composition relations. Mathematical and Engineering Calculations, units, dimensions conversion of units, conversion of equations, conservation of mass, mass and volume relationship in chemical reactions. Mole percent, weight percent. Basis of calculation, excess reactant, limiting reactant. Degree of completion. Density, specific gravity, normality, molality and molarity.

2. Behaviour of Ideal gases: Ideal gas law, Gage pressure, absolute pressure, density, specific gravity, molecular weight of gases, gas mixtures, Average molecular wt. of gas mixtures, Dalton's law, Amagat's law and their application, partial pressure, pure component volume, solving problems.

3. Vapour pressure: Liquefaction and liquid state, vaporization, condensation, dynamic equilibrium, equilibrium vapor pressure, superheat and quality, boiling point, effect of temperature on vapor pressures, Clausius-Clapeyron equation, Reduced conditions, reduced pressure, reduced temperature. Raoult's law, Hery's law and their application, equibrium diagram.

4. Humidity and saturation: Humidity, saturation, Relative saturation, percentage saturation, humid heat, Dew point, wet bulb and dry bulb temperature, humidity chart, Adiabatic vapovisation, problem solving and its application.

5. Solubility and crystallization: Dissolution, crystallization where solvents are formed and where solvents are not formed, super saturation, solubility of solids that do not form compound with solvents.

6. Material Balance: Input-output method, steady state, Key component, material balance with chemical reaction and without chemical reaction, simultaneous equations (distillation, absorption) Recycle, Bye-pass and Purge calculations, application of computer in solving material balance problems.
7. Energy Balance: Introduction to energy balance, Heat capacity, Mean heat capacity, entropy, specific heat, internal energy, First Law of Thermodynamics, Second law of Thermodynamics

## FLUIDIZATION ENGINEERING (CL 4105)

1. Newton's law of viscosity, Newtonian & None-Newtonian Fluids, Flow Behaviour. Laminar & Turbulent flows, Velocity distribution in laminar flow, Hagen Poiseunille equation
2. Definition of friction factor & Drag Coefficients, Friction factor vs Reynolds number relationship for flow of fluids in pipes, Drag Co-efficient Vs particles Reynolds number for flow around spheres

3. Bernoull's equation Basic equations for frictional losses for (a) Expansion (b) Contraction (c) bends & joints.Power requirement for pipe line flow.
4. Flow through packed beds-Erqun equation,
5. Phenomena of fluidization liquid like behaviour of a fluidized bed.Types of fluidization-particulate and Aggregative fluidization Advantages and disadvantages of fluidization over packed beds and moving beds. Industrial applications. Minimum fluidization velocity, Terminal velocity and pressure drop in a fluidized bed
6. Average particle size, spherosity, voidage, Expansion of liquid-solid fluidized bed, Richandson, Zaki equation, use of dimensional analysis,
7. Brief idea of the mechanism of gas-solid fluidization homogeneous & bubble phase, size of bubble, bubble velocity and its expansion.
8. Design of batch & continuous fluidizer for heat & mass Transfer, Entrainment & Elutriation-Entrainment at or above TDH, Entrainment below TDH
9. Elutriation
10. Pheumatic & Hydraulic Conveynance flow through horizontal pipe, flow of bulk density mixture, saltation velocity choking velocity pressure drop in pheumatic conveyance

**PROCESS ENGINEERING-1 (CL 4106)**

1. Preparation of process flow diagram and P & I diagram with process symbol.
2. Sulphuric Acid: Different Raw Materials, methods of production. Equilibrium of $SO_2$, Oxidation-Characteristics Product & Raw material, specification, storage & handling, aconamics.
3. Cryogenics: Oxygen and Nitrogen, production. Storage and handling.
4. Nitrogen Industry: Ammonia. Reaction equilibrium of ammonia synthesis, Ammonium sulphate, Nitric Acid, Ammonium Nitrate, Urea; Methods of production characteristic Specifications, Storage and handling.
5. Phosphorous Industry: Phosphorous, Phosphoric acid, sodium and Ammonium Phosphates, single and triple supper phosphates, Methods of production, storage & handling.
6. Water: Industrial and municipal water, sewage treatment.
7. Rural Development.
8. Chlor-Alkali Industry: Soda Ash, caustic soda, Bleaching powder, methods of production, storage & handling.
9. Marine Industry: Common salt, Magnesium compounds, potassium compounds and Bromine; production, storage and handling.
10. Cement and Lime Industry: Cement, special cements, lime, manufacture of cement & lime.
11. Glass Industry: Glass, special glasses manufacture of glass & Glass-wool.
12. Ceramic Industry: Raw materials, chemistry of ceramics, unit wares heavy clay production, refractories, enamels, chameled metal kilns common types.
13. Electro chemical Industry: Aluminuim, magnesium, sodium production & uses, primary and secondary class fuel cells.

