CH-8101 ADVANCED TOPICS IN HEAT, MASS & MOMENTUM TRANSFER

L T P **Credits:4**
3 1 0

Unit-I

Review of: Molecular Transport Mechanisms, The analogy between heat, mass and momentum transfer, Viscosity and mechanism of momentum transport, Velocity distribution in laminar flow, the equation of change for isothermal system, Thermal conductivity and mechanism of energy transport, Temperature Distribution in solids and in laminar flow, Transport property

(11 Hrs)

Unit –II

Velocity Distribution in Turbulent Flow: Fluctuation and Time Smoothed Quantities, Time Smoothing of the equation of change for an incompressible fluid.Semi empirical expressions for the Reynolds stresses.

Interphase Transport in Isothermal System: Definition of friction factors, Friction factors for flow in tubes, Friction factors for packed columns.

Transport Past Immersed Bodies: The boundary layer and the entry region -- laminar boundary layer, turbulent boundary layer, Heat and mass transfer during boundary layer flow past a flat plate, Flow over cylinder and spheres -- Ideal flow, stokes flow past a sphere, drag coefficient correlation

(11 Hrs)

Unit –III

Heat and Mass Transfer in Duct Flow: Review of radiation, convection, conduction, resistance concept, slope at the wall, bulk and film temperature, Laminar pipe flow -- fully develop transfer and entry region, Heat and mass transfer during turbulent flow -- Review of turbulent models, correlation for fully developed flow, the analogy, other methods. Double pipe heat exchangers -- overall heat transfer coefficient, contact resistance and fouling factors, design equation, simple solution

(10 Hrs)

Unit –IV

Unsteady State Transport: Basic equations -- Heat Transfer equation, mass transfer equations, error function, heat transfer with negligible internal resistance, Finite slab and cylinder -- Fourier series solution, laplace transform solution, generalised chart solution, numerical solution, Other Geometry -- Infinite slab, semi infinite slab, cylinder and sphere

(10 Hrs)

Recommended Books:

Title	**Author**	**Publishers**
Heat Transfer	Holman, J.P.	McGraw Hill
Heat Transmission	McAdams	McGraw Hill
Unit Operations of Chemical Engg.	McCabe & Smith	McGraw Hill
Process Heat Transfer	Kern, D.Q.	Tata McGraw Hill
Principles of Heat Transfer	Kreith	Harper & Row
Fundamentals of Heat and Mass Transfer	Incropera & Dewitt	John Wiley
Heat Transfer	Rao, YVC	University Pub., Hyderabad

CH-8102 POLYMER REACTION ENGINEERING

L T P **Credits:4**
3 1 0

Unit -I

Introduction: Concept of various reactions such as single irreversible & reversible reactions, two reversible reactions in single and two phases, effect of temperature and pressure on single and multiple reactions, understanding the reaction mechanism of addition, step growth and co-polymerization

(10 Hrs)

Unit –II

Classification Of Reactors: Classification, performance of semi-batch homogeneous continuous flow stirred tank (HCSTR) and tubular reactors, size comparison, multiple reactor system, PFR in series or in parallel, Equal size mix reactor in series, mixed flow reactors of different size in series, reactors of different size in series

(10 Hrs)

Unit –III

Polymerization Reactor Design: Factors in reactor design, chances of phases such as concentrated or dilute solution and dispersed phase polymerization comparative characteristics of different reactor type such as batch vs continuous flow, tabular vs CSIR, design fundaments of semi-batch, tabular and stirred tank reactors. Non-elementary reactions kinetics i.e. polymerization, step and chain polymerization reactions, modeling of batch polymerization reactor, molecular weight distribution in anionic polymerization

(11 Hrs)

Unit –IV

Applications: Case studies of these reactors in various polymer product such as PE, polyester, SBR

(09 Hrs)

Recommended Books:

Title	**Author**	**Publishers**
Chemical Reaction Engg.	Octave Levenspiel	Wiley International Ed.
Elements of Chemical Reaction Engineering	Fogler, H.S.	PHI
Advanced Polymer Chemistry: A problem solving guide	Manoj chanda	Marshal Deccar Inc.
Fundamentals of Polymers International Ed. 1990	Anil Kumar & Rakesh K. Gupta	McGraw Hill
Polymer Reactor Engineering, First Ed. 1994	C. McGreavy	Blackie Academic and Professional,
An introduction to Polymer	Charles	Rammond B. Seymquer

CH-8103 ADVANCED POLYMER SCIENCE & ENGINEERING

L T P **Credits:4**
3 1 0

Unit –I

Introductory Survey: Definition and concept of polymers; classification of polymers; structure- properties relationship, configuration & conformation; solubility parameter; intrinsic viscosity; diffusion & permeability in polymers; crystallization from melt ; Kinetics of crystallization ; Theory of glass transition

(10 Hrs)

