Syllabus
for
Chemical, Polymer and Thermal Engineering (MTQP01)

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Note:

i. There will be one Question Paper which will have 75 questions.

ii. All questions will be complulsory.

iii. The Question Paper will be in English only.

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Unit 1: Engineering Mathematics

Linear Algebra: Matrix Algebra, Systems of linear equations, Eigenvalues, Eigenvectors.

Calculus: Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series, Vector identities, Directional derivatives, Line integral, Surface integral, Volume integral, Stokes's theorem, Gauss's theorem, Divergence theorem, Green's theorem.

Differential equations: First-order equations (linear and nonlinear), Higher order linear differential equations with constant coefficients, Method of variation of parameters, Cauchy's equation, Euler's equation, Initial and boundary value problems, Partial Differential Equations, Method of separation of variables.

Complex variables: Analytic functions, Cauchy's integral theorem, Cauchy's integral formula, Taylor series, Laurent series, Residue theorem, Solution integrals.

Probability and Statistics: Sampling theorems, Conditional probability, Mean, Median, Mode, Standard Deviation, Random variables, Discrete and Continuous distributions, Poisson distribution, Normal distribution, Binomial distribution, Correlation analysis, Regression analysis

Numerical Methods: Matrix inversion, solutions of non-linear algebraic equations, iterative methods for solving differential equations, numerical integration, regression, and correlation analysis.

Unit 2: Thermodynamics and Process Calculation

Steady and unsteady state mass and energy balances including multiphase, multicomponent, reacting, and non-reacting systems. Use of tie components; recycle, bypass, and purge calculations; Gibb's phase rule and degree of freedom analysis.

First and Second laws of thermodynamics. Applications of first law to close and open systems. Second Law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties, and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.

Unit 3: Fundamentals of Polymer Science and Technology

Monomers, functionality, initiators, inhibitors, retarders, polydispersity conformation and configuration of macromolecules, stereoisomerism and tacticity in polymers, geometrical isomerism. Polymer structure and properties: Crystalline and amorphous polymers, crystallinity, Basic determinants of polymer properties. Polymer chain flexibility. Structure-property relationship, Factors affecting chain flexibility. Glass transition temperature and crystalline melting points. Factors affecting Glass transition temperature Molecular weight and molecular weight distribution, molecular weight distribution curves, PDI, methods of molecular weight determination-end group analysis, colligative property measurements, light scattering, ultracentrifugation, viscometry, etc. Polymer fractionation techniques, GPC. Basic aspects of polymer synthesis, techniques of polymerization: mass, solution, suspension, emulsion and gas phase polymerization, mechanism, and kinetics of radical/ chain polymerization, Mode of termination - chain transfer to monomer, initiator, chain transfer agent, Inhibition & retardation. Living and non-living chain polymerization, coordination polymerization, co-polymerization, ionic polymerization, and ring-opening polymerization. Newer Techniques in Polymerization: Metathesis polymerization, Controlled polymerization methods, viz, Nitroxide mediated polymerization (NMD), Atom Transfer Radical Polymerization (ATRP), Group Transfer Polymerization (GTP), Reversible Addition Fragmentation Termination Modification of polymers, cross-linking, polymer architecture, Applications and limitations of polymers, future prospects, Polymer viscoelasticity, rubber elasticity, polymer solutions.

Unit 4: Fluid Mechanics and Mechanical Operations

Fluid statics, surface tension, Newtonian and non-Newtonian fluids, transport properties, shell-balances including a differential form of Bernoulli equation and energy balance, equation of continuity, equation of motion, equation of mechanical energy, Macroscopic friction factors, dimensional analysis, and similitude, flow through pipeline systems, velocity profiles, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds, Turbulent flow: fluctuating velocity, universal velocity profile and pressure drop. Particle size and shape, particle size distribution, size reduction and classification of solid particles; free and hindered settling; centrifuge and cyclones; thickening and classification, filtration, agitation and mixing; conveying of solids.

Unit 5: Heat and Mass Transfer

Equation of energy, steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation, and evaporation; types of heat exchangers and evaporators and their process calculations; design of double pipe, shell, and tube heat exchangers, and single and multiple effect evaporators.

Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption, membrane separations(micro-filtration, ultra-filtration, nano-filtration and reverse osmosis)

Unit 6: Process Control and Instrumentation

Measurement of process variables; sensors and transducers; P&ID equipment symbols; process modeling and linearization, transfer functions and dynamic responses of various systems, systems with the inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; transducer dynamics; analysis of closed-loop systems including stability, frequency response, controller tuning, cascade, and feed-forward control.

First principles model development; dynamics of first, second, and higher order linear systems, open loop and closed loop systems; linearization; feedback control; stability, Design of controller; dynamics of some complex processes; control valves and introduction to real-time computer control of process equipment; cascade, feedforward, adaptive control, ratio control. Introduction to advanced control strategies; Introduction to process instrumentation Process Flow Diagram (PFD), Actuators: Pneumatic Valve, Hydraulic actuator, Electric actuator; Sensors: Temperature Measuring Devices, Pressure Measuring Devices; Flow Measuring Devices.

Unit 7: **Chemical Technology and Plant Design**

Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals; polymerization industries (polyethylene, polypropylene, PVC and polyester synthetic fibers).

Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, optimization in process design and sizing of chemical engineering equipments such as heat exchangers and multistage contactors.

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