14. Electro thermal Industry: Artificial abrasives:- Production & Uses of Aluminium carbide and calcium carbide, miscellaneous, electro thermal products: common types;

**CHEMICAL ENGINEERING THERMODYMICS II (CL 4107)**

1. The thermodynamic Processes: Constant Volume process, Constant Pressure Process, Constant Temperature process, Adiabatic process, polytropic process and their application to ideal and non ideal gases.
2. Heat Effects: Heat capacities of gases as function of temperature, specific heats of liquids and solids, Heat Effects accompanying phase changes, the standard heat of reaction the standard heat of formation, the standard heat of Combustion effect of temperature on the standard heat of reaction the heat effect of mixing processes adiabatic flame temperature.
3. Thermodynamic properties of fluids: Relations among thermodynamic properties Thermodynamic properties of single phase system, The two phase region, Generalized Correlation of Thermodynamics properties of Gases.
4. The Second law of thermodynamics: Statement of the second law of thermodynamics, the Concept of Entropy, mathematical statement of the Second law, Entropy Changes and irreversibility, Lost work, Classieus inequality.
5. Thermodynamics of Flow process: Fundamental Equations such as continuity and Energy Equation, Joule Thompson Expansion, Liquefaction process compressors-Single and multi stages.
6. Heat Engine cycles: The carnot cycle, simple Power plant cycle, Rankine cycle the Otto Engine, the Diesel Engine, the Combustion Gas Turbine.
7. Refrigeration Cycles: The Carnot Cycle, The Air Refrigeration Cycle, The Vapour Compression Cycle, Absorption Refrigeration Machine and Heat pump.

# SEMESTER – V

## HEAT TRANSFER-II (CL 5108)

1. Boiling and Condensation: Film Condensation Theory, film Condensation inside Horizontal Tubes, Drop wise condensation, Pool Boiling Regimes, Forced Convection Boiling inside Tubes.
2. HEAT EXCHANGER: Classification of Heat Exchangers. Temperature Distribution in heat exchangers, Overall heat Transfer Coefficient, The LMTD method for heat Exchanger Analysis, LMTD Correlation, E-NTU Method for Heat Exchanger Analysis. Heat Exchanger Design (Single trial) Heat Exchangers-Shell & Tube, Double Pipe and Compact Heat Exchangers.
3. Crystallization: Theory of crystallization and classification of crystallizer. Design of crystallizer
4. RADIATION: Nature of Thermal Radiation, Block Body radiation, Radiation from Real Surfaces, Radiation incident on a surface, concept of view factor, Radiation Exchange in an Encloser, Equation of Radiative Transfer, Radiation Exchange between a Gray body and a black Encloser. Radiation flux from an Absorbing, Emitting slab at Uniform Temperature-An Analytical solution. Radiation through Gases & vapors.

## MASS TRANSFER OPERATION – I (CL 5109)

1) Molecular diffusion, convective diffusion, Fick's law, diffusivities, Differential equation for diffusion steady state equimolar counter diffusion, diffusion of A through stagnant B for liquid and gases.
2) Convective diffusion-mass transfer coefficient, Diffusion between two phases, interphase diffusion, Equilibrium, equilibrium relation, two film theory, overall mass transfer coefficient.
3) Diffusion in Turbulent flow-Eddy diffusion, mixing length, wetted wall column; mass, heat and momentum transfer, analogies, J D Factor.
4) Humidification-phase relations and definitions, Humid heat, humid volume, Enthalpy, adiabatic saturation process, wet bulb temp. dew point Lewis relation, humidity Charle's calculation for humidification dehumidification operations
5) Drying, Equilibrium, insoluble solids, soluble solids equilibrium Critical free bound and unbound moisture content, Drying operation, Batch drying, direct dryers, indirect dryers, rate, of batch drying, drying curve, mechanism of batch drying, cross circulation drying through circulating drying, continuous drying-Tunnel dryers, tube types dryers, Direct and indirect drum dryer continuous direct heat dryers, Drying at high temperature and low temperature.
6) Evaporator-Evaporation, evaporation with direct heating steam headed evaporators natural circulation units, horizontal tubes, vertical tubes coil evaporators forced circulation evaporators, film type Units.

7) Operation of evaporators-Heat transfer co-efficient, operation under vacuum, single and multiple effect evaporators, Economy and capacity of multiple effect system, calculations, forward and back ward and mixed feed operation, vapor recompression, integration of evaporators, into total plant economy.

**PHYSICAL AND CHEMICAL EQUILIBRIA (CL 5110)**

1. AUXILIARY FUNCTIONS:

Fundamental equations for closed system in term of internal energy, enthalpy, Hoelmholtz free energy and Gibbs free energy. Non-ideal gases, Virial equations. Isentropic factor and its effect on reduced vapour pressure. Generalized correlation of thermodynamic properties and compressibility factor. Application to gas mixtures.