Unit -II

Polymerization: Step polymerization (Carothers equation), reactivity of functional groups; kinetics of step polymerization; accessibility of functional groups in polymerization reaction; cross linking technology; distribution of molecular weight in bi-functional polymerization; prediction and practical consideration of gel point; Free radical polymerization (kinetics rate & nature; determination of absolute rate constants; Nature of termination and its effect on distribution on molecular weight, auto acceleration & its kinetic study; process conditions; relation between chain length & D.P. ;thermodynamics considerations

(11 Hrs)

Unit –III

Living polymers; Ionic chain polymers ; comparison between radical & ionic polymerization; cationic polymerization of C-C double bond ; Anionic polymers of C-C double bond, copolymerization; kinetics of copolymers; monomer reactivity ratio, significance of copolymerization's; block & graft copolymers; copolymer composition; copolymerization involving dines ; kinetics of stereo regular polymerization; detailed study of kinetics & mechanism of polymerization involving Zigler Natta catalysts & metallocene catalysts ;ring opening polymerization ; group transfer polymerization ; detailed study of kinetics & mechanism of formation of inorganic polymers

(10 Hrs)

Unit –IV

Techniques of polymers: design criterion for polymerization system; brief introduction & comparisons of various techniques of polymerization; bulk polymerization; solution polymerization (description of process, effects of process parameter on polymerization kinetics and distribution on molecular weight of polymers); emulsion polymerization (description of process, effects of process parameter on polymerization kinetics and distribution on molecular weight of polymers); inverse emulsion polymerization (description of process, effects of process parameter on polymerization kinetics and distribution on molecular weight of polymers); suspension polymerization (description of process, effects of process parameter on polymerization kinetics and distribution on molecular weight of polymers)

(10 Hrs)

Recommended Books:

Title	**Author**	**Publishers**
Advanced Polymer Chemistry	Manas Chanda	Marcel Dacker
Polymer Science & Technology	P. Ghosh	Tata McGraw Hill

Principles of Polymer	P.J. Flory	Cornell University Press
Polymer Science & Technology	J.R. Fried	PHI
Polymer Chemistry	Charles E Caraher	Marcel Dacker

CH-8104 PROCESS DYNAMICS & CONTROL

L T P **Credits:4**
3 1 0

Unit -I

Review of Laplace Domain Dynamics & Control: a) Laplace Transformation Fundamentals, i)Definition ii) Linearity property b) Laplace Transformation of Important Functions, i)Step Function ii)Ramp iii) Sine iv) Exponential v) Exponential multiplied by time vi) Dirac delta function (impulse) c) Inverse of Laplace Transformation d) Transfer functions)Multiplied by a constant ii) Differentiation w.r.t. time iii) Integration iv) Dead time e) Examples: f) Properties of transfer functions i) Physical reliability ii) Poles and zeroes iii) Steady state gains g) Transfer function for feedback controllers

Laplace domain analysis of conventional feedback control systems: Open loop & close Loop systems, i) Open loop characteristics equation, ii) Close loop characteristics equation & close loop transfer function

Stability criterion: Bode plot i)Phase margin ii) Gain margin

(10 Hrs)

Unit -II

Laplace domain analysis of advanced control systems: a) Cascade control i)Series cascade ii) Parallel cascade b) Feed forward control i)Fundamentals ii) Linear feed forward control iii) Non Linear feed forward control c) Open Loop unstable processes i)Simple systems ii) Effects of lags iii) PD control iv) Effect of reactor scale up on controllability d) Process with inverse response e)Model based control i)Minimal Prototype design ii) internal Model Control

Process Identification: a) Purpose b) Direct methods i)Time domain "Eyeball" fitting of step test data ii) Direct sine wave testing c) Pulse testing i)Calculation of G_{iw} from pulse test data ii) Digital Evaluation of Fourier transformation iii) Practical tips on pulse testing iv) Processes with integration d) Step testing e) ATV identification i) Autotuning, ii) Approximate transfer function f) Least square method g) State Estimators h) Relationships among time, laplaces and frequency domain, i)Laplace to frequency domain ii) Frequency to laplace domain iii) Time to laplace domain iv) Laplace totime domain v) Time to frequency domain vi) Frequency to time domain

(10 Hrs)

Unit -III

Multivariable processes: Matrix properties - State variables : a) Matrix mathematics i)Matrix addition ii) Matrix multiplication iii) Transpose of a matrix iv) Matrix inversion b) Matrix properties i)Eigen values ii) Canonical transformations iii) Singular values c) Representation of multivariable processes i)Transfer function matrix ii) State variables d) Open loop & close loop systems i)Transfer function representation ii) State variable representation

Analysis of multivariable systems: a) Stability i)Open Loop - Close loop characteristics equations ii) Multivariable nyquist plot iii) Characteristics of loci plots iv) Niederpinstri index b) Resiliency c) Interaction i)Relative gain array (Briscal array) ii) Inverse nyquist array (INA) iii) Deccoupling d)Robustness i)Trade off between performance and robustness ii) Doyle stan analysis iii) Stroquestad - Morari Method

