M.Tech. Course in Polymer Technology

Sl. No.	Course Code	Name of the subject	Core/ Elective	L	P	C
SEMESTER I						
1	POL 3101	Advanced Polymer Science	C	3	0	3
2	POL 3102	Applied Mathematics	C	3	0	3
3	POL 3103	Operation Management & Management Information Systems	C	2	0	2
4	POL 3104	Polymer Materials	C	2	0	2
5	POL 3105	Rubber Processing & Product Manufacture	C	2	0	2
6	POL 3106	Polymers for Bio-medical Applications/Polymers for Packaging/Speciality Polymers/ Chemical Engineering/ Material Science	E	3	0	3
7	POL 3107	Polymer Technology Lab I	C	0	2	2
8	POL 3108	Review Seminar	C	0	1	1
		Total Credit				18
SEMESTER II						
1	POL 3201	Plastics Processing	C	3	0	3
2	POL 3202	Advanced Polymer Rheology	C	3	0	3
3	POL 3203	Polymer Products Design	C	3	0	3
4	POL 3204	Characterization and Testing	C	3	0	3
5	POL 3205	Introduction to Mould and Die Design	C	2	0	2
6	POL 3206	Tyre Technology/Polymers in Space Applications/ Polymers in Electrical and Electronics Applications/ Polymer Nanocomposites	E	3	0	3
7	POL 3207	Polymer Technology Lab II	C	0	1	1
		Total Credit				18
SEMESTER III						
1	POL 3301	Project Work Report and Viva Voce	0	0	18	18
SEMESTER IV						
1	POL 3401	Project Work Report and Viva Voce	0	0	18	18

SYLLABUS FOR M. TECH. COURSE IN POLYMER TECHNOLOGY

(*2009 Admission onwards*)

POL 3101 ADVANCED POLYMER SCIENCE

Unit I

Different types of polymerizations like addition, condensation and stereoregular polymerization. Initiators used, important steps involved, kinetics and mechanism of addition, condensation and stereoregular polymerizations. Copolymerization and its kinetics. Important techniques of polymerization such as emulsion, bulk, solution and suspension.

Unit II

Polymer characterization, molecular weight determination by GPC, viscosity, light scattering and osmometry. Physical methods of polymer analysis such as IR, NMR, X-ray etc. Thermal analysis of polymers using DSC, TGA, DTA, DMA etc.

Unit III

Polymer degradation and stabilization: Thermal, oxidative, photochemical and ozone degradation, degradation under special environments. Mechanism of different types of degradation. Commonly used anti- degradants and the mechanism of their stabilization.

Unit IV

Solution properties of polymers: Thermodynamics of liquid mixtures of small molecules, entropy and heat of mixing of polymer solutions. Flory- Huggins theory of polymer solution, equation of state theory, Flory- Krigbaum theory and cluster type theory.

Unit V

Polymer synthesis: Synthesis of speciality polymers such as aromatic polyether, polyacetals, polyamides, polymers with metal in their back bone, phosphorus and sulphur-containing polymers, polymeric liquid crystals, conducting and photo conducting polymers. Polymer supported solid phase reactions, Merrifield method.

References:

1. Polymer Chemistry, Paul C.Hiemenz, CRC Press
2. Principles of Polymer Chemistry, P.J.Flory, Cornell University
3. Experimental Methods in Polymer Chemistry, J.F.Rabek, John Wiley & Sons Ltd.
4. Encyclopedia of Polymer Science & Engg., Vol.15, Wiley Interscience
5. Handbook of Polymer Synthesis, Part A & B, Hans.R.Kricheldorf (ed), CRC Press
6. A Text Book of Polymer Science, F.W. Billmeyer, John Wiley & Sons Ltd.

POL 3102 APPLIED MATHEMATICS

Unit I

Numerical Methods-I

Roots of equations: Bisection method, Regula falsi method, Newton Raphson method, Secant method, Fixed-point iteration method, Muller's method.

Solution of simultaneous linear equation: Jacobi's iteration method, Gauss Seidal method, Gauss Jordan method. Solution of simultaneous non linear equations: Newton Raphson method.

Unit II

Numerical Methods: II

Finite differences and Interpolation, Numerical differentiation, Numerical integration.

Numerical solution of ordinary differential equations: Taylor series method, Euler method, Runge Kutta Method, Milne's Method.

Unit III

Linear Programming

Formulation of LPP, Graphical method, Simplex method, Penalty method, Duality.

Transportation problem: North-West Corner rule, Vogel's approximation method, Stepping stone method, Modified Distribution method. Assignment problem.

Unit IV

Differential Equations-I

Introduction to methods of ordinary differential equations, linear equations, simultaneous linear equations.