2. THERMODYNAMIC PROPERTIES OF OPEN SYSTEM:

Partial Molal Properties, Chemical Potential, Potential Energy functions, Electrostatic Forces, Polar and non-polar molecules, Effect of Temperature and Pressure on chemical potential .Fugacity and Fugacity Coefficient. Application to pure component gases, liquids and gas mixture. Excess properties of mixing. Gibbs-Duhem Equation and its correlation in terms of partial pressure. Determination of fugacity using residual volume. Activity and activity coefficient. Thermodynamic properties from volumetric data –fugacities at moderate pressure, fugacity of a pure liquid or solid, fugacities at high pressure. Testing of equilibrium data. Equations of state generalized correlation, Acentric factor, calculation of thermodynamic properties using Fugacity & Fugacity coefficient and Activity & Activity coefficient.

3. PHASE RULE AND PHAQSE EQUILIBRIA:

Phase rule for reacting and non-reacting system. Claussius-Claypron equation. VLE calculation – Bubble point, Dew point and Flash calculation. Phase Equilibrium (VLE, LLE, VLLE)

4. EXCESS FREE ENERGY

Concept of excess free energy of mixing and its Gibbs-Duhem equation, Gibbs/Duhem equation in relation to Raoult's Law, Henry's Law, Lewis/Randal Rule and Partial pressure. Gibbs/Duhem equation and its interacted form like, Porter Van Laar, Margules, Wilson and Redlich/Kister Equation. Excess function of non-ideal solution.

5. CHEMICAL EQUILIBRIA:

Criteria for equilibrium. Equilibrium Constant and its dependence on temperature and pressure. Evaluation of equilibrium constant. Equilibrium conversion for single and multiple reaction systems.

**FLIUD AND PARTICLE OPERATIONS (CL 5111)**

1. Size reduction: Principles of crushing & Grinding, Grindability characteristics of materials for crushing, Type of crushers, grinders and Disintergraters for coarse, intermediate and fine grinding, open and close circuit grinding, laws of crushing.
2. Screening: Standard screens, Industrial screens, classification and performance of screens, Screen Analysis.
3. Classifiers: Dry and wet classifiers, spitz-kasten and other types Tabling, Jigging & Hydrocyclones.
4. Flotation: Principle and operation of flotation cells, Reagents used in flotation, flotation machines and Industrial applications.
5. Separators: Electrostatic & magnetic separators, Electrostatic precipitators, principle of centrifugal separation, Different types of centrifuges & cyclone separators.
6. Sedimentation: Theory of sedimentation, Design and operation of Batch & continuous thickeners.
7. Flow of solids through fluids: Free and hindered settling, stoke's law & Newton's Law used for separation of particles.
8. Filtration: Theory of filtration, batch and continuous filtration equipments, plate & frame filters, Rotary-Drum filters & leaf filters, filter Acid, characteristics of filter cakes & cloths, optimum time cycle and washing of filter cake.
9. Conveying & storage of solids: Belt conveyors, elevating conveyors & screw conveyors. Feeders-belt, apron screw, vibratory, Rotory Table & Reciprocating, Prismatic & Hydraulic conveying, storage bins.
10. Mixing & Agitation: Fundamentals of mixing, type of agitators, power requirement for liquid-liquid systems.

**ENERGY OPTION (CL 5112)**

1) Fuels: Solids, liquids and gaseous fuels, Availability and classification.
2) Coal: Theories of formation, Coal composition petrography of Coal calorific value of Coal, Chemical Constitution of Coal, Action of heat and solvent on coal, Coal preparation, handling and storage;
3) Industrial Coal Carbonization low and high temperature carbonization processes Design of Coke ovens with recovery system. Numerical problems based on Combustion, use of grates, combustion of pulverized fuel and fluidized bed combustion,
4) Efficient utilization of Indian coals,
5) Liquid fuels: Indian cruds & refinery products. Chemical Coal tar distillation Hydrogenation of Coal, Fiacher Tropse process, other liquefaction process, Synthesis gas from petroleum fractions.

6) Gaseous fuel: Natural gas producer gas reactions andits manufacture, water gas, carbureted water gas,
7) Analysis of flue gases, complete gasification of Coal Lurgi, Kopper's Totzek, winkler process synthesis gas form Coal. Renewable sources of energy and their potential
8) Low Temperature application of solar Energy-solar hot water solar drying solar refrigeration etc, Theory, performance analysis and design of liquid flat plate collectors. Solar air heater and their design Principles concentrating collectors-application and their designs, Thermal energy storage solar photo voltage cell,
9) Conversion of Bio-mass and their characteristic, physical thermo-chemical and Bio-logical methods of their conversion.
10) Wind energy and their conversion
11) Tidal geothermal and ocean thermal energy conversion systems.