Design of controller for multivariable processes: a) Problem definition b) Selection of controlled variables i)Engineering judgment ii) Singular value decomposition, c)Selection of manipulated variables d) Elimination of poor pairings e) BLT tuning f) Local rejection performance g) Multivariable controllers i)Multivariable DMC ii) Multivariable IMC

(10 Hrs)

Unit -IV

Sampled Data Controlled system: Sampling & Z-Transformations: a) Introduction i)Definition ii) occurrence of sampled data systems in Chemical Engineering b) Impulse sampler, c) Basic sampling theorem d) Z Transformation i)Definition ii) Derivation of Z transforms of common functions iii) Z Transform theorem iv) Inversion e) Pulse Transfer function f) Hold devices, g) Open loop & close loop systems h) Discrete approximation of continuous transfer function i) Modified Z-transforms ii) Definition, iii) Modified Z-transformation of common functions

Stability analysis of sampled data system: a) Stability in Z plane b) Root Locus design methods i)Z-plane root locus plot ii) Log Z plane root locus plot c) Bilinear transformation d) Frequency domain design techniques i)Nyquist stability critarion ii) Rigorous method iii) Approximate method

Design of Digital Compensator: a) Physical realizability, b) Frequency domain effects c) Minimal prototype design, i)Basic concept ii) Other input types iii) Load inputs iv) 2nd order processes v) Shunta dual algorithm vi) Dahlin algorithm d) Sampled data control of processes with dead time e) Sample data control of open loop unstable processes

(10 Hrs)

Recommended Books:

Name of Author	**Title**	**Publisher**
William L.Luyben	Processes modeling simulation and control for Chemical Enggs.	Mcgraw Hill
Donald R. Coughanowr	Process system analysis & control	-do-
George Stephanopolous	Chemical process control	Prentice Hal of India Pvt. Ltd, New Delhi

CH-8105A ADVANCED ENERGY TECHNOLOGY

L T P **Credits:4**
3 1 0

Unit –I

Introduction: Energy scenario, Energy sources & their availability, Prospects of renewable energy sources, Classification of energy sources, Quality & concentration of an energy sources, Resources of energy & energy use pattern in different regions of the world.

Energy Audit: Energy audit concepts, Elements, Measurements, Mass & energy balances, Evaluation of energy conserving opportunities, Presentation of reports case study, Laboratory work

(11 Hrs)

Unit -II

Energy Conservation: An economic concept of energy conservation, Laws of energy, efficiencies, Energy recovery from waste, Waste heat recovery systems and applications, Energy savings by recycling & by network analysis, Application of pinch technology to energy conservation, Energy conservation in fertilizer, refinery & petrochemical industries

(10 Hrs)

Unit –III

Solar Energy: Solar radiation, its measurement & prediction, Flat plate collectors liquid & air type. Theory of flat plate collectors, Advanced collectors, Optical design of concentrators, Selective coatings, Solar water heating, Solar dryers, Solar stills, Solar cooling & refrigeration, Thermal storage, Conversion of heat into mechanical energy, Active and passive heating of buildings, Solar cells

Nuclear Energy: Status, Nuclear raw materials, Nuclear reactors & other classification, Generation of nuclear power, Nuclear installations in India & their capacity of generation, Limitation of nuclear energy, Reprocessing of spent nuclear fuel, Cogeneration of heat & power

(11 Hrs)

Unit -IV

Wind Energy: Basic principles of wind energy conversion. Basic components, Classification, Advantages & Disadvantages of WECS (Wind Energy Collectors System), Types of wind machines (Wind Energy Collectors), Energy storage, Application of wind energy

Bio Energy: Bio mass conversion technologies, Biogas generation, Classification of Bio gas plants, Digester design considerations, Biomass as a source of energy, Methods for obtaining energy from Biomass, Thermal gasification of Biomass

(10 Hrs)

CH-8105B ADVANCED POLYMER MATERIAL TECHNOLOGY

L T P **Credits:4**
3 1 0

Unit -I

General Polymers: Cross linked PE; Chlorinated P.E. ; Chlorosulphonated P.E, High Molecular weight P.E. ; UHM- PE; very low density P. E ; Ultra low density P.E ; Nylon 10; Nylon 11; Nylon 12; Poly butylene terpthalate (PBT); Polycyclo Hexylene Dimethylene Terpthalate (PCT) ; Polyacrylic acid); poly methacrylic acid; cellulose tri accetate; C.A. butyrate; C.A. propionate; Ethylenevinyl accetate; Ethylenevinyl alcohol polyvinlidence chloride; poly(ethyene oxide); poly(Propylene oxide) poly ether ether ketone

(12 Hrs)