Series solution of differential equations: Bessel's equation, Legendrel's equation, and Hermite equation.

Unit V

Differential Equation - II

Introduction to methods of solution to partial differential equations, homogeneous and non-homogeneous linear equations of first order and second order. Applications: Wave equation, one-dimensional heat flow, two dimensional heat flow.

References:

1. Advanced Engineering Mathematics, Erwin Kreyzig, John Wiley, 1993
2. Higher Engineering Mathematics, Grewal. B.S., Khanna Publishers
3. Numerical Methods, Balaguruswamy, Tata Mc Graw-Hill Education
4. Operation Research, Taha. H.A., Prentice Hall
5. Operations Research, Kantiswarup, Sulthanchand
6. Differential Equations, George F. Simmons, Tata Mc Graw-Hill
7. Elements of Partial Differential Equations, Ian N.Sneddon, Courier Corporation
8. Numerical Methods, R.K.Jain, New Age International Ltd.
9. Differential equation, David Lemen, James Merk, Prentice Hall, 1988.

POL 3103- OPERATION MANAGEMENT & MANAGEMENT INFORMATION SYSTEMS

Unit I

Organization and Personnel Management, concept of organization, organizational structure, organization charts, types of organization, authority and responsibility, span of control, delegation of authority, type of ownership.

Personnel Management, recruitments and training, labour turnover, training methods, suggestion systems, industrial safety, wages and incentives, job evaluation and merit rating.

Unit II

Marketing and Management Accounting: Concept of marketing Vs Sales approach, Consumer behaviour and demand concept. Buying motives and factors influencing buying motives, pricing methods and tools sales promotion, marketing research, test marketing, advertising and selection of medias.

Management accounting, Fundamentals of book keeping, journals, ledger account, cash book, trial balance, understanding of trading account, profit and loss account and balance sheet.

Unit III

Production Management: Production system and different system approaches, product line determination, decision making, need for management decisions, type of decision, decision making techniques, operation, planning and control-quality control techniques, inventory and invertory control techniques.

ABC & VED Analysis, its importance-scheduling, network models, PERT/ CPM maintenance management and methods of maintenance.

Unit IV

Characteristics and capabilities of computers: Role of computer in fore casting, computer assisted production, planning and inventory control systems, computer application in finance accounting, booking and other operations, computer assisted training and development.

Unit V

Management Information Systems, need for information system, objectives of MIS, Management Information categories, characteristics of good MIS, Evolution of MIS, designing of MIS, implementation of MIS, application of MIS, Information system requirement.

References:

1. Principles of Management : Koontz & O'Donnell, McGraw Hill, New York
2. Financial Management : Prasanna Chandra, McGraw Hill Education
3. First step in book keeping : I.R. Batliboi, Standard Accounting Publications
4. Industrial organisation and Management : O. P. Khanna, Dhanpat Rai Publications
5. Industrial organization and Management : Lawrence L. Bethel, McGraw Hill College
6. Management Information systems : Gordon B. Davis, Margrethe H Olson, Mc Graw Hill, New York

POL 3104 POLYMER MATERIALS

Unit I

General Introduction to individual polymers:

Manufacture, structure, properties and applications of styrene butadiene rubber, poly isoprene rubber, comparative evaluation of these different unsaturated rubbers, comparison of polyisoprene rubber with natural rubber with respect to structure, properties and applications. Acrylonitrile- butadiene rubber and polychloroprene rubber.

Unit II

Manufacture, general properties and applications of butyl rubber, EPDM and EPM. Comparison of these rubbers with unsaturated elastomers with respect to chemical properties, vulcanization and end uses. Study of other speciality elastomers like hypalon, silicones, polyurethanes, fluorocarbons, ethylene vinyl acetate copolymers etc. Manufacture, properties and applications of different thermoplastic elastomers.

Unit III

Preparation, general properties and end use of polyolefins viz. polyethylenes, PVC, polyvinylidene chloride, PTFE, PP, polystyrene, olefin copolymers viz. copolymers of acrylonitrile, styrene, butadiene and vinyl chloride and their terpolymers. Polyacrylics, polyvinyl acetate and polyvinyl alcohol.

Unit IV

Preparation, properties and uses of polyamides like Nylon 6 and Nylon66, aromatic polyamides like Kevlar. Polyimides-their structure, preparation and uses. Silicone resins and fluids. Important polyesters in commercial applications. Detailed study on PET and unsaturated polyesters. Cellulose esters used in plastic application, polyurethane foam and coatings.

Unit V

Difference between thermoplastics and thermosets. Manufacture of different PF, UF and MF resins, their structure, properties and applications, moulding powders from these resins. Study of preparation, structure and curing of epoxy resins. Their important applications and advantages over other adhesives.