# SEMESTER – VI

## ELECTIVE - I

### FERTILIZER TECHNOLOGY (CL 6113)

1) Definition of fertilizer, nutrient requirement of different plants paddy, wheat, sugarcane
2) Natural way of fixing nitrogen, Nitrogen cycle, carbon cycle, different nitrogen fixing plants, bacteria and algae. Role of C/N ratio in the growth of different plants.
3) Organic manure.
4) Production of ammonia-its feed preparation, limitations of using different feed material for hydrogen generation, Reforming process and reformer design. Partial oxidation process and partial oxidation reactor design.
5) Hydrogen generation from high ash containing coals, design of different hydrogen generation units using high ash coals, kopper-Totzek suspended bed gasifier design.
6) Removal of Impurities from synthesis gas CO removal and shift reactor design.$CO_2$ removal methods, Design of $CO_2$ absorber, $NH_3$ synthesis loop design,
7) Design considerations for different types of $NH_3$ Reactors.
8) Urea production; special features of urea reactor, prilling tower design.
9) Phosphate fertilizers-different methods of production,
10) NPK reactors, production and drying of NPK fertilizers.
11) Coating of fertilizers for slow release of nutrients.
12) Cost consideration in fertilizer production.
13) Bio-fertilizer

### ENVIRONMENTAL ENGINEERING (CL 6114)

1) Air Pollution:- Environmental problem, Air pollution episode, Common air pollutants, lmpact of air pollutants on human health & vegetation. Air quality standards. Emission standard, Sources of Air Pollution- Particulates, CO, $SO_x$, $NO_x$, HC, natural & industrial sources, Emission factors, Fugitive emissions.
2) Atmosphere:
   The atmosphere and its constituents, wind profiles, turbulent diffusion, Temperature profiles in atmosphere, Stability class. Atmospheric transport of pollutants - dispersion and dilution, Plume rise, buoyancy and momentum factor, Designing of stack for air pollution control, Green house effect, Global warming.
3) Air Pollution Control: Various types of Air Pollution Control Equipment for industrial purposes e.g Cyclones, Bag Filters, Electro-static Precipitators
4) Introduction to Noise Pollution: Decibel, Relationship between sound power, intensity and sound pressure levels, multiple sound sources, ambient air quality standard with respect to noise, weighted sound levels and human reponse.

5) Water Pollution: General principles, Physical, Chemical and Biological properties, Water pollution episodes, Common water pollutants- impact on human health, aquatic life and materials. Sources of water pollution, Release of water pollutant from different plants.
6) Water pollution abatement mechanisms, Water quality parameters, Criteria, Standard for disposal of treated effluent,
7) Effluent disposal and water use. Waste water treatment, Flow sheet, Collection & pumping, Primary, secondary & tertiary treatments
8) Sludge source and characteristics, Sludge thickening, Sludge stabilization, chemical and thermal, Aerobic and anaerobic sludge digestion process, Sludge conditioning, Dewatering, Composting, Heat drying, Thermal reduction.
9) Introduction to radioactive nuclear pollutants

## MATERIAL OF CONSTRUCTION (CL 6115)

1) Types, composition, properties and Industrial application and application as material of construction of metals and non-metals.
   Metals- iron, mild steel, stainless steel, alloys steel, copper, brass and aluminium
   Non-metals- wood, stoneware, glass enamel living, silica, carbon and graphite, rubber and ebonite, plastics
2) Important shaping process
3) Refractories, cements, acid proof bricks
4) Testing of materials – a) destructive such as tensile test, impact test, bend test. b) non-destructive test such as ultrasonic flow detection, weld joint radiography by X-rays or $\gamma$ - rays, magnetic partial test, Dye penetration test stress sheering.
5) Corrosion:- Types and mechanism of corrosion, factors influencing corrosion combating corrosion, corrosion testing methods.

## MASS TRANSFER OPERATION-II (CL 6116)

1) Distillation: Vapour-liquid Equilibria, (Stripping/Rectification) Types of equipment: Bubble cap plate, sieve plate, packed tower, Calculations by enthalpy composition diagram, materials & Energy balances, the Mc.-Cabe Thiele methods, the Design and Control of stripping columns, rectifying columns and fractionating columns, feed plate efficiency, packed columns: concept of height equivalent to theoretical plate (H.E.T.P.), NTU(No. of Transfer Unit). Principles of flash distillation, differential distillation, batch fractionation, vacuum and steam distillation, azeotropic & extractive distillation, and molecular distillation.

2) Absorption: Conditions of equilibrium between liquid & gases, Mechanism of absorption, the two film theory, diffusion of a gases through a gas diffusion in the liquid phase, gas absorption equipments, plate & packed column; packing materials, capacity of packed towers, height based on gas and liquid film, operating line and graphical integration for height, absorption factor, special case

flooding in column, column diameter, Absorption efficiency, NTU (No. of transfer unit.) HTU (Height of Transfer Unit).

3) Extraction: Solid-liquid extraction; type of equipment, solid bed and dispersed contact, multistage counter current operation, methods of calculation, arithmetical and graphical. Liquid-liquid extraction: Types of equipments baffle plate column, centrifugal countercurrent extractor, plate column, spray column operation, methods of calculation: arithmetical and graphical.