Unit –II

Poly (Vinyl byrrdidone); poly (vinyl carlazole), poly (imide); poly amide- imide; poly sulfone; poly sulfide; poly (ether sulfone) poly(benzimidazone), poly (phenylene oxide); poly (phenylene sulfide); poly (ethyleneoxide) poly (propylene oxide); furan resins , resins; alkyd resins; lignin

(10 Hrs)

Unit -III

Spatiality polymers: Liquid crystal polymers; Thermo plastic elartomers; Inorganic polymers; water soluble polymer: Ablative plastics; conductive polymers; Ionic polymers; Heat resistant & flame retardant polymers; Bio degradable polymers; Ladder polymers; polymers in electrical & electronic applications; polymer in telecommunication & Power transmission

(10 Hrs)

Unit –IV

Additives: Smoke retardants; fragrances; slip agent; surface active agent, antitogging agent; antimicrobials; impact modifiers; processing aids, viscosity controllers; wetting agent; cling agent; anti block agent; optical whitener; purging compound; air release agent; extender

Compounding Tech of Rubbers & Plastics: Sequence of Compounding; Effect of Time; Effect of Temperature; Effect of Viscosity

(10 Hrs)

Recommended Books:

1. Polymer Science & Technology ; Joel.R.Fried; PHI.
2. Polymer Science & technology of Plastics and Rubbers; P.Ghosh; TMH.
3. Text Book of Polymer Science; Billmeyer.
4. Plastics Technology Handbook; Manas Chanda & Salik Roy.
5. Modern Plastics Handbook; McGrawHill.

CH-8105C ENVIRONMENTAL ENGINEERING

L T P **Credits:4**
3 1 0

Unit -I

Introduction: Environmental Pollution: Monitoring & Control, Effects of Pollutants on Living systems and Structures, Effluent Guidelines & Standards for Air, Water & Land disposals; Conservation of Material resources & Energy through Recycling

(10 Hrs)

Unit –II

Water Pollution: Waste-Water characterization & its Treatment, Treatment, Utilization and Disposal of sewage, Industrial Waste Water Treatment & Disposal

(10 Hrs)

Unit -III

Air Pollution: Types of Air Pollutants and their effects on Living beings, Greenhouse effect, Greenhouse gases, Impact of Greenhouse enhancement, Depletion of Ozone layer, Chemistry of Depletion, ozone hole, Montreal Protocol, Plume Characteristics and Design of Chimeney.

Solid Waste Pollution: Characterization of Solid waste, Disposal of Solid waste, Solid waste management, Reuse of Solid waste materials, Recovery of materials & materials & metals, conversion into useful products

(10 Hrs)

Unit –IV

Biodiversity: Magnitude of Biodiversity, Significance of Bio diversity, direct values, indirect values, Loss of diversity & its Causes, Saving Bio diversity, Ex-situ conservation, In-situ conservation

Environment Impact Assessment & Auditing: Environment impact assessment, project data, environment data, Prediction & Evaluation of impacts, environment Impact assessment in India context. Environment Auditing and Analysis of data, Cost benefit analysis in Pollution control, Mathematical Modeling for environmental Pollution control

(10 Hrs)

Recommended Books:

1. Manual on emergency Preparedness for Chemical Hazards Ministry of environment & Forests, govt. Of India.
2. Environmental engineering -G.N.PANDAY, G.C..CARNEY. Tata McGraw
3. Sustainable Business -Regency Corporation Ltd.,

CH-8105D BIO-DEGRADABLE POLYMERS

L T P **Credits:4**
3 1 0

Unit-I

Plastic Waste – sources and types of plastic waste, methods of recycling of plastics such as land filling, incineration, mechanical recycling and chemical recycling, methodology for plastic waste recycling

(10 Hrs)

Unit-II

Polymer degradation: types of polymer degradation, factors affecting the degradability of polymers, chemistry of polymer biodegradation, biodegradation of common plastics and starch based products

(10 Hrs)

Unit-III

Testing: Screening test for ready biodegradability, test for inherent biodegradability, test for simulation study, Petri dish screen, environmental chamber methods, soil burial methods

(10 Hrs)

Unit-IV

Recycling technology for biodegradable plastics – conventional and complicated recycling, Environmental implication of polymer degradation

(10 Hrs)

Recommended Books:

1. Handbook of Plastic Technology, Vol. II by Allen, Baker & Bhatia.
2. Chemistry in Technology of Biodegradable Polymer, G.J.L. Griffin
3. Plastic waste recycling, AICTE.

AM-8201 STATISTICS & NUMERICAL METHODS

L T P **Credits:4**
3 1 0

Unit -I

Operations Research: Linear Programming, Duality in linear Programming, Transportation and Assignment problems, Dynamic Programming, Non-linear programming

(10 Hrs)

Unit –II

Ordinary Differential Equations: Review of Taylor series Method, Picard's method Euler's Method, Modified Euler's method RungeKutta method. Finite Difference Technique, Orthogonal Collocation method, Galerkin finite element technique for Ist & 2nd order O.D.E.