References:

1. Rubber Technology - Maurice Morton, Springer
2. Rubber Technology and Manufacture - Blow C. M., Butterworth-Heinemann Ltd.
3. Plastics Materials - J. A. Brydson, Butterworth-Heinemann Ltd.
4. Synthetic Rubber - Whitby G. S., John Wiley & Sons
5. Introduction to Industrial polymers - Henri Ulrich, Hansen Publishers
6. Man Made Fibres – R. W. Moncrieff, Butterworth-Heinemann Ltd.

POL 3105 RUBBER PROCESSING AND PRODUCT MANUFACTURE

Unit I

Processing of field latex into various forms like (a) preserved field latex (b) latex concentrate process like centrifuging and creaming (c) ribbed smoked sheets (d) crepe rubber (e) technically specified solid block forms (crumb rubber) (f) superior processing rubber etc.

Unit II

Additives used in rubber compounding: Curing systems, antidegradants, plasticisers, fillers, colourants, blowing agents etc. General compound design.

Unit III

Machinery used for mixing, two roll mill, internal mixers and continuous mixers, extrusion technology, calendering and different types of calenders.

Unit IV

Moulding: Compression, transfer and injection moulding, different methods of vulcanization such as rotocure, autoclave open steam, high energy radiation etc.

Unit V

Manufacturing methods for the products like (a) rubber foot wear (b) beltings (c) hoses and tubings (d) wire and cables (e) rubber to metal bonded articles (f) mechanical seals, cellular products, manufacture of latex products like foam, dipped goods, latex thread etc.

References:

1. Natural Rubber Handbook - R. R. I. I. Kottayam
2. Rubber Technology and Manufacture - C. M. Blow, Butterworth-Heinmann Ltd.
3. Polymer Latices - D. C. Blackley, Vols.III, Springer
4. Polymer Processing - D.H.Morton Jones, Chapman & Hall

5. Rubber Technology Hand Book - Werner Hofmann, Hanser Publishers
6. Rubber Processing - P.K.Freakly, Plenum Press
7. The Applied Science of Rubber - W. J. S.Naunton, E.Arnold, Cornell University

POL 3106 POLYMERS FOR BIOMEDICAL APPLICATIONS

Unit I

Introduction to classes of materials used in medicine, world-wide market for biomaterials, clinical implications of biomaterials development.

Types of materials-inert, toxic, bioactive, natural materials - collagen, biopolymers etc.

Introduction to biocompatibility, requirements and standards, cell-material interaction, testing of biomaterials, in vitro assessment, in vivo assessment of tissue compatibility, testing of blood materials interaction, animal models.

Unit II

Polymers as biomaterials, silicones, polyurethanes, polyvinyl chloride, polyethylenes, ultra high molecular weight polyethylene, polyacrylates, polyether ether ketone, water soluble polymers, hydrogels, bio-adhesives, diffusion principles, polymers for controlled drug delivery applications, polysaccharides, poly(orthoesters), polyanhydrides, aminoacid derived polymers, polyphosphazenes, bacterial polyesters, etc.

Concepts of polymer composites, composites - reinforcing systems-fabrication, mechanical properties, dental filling composites, fibrous and particulate composites in orthopedic implants.

Biomimetic materials, nanoscale materials/engineering; bioactive/ bioresponsive materials, polymer scaffolds, principles of tissue engineering.

Unit III

Medical devices, medical device development, material choice, device design, extracorporeal devices, oxygenators, intravenous

catheters, stents, polymeric implants, heart valves, total artificial heart, cardiac pace makers, vascular grafts, artificial kidney, dialysis membranes, hard tissue implants, orthopedic implants, fracture plates, intramedullary devices, spinal fixation, joint replacements, bone cement, soft tissue replacements, wound dressing, artificial skin, sutures, contact lenses, tissue adhesives, maxillofacial implants, ear and eye implants, controlled drug delivery systems, biosensors, gloves, condoms, urinary catheters, intrauterine systems, cosmetic implants.

Regulation and standards for quality, FDA, EU-medical directives, GMP, GLP, ISO, CE marking etc.

Unit IV

Degradation of polymers in biological environments, biodegradable polymers, polylactic acid, polyglycolic acid, polylactic acid co-glycolic acid, polycaprolactone, hydrolysis, enzymatic degradation.

Surface modification techniques, plasma modifications, coating methods.

Sterilization methods-dry heat, steam, ethylene oxide, gamma ray, effect of sterilization on polymers, importance of packaging, shelf-life.

References:

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons, Biomaterials Science, An introduction to Materials Science, 2nd Edn, Elsevier Academic Press, London, 2004.