4) Introduction to advanced separation techniques, Reverse Osmosis, ultra-filtration, ion exchange

**PROCESS EQUIPMENT DESIGN (CL 6117)**

1) Piping: Design of piping system for transfer of fluid covering pipes, valves, fittings, Instrumentation, insulation, Pumps etc.
2) Heat Exchangers: Design of
   -Double pipe heat Exchanger.
   -Shell & Tube Heat Exchanger
   -Condenser etc.
3) Evaporators: (Double & Tripple effect)
   Design of Evaporators Considering B.P.R., Over all heat transfer Co-efficient, enthalpy concentration chart, heating surface and mechanism of vacuum system etc.
4) Distillation column: (Bubble cap/sieve Tray)
   -Number of plates
   -Tower Diameter / Height
   -Tray spacing
   -Bubble caps details and nos of bubble caps.
   -Internal details such as inlet/outlet weir, Down comers etc.
   -Shell thickness
   -Pressure drop across Tower etc.
5) Absorption column (Plate/Packed Tower)
   -Number of plates
   -Tower Diameter
   -Bubble caps details and Nos. of bubble caps
   -Tray spacing & Tower Height
   -Pressure drop across Tower
   -Tower packing details & packing height
   -Shell thickness etc.
   -Spray Nozzles & Demister details

**PROCESS ENGINEERING – II (CL 6118)**

1. Petrochemicals:- Constituents and classifications, products of Refining, petrochemicals methods, synthetic gas, petrochemicals from Ethane, Ethylene & Acetylene, petrochemicals form Aromatics, Butanes, Butanes, Distillation of hard wood and Hydrolysis of wood products for soft wood,
2. Cellulose derivatives, Oil & fats, Vegetable oils, animal fats, and waxes, soap and detergents, synthetic detergents, organic surface coatings.
3. Fermentation Industry:- Industrial alcohol, Absolute alcohol, beers wine liquor, butyl alcohols, leather Industry, leather from Animal skins, gelatin & glues, synthetic leather. Paint & varnish : Paints pigments, metallic powder, varnished Intermediate dyes, Intermediates, nitration, sulfonation, Oxidation & Alkylation, hydrolysis, condensation & Addition Reaction & Dyes.
4. Plastics: Polymerization fundamentals, thermosetting resins, thermoplastic resins, thermo plastics based on celluloses, laminate & synthetic fibers, viscose and cuproamonium Rayon, cellulose Acetates, nylons, Polyesters spun fibers, melt dry wet finishing of textiles.
5. Paper & pulp, production of pulp for paper, Recovery of chemical from paper manufacture, paper Board.
6. Sugar & starch; manufacture of sugar, starch and related products.
7. Pharmaceuticals, special significance, antibiotics, penicillin, streptomycin tetracyclines, anti-T-H drugs, Anti malarial drugs vitamin, manufacture of penicillin.
8. Pesticides U.D.T., B.H.C. parathion.

# SEMESTER – VII

## ELECTIVE - II

### ENERGY CONSERVATION METHODOLOGY (CL 7119)

1. Energy Scenario: Primary and Secondary Energy, Commercial, Non-commercial, renewable and non-renewable energy, global primary energy reserves, energy pricing in India, energy sector reforms, energy and environment, energy conservation act 2001.
2. Energy Management & Audit: Definition & objective, type and methodology, energy audit reporting, bench marking and energy performance, maximizing system efficiency, energy audit instruments.
3. Energy Monitoring and Targeting: Elements of monitoring and targeting system, rationale for monitoring, targeting and reporting, data and information analysis, Cumulative Sum.
4. Global environmental concerns: Global environmental issues, Ozone layer depletion, global warming, loss of bio diversity, climate change problem and response, conference of parties, prototype carbon fund.
5. Boilers: Boiler system, types and classification, performance evaluation of boilers, energy conservation opportunities.
6. Steam System: Properties of steam, steam distribution, steam pipe sizing, design, proper selection, operation and maintenance of steam traps, performance assessment methods for steam traps, energy saving opportunities.
7. Furnaces: Types and classification, performance evaluation, fuel economy measures.
8. FBC Boilers: Mechanism, retrofitting of FBC systems to conventional boilers, merits.
9. Co-generation: Principle, technical options, classification, factors influencing cogeneration choice, Prime movers for cogeneration.
10. Waste Heat Recovery: Classification & application, benefits, commercial waste heat recovery devices.
11. Compress Air Svstem: Types, compressor performance, energy efficiency in compressed air system.
12. HVAC and Refrigeration System: Types, common refrigerants and properties, selection of suitable refrigeration system, performance assessment of refrigeration plant, factor affecting performance and energy efficiency of refrigeration plants, energy saving opportunities.