(09 Hrs)

Unit –III

Partial Differential Equations: Finite differences technique, orthogonal collocation method, Galerkin finite element method for parabolic partial differential equations

(08 Hrs)

Special functions: Bessel Functions, Legendre Polynomials, Jacobi Polynomials - their generating functions, orthogonality properties etc

(07 Hrs)

Unit -IV

Statistics: Multiple and partial corelations, Bivariate Noprmal distribution, Theory of sampling & testing of Hypothesis, Chi square distribution, student's t-distribution, Snedecor's F-distribution, Fisher's Z- distribution

(06 Hrs)

Recommended Books:

AUTHOR	TITLE	PUBLISHER
Gupta, Santosh K.	Numerical methods for Engineers	New Age International
Jain, M.K.	Numerical solutions of Differential Equations	Wiley Eastern Ltd
Kamboj N.S.	Mathematical Programming Techniques	Affiliated, East West Press
James F.Scarborough	Numerical Mathematical Analysis	Oxford (I) Pvt. Ltd.
Grewal, B .S.	Higher Engineering Mathematics	Khanna Publishers.
Kapoor, J.N. & Saxena,H.C.	Mathematical Statistics	S.Chand & Co. Ltd.
Gupta, Prem Kr. & Hira, D.S.	Problems in operations Research	S.Chand & Co. Ltd.

CH-8202 PROCESS MODELING & SIMULATION

L T P **Credits:4**
3 1 0

Unit –I

Mathematical Modeling: Unsteady state and steady state modeling , Development of System of procedures, Development of software program for process equipments, Application of simulation to optimization

(10 Hrs)

Unit –II

Differential equation and population balance models, Physical & Thermodynamics properties

(10 Hrs)

Unit –III

Numerical methods for digital simulation

(12 Hrs)

Unit –IV

Introduction to Monte Carlo simulation techniques; Simulation of continuous systems; i) Pure Pursuit problems ii) Serial case problem, Random variables: Random Variable Table, Pseudo Random variable, Generation of Random Variables, Mid-square Random Variable Generator, Residual method, Arithmetic congruential generator, Combined congruential generators, qualities of an efficient random variable generator. Uniformity test: "Kolmogorov - Smirnov Test", "Chi- squared test" , testing for Autocorrelation : Uniformity test, Chi-squared test for Auto Correlation, Poker Test. Application of Monte Carlo Method in Chemical Technology

(10 Hrs)

Recommended Books:

AUTHOR	TITLE	PUBLISHER
B.Wayer	Chemical Engineering Process Dynamics	Prentice Hall
Bequette	Analysis and Simulation	PHI
Chawla	Process Modeling & Simulation	McGraw Hill
Leubegr	System Modelling & Simulations Control for Chemical Engineers	PHI

CH-8203 ADVANCED POLYMER CHARACTERILIZATION

L T P **Credits:4**
3 1 0

Unit -I

Mechanical Properties: Review of mechanical properties (tensile,textrural, compressive, creep, stress relaxation, impact, abrasion, hardness), Detailed study of shear strength, Fatigue properties of polymers.

Thermal Properties: Review of thermal properties (short term test, MFI,Thermal conductivity, thermal expansion, Brittleness temperature), Detailed study of Heat Resistance test, Ultra Low temperature Index, DSC, TGA, TMA, DTA

(12 Hrs)

Unit –II

Electrical Properties: Review of electrical properties (Dielectric strength, dielectric Arc resistance; VL Requirement.

Chemical Properties: Stress-Strain of Plastics; Environmental Stress Cracking Resistance.

Optical Properties: Photo Elastic properties; Luminous Transmittance & Haze

(10 Hrs)

Unit -III

Other Tests: Plasticizer Absorption Tests; Burst Strength Tests; Crush Test, Acetone Acid Immersion Test; Toxicity.

Characterization Tests: Rheometer Tests; Gel Permeation Chromotagraphy (GPC); FIIR.

Failure Analysis: Types of Failure; Analysis of Failure;

Conditioning Procedure: Removal of moisture, Removal of volatile matters

Quality Control: Statistical Quality Control (SQC); 10.2 Quality Control system

(10 Hrs)

Unit -IV

Testing of Rubbers: Physical Testing of Vulcan sates; Processing & Vulcanisation Tests.

Testing of Fibers: Testing of Polyester, Testing of polyamides, Testing of acrylics, Testing of cellulosics, Testing of carbons in glass

Testing of Foam Plastics: Foam Properties; Flexible foam Test Methods, Rigid Foam Test Methods.