2. J. Park and R.S.Lakes, Biomaterials An Introduction, 3rd Edn., Springer Science, New York, 2007.

3. F.Silver and C. Doillon, Biocompatibility, Interactions of biologicals and Implantable Materials Volume 1. Polymers, VCH Publishers, New York, 1989.

4. Shalaby W. Shalaby, Biomedical Polymers, Designed to degrade systems, Hanser Publishers, New York, 1994.

5. D.L.Wise et al. Eds., Encyclopedic handbook of Biomaterials and Bioengineering, Part A. Materials & part B. Applications, Volume 1 &2,., Marcel Dekker Inc., New York, 1995.

POL 3106 POLYMERS FOR PACKAGING

Unit I

Edible and biobased food packaging materials, Edible films and coatings, Polysaccharide based coatings, Lipid based coatings, Protein based coating, First, Second and Third biobased packaging materials.

Unit II

Permeability of thermoplastic polymers, Multilayer films, Processing, Deteriorative reaction in foods, Enzyme reactions, Chemical reactions, Physical change, Biological change, shelf life of foods, Factors controlling shelf life.

Unit III

Aseptic packaging of foods, Sterilization of packaging materials, Packaging of microwavable foods, Active and intelligent packaging, Modified atmospheric packaging, Packaging of fresh foods, Packaging of horticultural products.

Unit IV

Packaging of dairy products, Packaging of cereals, snack foods and confectionary, Packaging of beverages, Comparison of polymer packaging with paper, metal and glass materials, printing processes, Safety and legislative aspect of packaging.

Books

1) Food Packaging – Gordon.L Robertson, Taylor and Francis (2006).

2) Plastics packaging, RJ Hernandez, Susan EM Selke, John D Culter, Hanser Publishers.

POL 3106 - SPECIALTY POLYMERS

Unit I

High temperature and fire resistant polymers, improving low performance polymers for high temperature use, polymers for low fire hazards, polymers for high temperature resistance, fluoropolymers, aromatic polymers, hydrocarbon polymers, polyphenylene sulphide, polysulphones, polyesters, polyamides, polyketones, heterocyclic polymers.

Unit II

Polymers with electrical and electronic properties, conducting polymers, conducting mechanisms, polyacetylene, polyparaphenylene polypyrrole, organometallic polymers, photoconducting polymers, polymers in non linear optics, polymers with piezoelectric, pyroelectric and ferroelectric properties, photoresists for semiconductor fabrication, liquid crystalline polymers.

Unit III

Ionic polymers-synthesis, physical properties and applications, Ion- exchange, hydrophilicity, Ionomers based on polyethylene, elastomeric ionomers, Ionomers based on polystyrene, PTFE, Ionomers with polyaromatic backbones, Polyelectrolytes for ion exchange, polyelectrolytes based on carboxylates, polymers with integral ions, polyelectrolyte complexes, Biological and inorganic ionic polymers.

Unit IV

Polymer concrete, polymer impregnated concrete, ultra high modulus fibers, polymers for biomedical application, polymeric binders for rocket propellants, polymer supported reagents.

Unit V

Polymers in telecommunications and power transmission: Polymers as insulators, electrical breakdown strength, capacitance, dielectric loss and cable attenuation, submarine cable insulation, low fire risk materials, polymers in power transmission, optical fibre telecommunication cables.

References:

1. Encyclopedia of Polymer Science & Engineering H.F. Mark (Ed) John Wiley & Sons, New York (1989) Relevant Volumes.

2. Plastics for Electronics, Matrin. T. Goosey, Elsevier Applied Science Publishers (1985)

POL 3106 CHEMICAL ENGINEERING

Unit I

Unit operations, classification, material balances, recycle, material balance with chemical reactions, heat balances, dimensional analysis, Buckingham theorem.

Unit II

Fluid statics, pressure in a fluid, manometers, viscosity of fluids, Newton's Law, laminar and turbulent flow, Bernoulli's equation. Hagen Poiseuille equation, friction loss in laminar flow and turbulent flow, friction factor, friction loss in expansion, contraction and pipe fittings, fluid flow measurement, venturimeter, orifice meter, pitot tube, centrifugal and positive displacement pumps.

Unit III

Steady state heat transfer, Fourier's law, thermal conductivity, convective heat transfer coefficient, conduction through cylindrical wall, combined conduction and convection, forced convection, heat transfer, boiling and condensation, unsteady state heat conduction, evaporation, types of evaporators, single effect evaporator calculation.

Unit IV

Similarity of mass, heat and momentum transfer processes, Fick's law of molecular diffusion, molecular diffusion in solids, packaging materials.