### CHEMICAL PLANT OPERATION AND SAFETY (CL 7120)

1. Process Plants-continuous and batch plants, Procedures for systematic study of plants and equipment start up and shut down, Operations at steady state, Safe commissioning of plants.
2. Identification, Classification and Assessment of various types of Hazards, Safety Audits.
3. Reactivity, Instability and Explosivity, Hazard Indices, Hazard Assessment and

Operability(HAZOP) Studies-Case Studies

4. Consequece Analysis; Discharge Model, Flash and Evaporation, Dispersion Models
5. Explosions and Fires: Unconfined vapour cloud explosion and Flash Fires, Physical explosion, BLEVE and fireball, Confined Explosion, Pool Fire & Jet Fire
6. Effect Models: Toxic gas effects, Thermal effects, Explosion effects, Evasive actions
7. Event Probability and Failure frequency analysis: Incident frequency from historical record, Frequency modeling technique by fault tree and Event tree analysis
8. Risk Estimates: Risk Indices, Individual Risk, And Societal Risk.
9. Emergency Planning and Disaster Management Plan: Work emergency PLANNING, works emergency procedures, Disaster Management Plan

## ELECTIVE – III

### POLYMER SCIENCE AND ENGINEERING(CL 7121)

1. Classification of polymers. Thermosets and thermoplastics. Physical states and transition.
2. Glass transition and its Measurements.
3. Crystallization and measurement of crystalinity.
4. Polymers synthesis step growth polymerization with examples: Chain growth including free radical.
5. Aionic and cationic polymerization.
6. Polymer kinetics molecular weight and its distribution
7. Copolymers and copolymerization.
8. Polymerization systems including bulk solution suspension and emulsion
9. Rubber elasticity
10. Flow of polymers Techniques for processing of polymers.
11. Properties of commodity and Engg. polymers. end application, polymer based industries.

### ENVIRONMENTAL ENGINEERING AND WASTE MANAGEMENT(CL 7122 )

1. The concept of ecological balance and the contribution of industrial and human activities in the changes in environmental quality.
2. The ecological cycles. concept of pollutants and regulatory measures for the maintenance of air and water quality. The course also covers the air pollution its source and dependence on the atmospheric factors like wind velocity temperature gradient etc. concept of atmospheric stability and its relationship with dispersion of pollutants models for the prediction of air quality. Health effects of various

pollutants control of emission of pollutants including the design of particulate matter separation by multi-cyclone systems ESR bag filters scrubber and cleaning of gaseous components by wet scrubber, adsorption by activated carbon etc. Water pollution its causes and effects pollutants and its dispersion in water bodies to predict water quality through modeling concept of inorganic and organic wastes and definition of BODSs and COD.

**CHEMICAL PLANT MANAGEMENT(CL 7123)**

1. ECONOMIC STUDY:

Simple, Compound and continuous interest, calculation of equivalence involving interest, present worth, capitalized cost. Common methods of depreciation-their comparison, Formation of business organisation, source of Finance and their formulation.

2. MANAGEMENT:

Functions of management of execution. Managerial activities in planning, organisation staffing-direction and control. Authority span of control and coordination. Line staff and functional relations of authority in an organisation. Morale building and leadership qualities. Personnel management, principles and functions.

3. FINANCIAL AND COST ESTIMATIONS:

Cost of production, inventory control, Balance sheets, income statement cost and financial ratios to study profits, returns, earnings. Investments etc. cost benefit ratio, Economic optimum production unit and incremental costs. Profits, break oven point etc. and the relation with production. Pay back period, internal rate of return. Financial and economic analysis.

4. PROFITABILITY TECHNIQUES:

Different profitability techniques for analysis, financial proposals like cumulative cash, discount cash, payment time, present worth, capitalized cost comparison, Alternate investments and replacements, Inflation and investments.

5. QUALITY AND STANDARDS:

Quality Assurance plan, staged final inspection standards, and standardization cost. Quality control techniques, comparison.

6. INDUSTRIAL RELATIONSHIPS:

Trade Unions, trade disputes, joint consulation, councilliation and arbitration. Introduction to Industrial laws, Factories Act, Provident Fund Act. Sick Industrial companies (Special provision) Act, minimum wages Act, Workmen's compensation Act., contract labour- Regulations & Abolition act. Industrial Dispute Act. Provident fund Act.

## COMPUTER AIDED DESIGN IN CHEMICAL ENGINEERING (CL 7124)

1. Software development for design of various chemical equipments.
2. Design of minimum energy heat exchanger network sequencing
3. Energy integration in distillation column
4. Simulation of process flow sheets using software package, Aspen Plus.

## PROCESS CONTROL & INSTRUMENTATION (CL 7125)

1. Static and dynamic characteristics of instrument-static error, reproducibility, lag coefficient, dynamic lag, dead zone.
2. Working principles and construction of measuring instruments for:-temperature pressure, vacuum, flow and level.
3. General principles and construction of transmitters, indicators and recorders.
4. Control valves; types, construction (globe, gate, butterfly, ball actuators, valve poitioners), flow equations, Rangeability, turndown, sizing formulas and application.
5. Working principles, and construction of liquid and gas analysers based on pH, paramagnetic and infrared properties.