Professional Testing Organizations: ASTM,ISO,BIS, ISI

(10 Hrs)

Recommended Books:

1. Hand Book of Plastic Testing Technology: U.RhenShah.
2. Text Book of Polymer Science : Billmeyer.
3. Plastics Technology Hand Book: Manas Chanda/ Salil Roy.

CH-8204 ADVANCED POLYMER RHEOLOGY & PROCESSING

L T P **Credits:4**
3 1 0

Unit -I

Polymer Processing: Introduction, Brief introduction of processing techniques - their correlation ; MFI for various processing techniques .

Extrusion: Design of screw for different plastic; Extrusion coating & limitation(Need, material, application and properties ; Co extrusion ; Analysis of flow extruder (both single and twin screw)

(10 Hrs)

Unit –II

Injection molding: Structural foam injection molding ; sandwich molding ; gas injection molding ; Details of RIM ,RRIM and SRIM molding , applications of the techniques .

Other process: Multilayer blow molding; slush molding ; sinter molding ; resin transfer molding ; Deborah number and its impotence in blow molding, biaxial orientation and effect of stretching on blown product .

Pultrusion : introduction ; Process details; Parameters; Applications

(10 Hrs)

Unit –III

Rheology & structure: Effect of molecular weight; Temperature; Pressure; time; Stress; chain stiffness; Chain branching; crystalline; Binder / filler/ plasticizer/ lubricant. Rheology in polymer processing: Introduction; low flow process;mixing process. Constrained flows; Free surface flows; Bulk deformation.

Rheometry; Capillary Rheometry; coniette rheometer; cup & cone rheometer; Rheometric characterisation of polymer solution & melts ; Apparatus required for setting a Rheology lab

(12 Hrs)

Unit –IV

Polymer Rheology: Newtonians fluid; non newtonian fluid; ideal elastic deformation. Hookean solids; pure viscous flow; Newtonian liquids; plastic flow, Bingham flow ; stress-strain behavior; Influence of time; relaxation; relaxation curve; creep; Maxwell & Voigt model.

Viscous flow: Polymer shape in solution; dilute solution; Intrinsic viscosity; effect of concentration; Models for non newtonian flow; viscosity of ploymer suspensions ; Mark-houwink -sakurada equation; Rheological behaviour of crystalline solid liquid, solution & suspensions

(10 Hrs)

Recommended Books:

1. Principles of Polymer Chemistry: PJ Flory.
2. Principles of Polymer Systems : F.Rodrigues
3.Plastics Rheology: RS Lenk.
4. Polymer Science & Technology: Fried
5. Polymer melt Rheology: FN Goswell

CH-8205A APPLIED THERMODYNAMICS

L T P **Credits:4**
3 1 0

Unit -I

Review & applications of Laws of thermodynamics and other basic concepts, Molecular theories of thermodynamics and their applications, Practical applications of thermodynamics to distillation, CSTR, PFR, compressor etc, Activity & activity coefficient; variation of activity coeff. with temp. & composition; Prediction of mixture properties for gases ,liquid & solid systems, excess properties & their applications

(10 Hrs)

Unit -II

Thermodynamic properties: Inter-relationship of properties; equations of states; law of corresponding states with practical examples; Maxwell's relations; mathematics of property changes, Jacobian method.

Thermodynamics of flow systems: Flow of compressible fluids through nozzles and diffusers; the converging diverging nozzles; work & efficiency calculation for flow systems.

(10 Hrs)

Unit –III

Multi component systems: Partial molar properties & chemical potential; Tabulation & use of mixture property data; fugacity; Lewis Randall rule- ideal solutions; solution behavior of real gases, liquids and solids.

Multi component phase equilibria : Criteria for equilibria; computation of partial fugacities; vapour liquid equilibria, isotropic behavior; phase equilibrium involving solid - liquid and solid- vapor equilibrium; free energy composition diagram; applications of Gibbs-Duhem equation

(12 Hrs)

Unit –IV

Equilibrium in chemically reacting systems: Work production from chemically reacting systems; development of equilibrium constant in terms of measureable properties; effect of temp & pressure on equilibrium constant; adiabatic reactions; equilibrium with competing reactions, Heterogeneous reactions and Gibbs Phase rule

(10 Hrs)

Recommended Books:

1. Chemical Engg Thermodynamics by Smith & Van Ness .Pub. by McGraw Hill....
2. Chemical Engg Thermodynamics by Y.V.C. Rao.
3. Chemical Engg Thermodynamics by Balzhiser, Samuels & Eliassen. Pub. by Prentice Hall International Series.