Distillation, relative volatility, simple distillation methods, steam distillation, distillation with reflux, Mc Cabe-Thiele method of calculation of number of theoretical stages, total and minimum reflux, tray efficiency, gas absorption, plate and packed columns for absorption and distillation.

Unit V

Introduction to drying and drying equipments - principles of liquid, liquid extraction and solid liquid leaching equipments. Filtration, type of filters, bed filter, plate and frame filter press, leaf filter, filter media and filter aids. Settling and sedimentation, free and hindered settling, sedimentation, centrifugal separation, disc bowl centrifuge, cyclones, electrostatic precipitator.

References:

1. Introduction to Chemical Engineering, W.L.Badger and J.T.Banchero, Mc Graw Hill (1955)
2. Principle of Industrial Chemistry, Chris A Clausen & Guy C Maltson, John Wiley & Sons (1978)
3. Unit operations of Chemical Engineering, Warren McCabe & Julian Smith, Mc Graw Hill (1983)
4. Chemical Engineering, J.M.Coulson and J.M.Richardson, Pergamon press (1979) relevant volumes.

POL 3106 - MATERIAL SCIENCE

Unit I

Crystal symmetry: Crystal systems, crystal planes, X-ray and neutron diffraction from crystals – structure determination, Bonding in crystals, ionic, covalent, metallic and molecular bonds, bond energies, imperfection in crystals-defects and dislocations. (15hrs.)

Unit II

Mechanical properties : Elastic deformation, anelastic deformation, viscous deformation, plastic deformation, mechanical testing, fracture, fatigue, creep and environment assisted cracking.

Unit III

Metals and Alloys: Solid phases, solid solutions-alloys-Hume Rothery rules, phase rule, phase diagram, binary system, iron and cast iron steels, alloys for high temperature. (12hrs.)

Unit IV

Ceramic & Polymers: Classification of ceramics, structure of ceramics, electrical properties, thermal and mechanical properties, refractories and glasses, properties of polymers in relation to other materials (10 hrs.)

Unit V

Electrical conduction in metals: Semiconductors-energy gaps, impurity semiconductors, pn-junction and transistor action, compound semiconductors and their uses. Insulators-dielectric properties, Ferro electrics, Piezo-electricity and its uses. Magnetic materials-ferromagnetism, magnetic domains in materials, ferrite, magnetic alloys. (18 hrs.)

References:

1. Materials Science & Processes-S.K.Hajra Choudhury (Indian Book Distributing Company)
2. Material Science & Engg. a first course - V.Raghavan, PHI Heraning Pvt. Ltd.
3. Materials Science - J.C.Anderson & K.D.Leaver, Springer
4. Introduction to solid state Physics - C.Kittel, Wiley
5. Introduction to materials science – M.J. Starfird & A.M. Sharanger

POL 3107 - POLYMER TECHNOLOGY LAB I

Unit I

Identification of Rubbers - NR, SBR, BR, IR, IIR, EPDM, Hypalon, Thiokol, Silicone, CR, NBR and Thermoplastic Elastomers, Rubber Compounds.

Unit II

Identification of Plastics - PE, PP, PS, PVC, PVA, PF, UF, MF and Polyester.

Unit III

Preparation of polymers, PMMA, PS, UF, PP, MF and Polyester resin etc.

Unit IV

Estimation of polymer molecular weights by Viscometry, Gel Permeation Chromatography and End Group Analysis.

References

1. The Identification of Plastics and Rubbers, K.J. Saunders, Chapman and Hall
2. Experimental Methods in Polymer Chemistry, Jan F. Rabek : Wiley, New York
3. Analysis of Rubber and Rubber - like Materials, M. John, R. Loadman, Kluwer Academic Publishers

POL 3201 PLASTICS PROCESSING

Unit I

Introduction to plastics processing, additives for plastics, mixing and compounding of plastics, mixing and compounding equipments.

Unit II

Injection Moulding: Types of machines, constructional features, details of moulding process, injection moulding of thermosets.

Unit III

Extrusion: Constructional details of extruders, twin screw extruders, dies and take - off equipment, post extrusion processing, calendering, laminating.

Unit IV

Compression moulding: Hydraulic presses, press capacity and pressure calculations, moulding process. Transfer moulding: Moulding process, advantages. Blow moulding: Extrusion and injection blow moulding. Rotational moulding: Process and equipment. Reaction injection moulding: Introduction, process, advantages.

Unit V

Reinforced plastics: Materials, processing techniques viz - hand lay up, spray lay up, filament winding, autoclave and bag moulding; RRIM.

References:

1. Plastics Engineering, R.J.Crawford, C.J.Pergamon Press.
2. Plastics Engineering Handbook - Edited by Joel Fradas, Van Nostrand Reinhold Company.
3. Polymer Processing - D.H.Morton Jones, Chapman and Hall.
4. Polymer Mixing Technology - George Matthews, Elsevier Science Ltd.