6. Introduction to process control; laplace transform, transfer function, input/output models, first order systems, forcing functions.
7. Dynamic behavior of first order systems, response of first order systems to different inputs, first order systems in series, linearization, second and higher order systems.
8. Dynamic behaviour of second order system, transportation lag.
9. Feedback control, Block diagrams, servo problem and regulator problem, controllers-P,PI, PID,. Concept and dynamics of feedback control.
10. Final Control element, stability, general concept, Routh stability criterion, frequency response technique, Bode diagram, Nyquist diagram, control system design by frequency response technique, controller tuning; Ziegler-Nichols controller settings, Cohen and Coon method, continuous cycling method.
11. Controller mechanism; actual vs ideal controller, pneumatic vs electronic controllers.
12. General understanding of feedback, feed forward, ratio, cascade, adaptive and inferential control.
13. Instrumentation and control schemes for distillation units heat exchangers and chemical reactors.

# SEMESTER – VIII

## ELECTIVE – IV

### BIOCHEMICAL ENGINEERING FUNDAMENTALS (CL 8126)

1. Introduction to biochemical process Industries-Industrial alcohols antibiotics acids, alcoholic beverages, enzymes, vitamins single cell protein.
2. Food processing and biological waste treatment.
3. Interaction of chemical engineering principles with biological sciences Life processes, unit of living system.
4. Microbiology, reaction in living systems, Biocatalysts, model reactions.
5. Fermentation mechanism and kinetic models of microbial growth and product formation
6. Fermenter types, modeling of batch and continuous fermenter,
7. Bioreactor design, mixing phenomena in bioreactors sterilization of media and air sterilization equipment batch and continuous sterilizer design.
8. Biochemical product recovery and separation, membrane separation process reverse osmosis dialysis, ultra-filtration, chromatographic methods, absorption, chromatography gel filtration, affinity chromatography etc Electro kinetic separation electro dialysis electrophoresis waste water treatment activated sludge process anaerobic digestion trickling filter.

### PETROLEUM REFINERY ENGINEERING (CL 8127)

1. History and growth of petroleum Industry in India. Crude oil and their characteristics, Composition, classification and evaluation of different crudes.
2. Physical properties:- Specific gravity, characterization factor, viscosity, viscosity index, viscosities gravity consent Reid vapour pressure, aniline point, flash & fire point, pour and cloud points octane and cetane numbers, ASTM TBP and Diesel index, smoke point.
3. Primary Refining:- Dehydration, distillation, desulphurization, stabilization, Atmospheric & vacuum distillations, naphtha, Diesel and furnace oils their specification and characteristics.
4. Secondary Refining: Thermal and catalytic cracking, Dubbs method of thermal cracking, fluidized thermo for and fixed bed catalytic cracking & their products. Tube still heater and its design, Hydrocracking, Hydrotreating.
5. Multicomponent distillation:- Its application to petroleum Industry, basic principle on design of multicomponent distillation column.

6. Principle of multicomponent extraction Edeluane process, Due sol Process, odex process, propane and furfural extraction & Refining.

7. Dewaxing: Filter preess method and solvent method. Production of waxes and lube oils use of compression and absorption refrigeration purification of gasoline, kerosene, lubricating, oils etc, by Doctor and other treatments.

8. Special process:- Alkylation, isomerization polymerization and Reforming vis breaking, Delayed coking.
9. Blending storages, fire protection, waste disposal, air pollution etc. in petroleum industry. Energy conservation in petroleum Industry.

**ELECTIVE V**

**PETROCHEMICAL TECHNOLOGY (CL 8128)**

1. Introduction: Composition of petroleum, laboratory tests, refinery products, characterization of crude oil.
2. Indian petrochemical Industries: A review.
3. Feed stocks for petrochemical Industries and their sources.
4. A brief introduction to catalytic reforming.
5. Delayed coking Hydrogenation and Hydro cracking Isomerization. Alkylation and polymerization, Purification of gases.
6. Separation of aromatics by various Techniques.
7. Petrochemicals from Methane.
8. Petrochemicals from Ethane-Ethylene-Acetylene,
9. petrochemicals from $C_3$, $C_4$, and higher hydrocarbons synthetic gas chemicals.
10. Polymers from Olefins.
11. Petroleum Aromatics, synthetic Fibers, Rubber, Plastics and Synthetic Detergents
12. Energy conservation in petrochemical Industries.
13. Pollution control in petrochemical industries.
14. New Trend in petrochemical industry.

**ELECTIVE V**

**CHEMICAL REACTOR ANALYSIS (CL 8129)**

1. Heterogeneous processes, global and intrinsic rates, Mechanism of catalytic reactions.
2. Engineering properties of catalysts-BET surface area, pore volume, pore size, pore size distribution.
3. Development of rate equations for solid catalyzed fluid phase reactions, Estimation of kinetic parameters.
4. External mass and heat transfer in catalyst particles. Stability and selectivity,
5. Packed bed reactor, slurry reactor, Trickle bed reactor and fluidized bed reactor.