CH-8205B POLYMERS IN BIO-MEDICAL APPLICATIONS

L T P **Credits:4**
3 1 0

Unit -I

Biodegradability of Polymers – Mechanisms and Evaluation Methods, Biodegradation, Behavior of Polymers in Liquid Environments

Biomaterials: Polymeric Biomaterials, Polymerization and Basic Structure Polymers Used as Biomaterials Sterilization, Surface Modifications for Improving Biocompatibility, Composite Biomaterials-Structure Bounds on Properties, Anisotropy of Composites, Particulate Composites, Fibrous Composites, Porous Materials and Biocompatibility. Glycolide/Lactide Based Biodegradable Linear Aliphatic Polyesters Non-Glycolide/Lactide Based Linear Aliphatic Polyesters Non-Alphatic Polyesters, Biodegradation Properties of Synthetic Biodegradable Polymers and Preservation Techniques for Biomaterials.

(10 Hrs)

Unit -II

Tissue Engineering; An Introduction to Tissue Engineering, Tissue-Engineering Strategies, The Importance of Polymer Scaffolds in Tissue Engineering, The Role of Growth Factors and Cytokines in Tissue Engineering, The Complexity of Growth Factor Release, Basic Principles and Considerations, Reconstruction of Connective Tissues Reconstruction of Epithelial or Endothelial, Surfaces Bioreactor Design in Tissue Engineering,. Regenration Templates: The Problem of the Missing Organ, Principles for Identification of Regeneration Templates, Structural Specificity of Dermis Regeneration Template (DRT), In Situ Synthesis of Skin with DRT, Modifications of DRT: Use of a Living Dermal Equivalent, The Bilayered Skin-Equivalent Graft, Structural Specificity of Nerve Regeneration Template (NRT), In Situ Synthesis of Meniscus Using a Meniscus Regeneration Template (MRT), The Roles of Mass Transfer in Tissue Engineering; Topology and Transport Characteristics of Living Organisms, Fundamentals, on the Bases of a Quantitative Description

(12 Hrs)

Unit -III

Role of polymers in drug delivery: Introduction, Currently available polymers, Diffusion-controlled systems, Solvent-activated systems, Chemically controlled systems, Magnetically controlled systems, Soluble polymers as drug carriers, Pinocytosis, Ideal soluble polymers, Biodegradable or bioerodible polymers, Drug release by matrix solubilization, Erodible diffusional systems, Monolithic systems, Mucoadhesive polymers, Polymers containing pendant bioactive substituents, Matrix systems, Heparin-releasing polymers, Ionic polymers, Oligomers, Miscellaneous; Polymeric Nanoparticles as Drug Carriers, Polymers Used for the Delivery of Genes in Gene Therapy

(10 Hrs)

Unit -IV

Oral drug delivery: Introduction, Features of the GI tract, Targeting of drugs in the GI tract, Mathematical models for controlled-release kinetics, Design and fabrication of oral delivery systems, Miscellaneous forms of controlled release, Ion-exchange resins, Altered density: Drug-coated micropellets, pH-independent formulations, Pro-drugs Barrier coating, Embedment in slowly eroding matrix,. Embedment in plastic matrix, Repeat action, Hydrophilic matrix, Polymer resin beads, Passage-sponge formation, Drug complex formation, Bio adhesives, Local, targeted systems, Synchron system, Pennkinetic and other liquid controlled-release systems, Controlled-release capsules, Controlled-release tablets, Hoffmann-La Roche's Web Delivery System, Hydrodynamic cushion system,

Floating delivery system, Meter release system, Hydrodynamically Balanced System, Other oral controlled drug delivery systems, Survey of oral controlled-release products, Recent advances, Current development of oral drug delivery systems.

Applications of Hydrogels in Drug Delivery : Basic Concepts of Hydrogel Drug Delivery, Environment-Sensitive Hydro gels, Biodegradable Hydro gels, Specific Applications of Hydro gels in Oral Drug Delivery, Hydrotropic Hydro gels for Delivery of Poorly Soluble Drugs

(10 Hrs)

Recommended Books:

1. Biomaterials *for* delivery *and* targeting *of* proteins *and* nucleic acids. By Anjan Nan and Hamidreza Ghandehari
2. Biomedical Polymers and Polymer Therapeutics. By Emo Chiellini
3. Surfactants and Polymers in Drug Delivery. By Marcel Dekker,
4. Polymer in drug delivery. By Ijeoma F. Uchegbu
5. The Biomedical Engineering HandBook, Second Edition. By Ed. Joseph D. Bronzino, 2000, CRC Press (USA).

CH-8205C POLYMERS COMPOSITES AND BLENDS

L T P **Credits:4**
3 1 0

Unit -I

Thermoplastic Composite: Need for additive; Fiber reinforcement; long fiber reinforcement; natural fiber reinforcement; Mineral powder filler; Polymers; surface treatment; Study of thermoplastic composite; Application of thermoplastic structural composite; glass filled thermoplastics.