POL 3202 ADVANCED POLYMER RHEOLOGY

Unit I

Polymer viscoelasticity, the ideal elastic response, pure viscous flow, viscoelasticity, mechanical models for linear viscoelastic response, Max well and Voigt models, four parameter model, material response time. Deborah number, Maxwell-Weichert model, generalized voight element. Superposition principles: Boltzmann superposition, time temperature superposition, WLF equation, shift factor. Rubber elasticity, ideal rubber, entropy elasticity, dynamic measurements, structure elucidation, hysteresis, rebound resilience, definition for storage and loss modulus, loss tangent and complex modulus, fatigue.

Unit II

Yield and fracture of polymers, cold drawing, yield criteria, temperature and strain rate dependence, fracture: theories of fracture, fracture toughness, crazing, impact testing of polymers, Elastic - plastic fracture mechanism, rubber toughening, oriented polymers, undesirable and desirable orientation, drawing, experimental methods for investigating the degree of orientation.

Unit III

Newtonian and non - Newtonian flow, pseudoplastic, bingham, dilatant and thixotropic behaviour, origin of non - Newtonian flow, Factors influencing flow behaviour, molecular weight and distribution, chain branching and temperature, evaluation of processability, standard test methods for melt flow rate, flow and scorch in rubbers, methods for thermoset materials.

Unit IV

Power-law fluids, drag flow and pressure flow of power-law fluids in simple geometries. Measurement of flow properties, capillary viscometers, coaxial cylinder viscometer and cone and plate viscometer, characteristics, Rabinowitsch correction, Bagley correction, extensional viscometers, melt fracture, normal stress and die swell.

Unit V

Fiber-polymer interaction, filler geometry, volume fraction, filler surface, wettability, filler surface treatment, rheology, effect of polymer matrix, steady shear viscosity data. Application of rheological studies in polymer processing - extruder screw and die, analysis of pressure, drag and leakage flow, characterization and interaction of screw and die, balanced runner moulding. Compounding techniques, compounding/mixing variables.

References:

1. R.J.Crawford - Plastic Engineering, Pergamon Press
2. Brydson, JA. - Flow properties of polymer melts- Van Nostrand Reinhold
3. Cogswell, F.N. - Polymer melt rheology-CRC Press

POL 3203- POLYMER PRODUCTS DESIGN (2012 onwards)

Unit I

Introduction to structure and physical properties of polymers, stress- strain behaviour of polymers. Effect of fillers on properties of polymers. Stress analysis of polymers, structural design of beams, plates and other structural members.

Unit II

Gear Design: Materials, strength and durability, moulded v/s cut plastic gearing, inspection assembly and operation. Bearings: Self lubricated plastic materials, rubber bearing, type of bearings, designers check list. PVC piping: Raw materials, pipe design, specification and test procedure, manufacturing process.

Unit III

Elastomeric ring seals: Basic configurations, design method, design consideration, static and dynamic seals. Vibration dampers: Basic vibration damping relations, Octave rule for damped systems, estimating damping in structures, controlling resonant peaks with damping, response of damped structures to shock. Flexible coupling: Vibration of two mass system, specification and selection of couplings, types of couplings.

Unit IV

Fundamentals of CAD: Need for drafting and design in the modern world, software used in CAD/CAM., 2D modeling and dimensioning-entity, object creation, editing, viewing, zooming, dimensioning and plotting. Geometric modeling - wireframe, surface and solid modeling.

Unit V

Engineering analysis-FEM, design review and evaluation, automated drafting, design data base, software used in CAD, data exchange between CAD and CAM. Fundamentals of CAM: Definition of automation, levels of automation, high volume discrete parts production, Detroit type of automation, transfer machines, analysis of automated flow lines, assembly machines, flow line balancing, line balancing.

References:

1. Plastics Products Design Handbook, Edward Miller, Marcel Dekker, Part A & B, New York 1983.
2. Theory and Practice of Engineering with Rubber, P.K.Freekly & A.R.Payne, Applied Science, London 1978.
3. Elastomers, Criteria for Engineering Design, C. Hepburn and R.T.W. Raynolds, Applied Science, London 1979

4. Plastic Product Design Engineering Hand Book, S.Levy & J.H.Dubois, Van Nostrand Reinhold Co., New York, 1977.
5. Plastic Product Design, R.D. Beck, Van Nostrand Reinhold Co., New York 1970.
6. Engineering with Rubber: How to design Rubber Components, A.N. Gent, Ed. Hanser, Munich 1992.
7. CNC and Computer aided manufacturing, Kundra T. K.,Rao P.N. and Tiwari N.K., Tata McGraw Hill
8. Tool & Manufacturing Engineers Hand Book, SME.
9. "CAD/CAM" M.P.Groover, E.W.Zimmers, Prentice Hall, 1984
10. "CAD/CAM/CIM", P. Radhakrishnan
11. Fundamentals of engineering drawing and Auto CAD Mohammed Parvez, 3rd edition, Galgotia Publications