6. Intra-particle heat and mass transfer-Wheeler's parallel pore model, random pore model of Wakao and smith.
7. Effective diffusivity isothermal and non-isothermal effectiveness factor, deactivation of catalyst.
8. Ideal and non ideal flow in reactors,
9. Design of fixed bed catalytic reactor-isothermal, adiabatic, non isothermal programmed reactors: one dimensional, two dimensional approaches.
10. Reactor-stability control and optimization,
11. Computer aided reactor design.
12. Transient CSTR analysis. Hot spot equation, optimization using Lagrange multiplier, poyntrogin's maximum principle.

**ELECTIVE VI**

**PROCESS DYNAMICS AND CONTROL(CL 8130)**

1. Review of dynamic behavior of linear systems and their control system design. Linear processes with difficult dynamics.
2. Nonlinear process dynamics: phase plane analysis; multiple steady-state and bifurcation behavior; process Identification;
3. Controller design via frequency response analysis; model based control; cascade, feed forward & ratio control; controller design for nonlinear systems;
4. Introduction to Multivariable systems, Interaction analysis and multiple single loop design.
5. Design of multivariable controllers; Introduction to sampled-data systems; Tools of discrete-time systems analysis;
6. Dynamic analysis of discrete-time systems;
7. Design of digital controllers;
8. Introduction to model predictive control; convolution models;
9. Model predictive control of MIMO systems.

**ELECTIVE VI**

**MINERAL BENEFICATION (CL 8131)**

1. Exploitable characteristics of minerals, Economics of mineral beneficiation, power laws
2. Principles of crushing and grinding, grindability, Evaluation of particle size. Size distribution curves and their significance.
3. Mechanism of breakage of material classification design and application of crushers and grinders.
4. Industrial screening, classification and performance of screens,

5. Dry and wet classifiers.
6. Thickeners, hydrocyclone, filtration, tabling, jigging, magnetic and electrostatic separation, surface behavior and flotation principles, flotation machines differential flotation and flotation circuit design,
7. Elements of hydrometallurgy microbial leaching etc.
8. Important beneficiation circuits of minerals like chalcopyrite, sphalerite, galena, bauxite etc.

## CHEMICAL REACTION ENGINEERING (CL 8132)

HOMOGENEOUS REACTION

1. Chemical Kinetics: Type of reaction. Analysis of simple and complex rate equations. Constant volume & Variable volume system. Thermodynamics restrictions.
2. Ideal Reactors: Concept of ideality. Development of design expressions for batch, tubular & stirred tank reactors. Combination of the different reactors. Comparison, advantage & limitations in application.
3. Thermal Characteristics of Reactors: Isothermal, adiabatic and non-adiabatic conditions. Principle of reactor Stability & optimization. Simplified objective functions Residence Time Distribution: Residence time functions and relation among them. Application to ideal reactors, Modeling of real system. Non-ideality parameters. Prediction of reactor performance. Concepts of micro and macro mixing.

HETEROGEOUS REACTIONS

4. Heterogamous catalysts: Homogeneous processes, global and intrinsic rates, mechanism of catalytic reactions. Engineering properties of catalysts-BET surface area, pore volume, pore size distribution. Development of rate equations for solid catalyzed fuid phase reactions. Estimation of Kinetic parameters Catalysts poisoning, deactivation of catalyst.
5. Kinetics of Fluid Solid Reactions: External transport processes. Reaction & diffusion within porous catalysts. Effective diffusivity, thermal conductivity & effectiveness factor. Analysis of rate data. Rate expressions for non-catalytic fluid solid system.
6. Design of Reactors: Designing outline & selection criteria of fixed bed, fluidized bed and slurry reactors.

**TRANSPORT PHENOMENA (CL 8133)**

1. Newton's Law of Viscosity. Momentum flux, Momentum transport Mechanism. Theory of Viscosity of gases at low density. One dimensional laminar flow for falling film, flow through circular tube, Hagen-Poiseuclle law. Equation of change for isothermal systems. Continuity equation, Equation of motion, Navier-Stokes equation, Euler equation, Bernoulli equations,

1. Fourier's Law of heat conduction, theory of thermal conductivity of gases at law density. Shell energy balance, Boundary conditions, One dimensional energy transport with Electrical and viscous heat sources. Equation of change for non-isothermal systems. The equations of energy for three dimensional systems under unsteady states condition.

2. Definitions of concentration, velocities, and fluxes. Fick's Law of diffusion. Theory of ordinary diffusion in gasses at low density. Diffusion through a stagnant gas film. Shell mass balance. Concentration profile, average concentration, and mass flux. Diffusion through a Non-isothermal spherical film. Diffusion with homogeneous chemical reaction, with Heterogeneous chemical reaction Equations of continuity for binary mixture. Fick's second law of diffusion. Boundary layer theory in momentum, thermal and Mass transfer.