Thermoset composites : Introduction; Resins (Polyester, epoxy, vinyl ester, PF, bismaleimide, polyamide etc) ; fiber (glass, carbon, aramid, ceramic, mettalic fiber formals; BMC/ SMC ; prepag; Applications

(14 Hrs)

Unit –II

Mechanical properties : Modulus ; Strength; Influences of resin characteristics and resin reinforcement interaction on composite strength ; Interfacial adhesion & coupling agent ; Strength of fiber composites; creep behavior; fatigue behavior ; Impact behavior; Dynamic Mechanical properties

(08 Hrs)

Unit -III

Fabrication Methods: Manual (Hand-lay- up, Spray-up. Auto clove molding); Semi auto (cold press molding. Hot press molding, resin injection, vacuum injection), automatic (filament winding, centrifugal casting, pultrusion, injection molding, compression molding), sandwich constructions

(12 Hrs)

Unit -IV

Polymer Alloys/ Blends: Introduction; nature of polymer blends; factors affecting nature of polymer blends; melt flow & Morphology of blends; polymer / Polymer miscibility; compatibility ; Rubber toughening of plastics; blends of stiff compounds; preparation; processing; development of thermoplastic alloys

(08 Hrs)

Recommended Books:

1. Polymers & Composites
2. Thermoplastic Aromatic Polymer composite : F.N Cogswell
3. Polymer Alloys / Blends : Ultracki
4. Hand-Book of composite : Peters
5. Engg. Polymers : Dyson

CH-9101 POLYMER PRODUCT DESIGN

L T P **Credits:4**
3 1 0

Unit -I

Design Development:: End use requirement; Preliminary Design; Material selection; Design modification; CAD/CAE; Flow Analysis; Stress Analysis
Prototype & Testing; End use Testing.
Design of Industrial Products: Injection Molded Products; Extruded Products; Rotational Molded Products; Blow Molded Products; Vacuum Formed Products; Compression Molded Products

(10 Hrs)

Unit -II

Product Designing with Special Emphasis on: Strength; Appearance; Precision; Mold ability; Environmental Conditions; Economic Factors.
FRP Part Design: Merchantability of FRP; Design of common machine parts; FRP and common applications

(10 Hrs)

Unit -III

Suggested Wall Thickness for Thermoplastics/Thermo sets: Design equations for finding thickness, Calculation of optimal thickness.
Basic Principles: Thread; Holes; Fillets & Radii; Taper or Draft; Warpage; Shrinkage; Wall Thickness; Ribs & Bones; Under Cuts Inserts; Parting Line; olerances

(10 Hrs)

Unit -IV

Rubber Product Design: Tyres & Tubes; Manufacturing; Film Shining; Flow Sheet for Manufacturing; Design of Tyres; Cable -Type Manufacturing. Film Shining; Flow Sheet of Manufacturing; Design of Cable; Applications; Belt -Type; Manufacturing flow Sheet; Design of V-Belt & Conveyor Belt; Application; Hose -Type; Manufacturing with Flow Sheet, Calculation of Pressure; Design of Hose; Vibration Isolator; Type like Railway Sleeper; Earthquake Protector; Bridge Bearing; General Design & Force Calculation

(12 Hrs)

Recommended Books:

1. Polymer composites ed: S.T.Sanders
2. Plastic product Desdign Beck
3. Handbook of Composites S.D.Peters
4. Principle of polymer processing R.T.Pfenner

CH-9102 RUBBER TECHNOLOGY

L T P **Credits:4**
3 1 0

Unit -I

General Introduction: Basic concept & definition, Rubber Plantation & Production of Natural Rubber; Degradation & Aging of rubbers structure, property and applications of rubbers, Current trends in rubber science & Technology

(08 Hrs)

Unit -II

Moldification & Reinforcements: Modifications of Rubber (Physical & Chemical), Physics of Rubber (Theory of Rubber Elasticity), Adhesion; Reinforcement-Carbon Black (HAF, ISAF, SAF, SRF, MT etc.), Silica and clay etc.

(12 Hrs)

Unit –III

Compounding & Vulcanization: Compounding Ingredients (Plasticizer, ZnO/Stearic Acid, Sulphur, Accelerators, Anti-Oxidants/anti-Ozonants Special Additives (Anti-Bacterial agents, Coloring agents, Tackifiers etc.); Vulcanization system (EV, Semi EV, CV) & their mechanism

(10 Hrs)

Unit -IV

Synthetic Rubber: Choloroprene Rubber; Silicone Rubber; SBR, Nitrite Rubber; Butyl Rubber; Poly isobutylene; PU elastomeric; Floroelastomer, Ethylene Propylene-Dine Elastomeric.

Processing: Processing of manufacturing of rubber products e.g. conveyer belts automobile of rubber, Analysis & testing of rubbers.

(12 Hrs)

Recommended Books:

AUTHOR	TITLE	PUBLISHER
M. Morton	Rubber Technology	Van Nostrand Reinhold Co. (ACS)
G. Alliger, I.J. Sjothun	Vulcanization of Elastomers	Robert E. Krieger Pub. Co., New York
J.A. Briston	Rubber Materials	
Roberts	Natural Rubber Science & Technology	