POL 3204 – CHARACTERISATION AND TESTING

Unit I

Introduction to testing of polymers and polymer products, standards organisations like BIS, ASTM, BS, DIN, ISO etc. Preparation of test pieces and conditioning. Importance of specifications and standards in quality control of polymers and polymer products.

Unit II

Quality control tests on natural rubber and important synthetic rubbers. Specification tests on natural rubber latex. Difference in the approach to testing of rubbers, plastics and fibers. Testing for processing properties. Viscometers, Rheometers and Plastimeters. Testing for elastic properties, scorch, cure rate, optimum cure time, MFI, density, dimensional measurements, gel time etc.

Unit III

Short term and long term static stress-strain properties, tensile test equipments, dynamic stress-strain measurements: Forced vibration and free vibration methods. Impact tests, falling weight, Izod and Charpy equipments. Testing of hardness of rubber and plastic products. Measurement of creep, stress relaxation and set. Dynamic fatigue of polymer products.

Unit IV

Testing of important thermal properties like specific heat, thermal conductivity, glass transition temperature etc. Heat ageing tests, important electrical properties like resistance and resistivity, dielectric strength, surface discharge, tracking, permitivity and power factor. Testing for chemical resistance. Effect of ozone, oxygen, acids, alkalies and humidity. Fire testing, oxygen index test, weathering, environmental resistance, Gas permeability. Extraction and swelling.

Unit V

Important quality control tests to be performed on rubber products like tyres, tubes, beltings, hoses, dipped goods and foam rubber. Testing of plastic products like laminates, films, foot wears, cables and wires.

References:

1. Hand Book of Plastic Test Methods, R.P.Brown (Ed.), George Godwin, London 1981
2. Physical Testing of Rubber, R.P.Brown, 3rd Ed. Springer 1995
3. ASTM, BS, BIS, ISO and DIN Standards for tests of Plastics & Rubbers
4. Hand Book of Plastics Test Methods. G.C.Ives, J.A. Mead, M.N. Riley Iliffe, London, 1971
5. Polymer Latices Vol. I, II & III, D.C. Blackley, Springer
6. Hand Book of Plastics Testing Technology, Vishu Shah, Wiley 1998

POL 3205 - INTRODUCTION TO MOULD AND DIE DESIGN

Unit I

Introduction: Common machine tools for mould making, lathes, milling machines, grinding machines, drilling machines, casting & electrochemical techniques, EDM, common materials for mould making, introduction to CAD/CAM.

Unit II

General features of Injection Moulds, cavities and cores, insert/ bolster combinations, different bolsters, ancilliary items, ejection techniques, ejector plate assembly.

Unit III

Feed System, runners, guidelines for designing, significance of gates, various types and their design, principles of mould cooling, different cooling circuits.

Unit IV

Dies for extrusion: Important aspects of die design, Newtonian and non-Newtonian flow, land length, entry geometry, Features of typical tube extrusion die. Dies for various applications.

Unit V

Compression moulds: types of moulds and features. Introduction to moulds for transfer moulding, rotational moulding, reaction processing and blow moulding.

References:

1. How to make injection moulds, Georg Menges, Walter Michaelin and Paul Mohren, Car Hanser Verlag GmbH & Co.
2. Injection Mould Design, R.G.W. Pye, 3rd ed., George Godwin Books, 1983
3. Extrusion of Plastics, E.G. Fisher, Newnes Butterworths, 3rd ed., 1976
4. Plastic Mould Engineering Handbook, J.Harry Du Bois and Wayne I. Pribble, Springer

POL 3206 - TYRE TECHNOLOGY

Unit I

A historical introduction to the design and development of tyres of various kinds and types. The current status of tyre industry in India

and its future prospects, tyre sizing and marking on the tyres. Different types of tyres: bias, radial, bias-belted tyre and tubeless tyre - their basic functions and performance comparisons. Different components of a tyre, its geometry, basic functions. Functions of a pneumatic tyre: load carrying capacity, vibration and noise reduction, tyre function as a spring, contribution to driving control and road adhesion, the tyre friction contribution to driving control, steering control and self aliging torque.

Unit II

Cord-rubber composites and its properties, failure mechanism of cord reinforced rubber. Mechanics of tyre pavement interaction. Tyre forces on dry and wet road surfaces. Tractive forces on dry, wet, ice snow and irregular pavements, breaking and traction of tyres.

Unit III

Tyre wear, rubber friction and sliding mechanism, various factors affecting friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc. on noise.

Unit IV

Manufacturing techniques of various tyres like two wheeler and car tyres, truck tyres, OTR, farm tyres, aircraft tyres. Principles of designing formulations for various rubber components. Tyre reinforcement materials (Textile, steel, glass etc.). Criteria of selection, different styles and construction, textile treatment. Tyre mould design, green tyre design principles, methods of building green tyres for bias, bias-belted, radial and tube-less tyres, green tyre treatments. Tyre curing methods, post cure inflation, quality control tests. Tyre related products, their design and manufacturing techniques, tubes, valves, flaps, bladders. Different types, features and operation of tyre building machines, bead winding machine, wire/glass processing machines, bias cutters, curing presses.

Unit V

Measurement of tyre properties, dimension and size-static and loaded. Tyre construction analysis, endurance test, wheel and plunger tests, traction, noise measurements. Force and moment characteristics,

cornering coefficient, aligning torque coefficient, load sensitivity and load transfer sensitivity. Rolling resistance, non uniformity, dimensional variations, force variations, radial force variation, lateral force variation, conicity and plysteer.

Type, balance, and mileage evaluations. Tyre flaws and separations. X- ray, holography etc. Foot print pressure distribution.

BIS standards for tyres, tubes and flaps.

References:

1. Tyre Science & Technology (Journal of the Tyre Society) Akron, Ohio.
2. Tyre Technology, Tom French, Taylor & Francis
3. Tyre Mechanics & Testing (Sponsored Course, Feb. '83) Roorke
4. Mechanics of Pneumatic Tyres, Samuel Clark, US Department of Transportation, Washington.
5. a) Year Book - Tyre and Rim Association
   b) Engineering Design Informations, The Tyre & Rim Association.
6. Tyre, Valve & Rim data, ITTAC, New York.
7. "Automobile Tyres", LFK Setright Chapman & Hall, London.
8. Tyre Technology, F.J.Kovac, GOODYEAR Tyre and Rubber Company, USA.

POL 3206 POLYMERS IN SPACE APPLICATIONS

Unit I

Polymers for aerospace research- adhesives, coatings, ablatives. Synthesis and processing of advanced thermoplastics: PEEK, polycarbonates, polyethers, polyethersulphones. Synthesis and processing of thermal protection systems in space research. High temperature resistant resins such as epoxy, phenolic and polyimides. High temperature resistant polymers with metals in their back bone - Boron, Silicon and Phosphorous containg polymers for space applications.

Unit II

Composites for satellites and launch vehicles: Composites- type of composites- fibre composites, particulate composites, foam composites. Desired properties of a matrix. Polymer matrix : Thermosets and thermoplastics. Fiber reinforced polymer (FRP) Types of fibers, mechanical properties of fibers, glass fibers, carbon fibers, aramid fibers, metal fibers, alumina fibers, boron fibers, silicon carbide fibers, silica fibers, etc. Theory of reinforcement, property dependence on resin and reinforcement, directional properties. Laminated composites- Lamina & Laminate lay-up, ply-orientation definition. Strength of laminates, laminate stiffness and ABD Matrices, special classification of laminates, symmetric, antisymmetric and non-symmetric laminates.

Unit III

Testing of Composites: Mechanical testing of composites, tensile testing, compressive testing, intra laminar shear testing, inter laminar shear testing, fracture testing etc. Joining of composites: Adhesively bonded joints & mechanically fastened joints, environmental effects on composites.

Composite characterization by mechanical, thermal and DMTA techniques. Failure mechanics of composites.

Unit IV

Propellant binders: Classification of propellants- solid, liquid, hybrid and air breathing. Solid propellants – homogenous smokeless propellants, Heterogeneous (composite) propellants. High energy binders- synthesis, characteristics, applications. Glycidyl azide polymer and its homologues, polynitrato methyl methyl oxetane, poly glycidyl nitrates.

References

1. High Performance Thermosets, Chemistry, Properties and Applications, S.C Lin, E.M. Pearce, Hanser Publictions, 1994

2. Engineered Materials Handbook vol 3 Adhesives and sealants, Vol.3, C.A. Dostal etal, ASM International, 1990

3. Composites manufacturing; materials, product and process engineering, S.K. Mazundar, CRC press, Boca Raton 2002.

4. Polymer composite-from nano-to macro-scale, K. Friedrich etal, Springer, NY 2005

5. Chemistry and Technology of Explosives, Vol.2, Vol.3 and Vol.4, T. Urbanski, Pergamon Press, New York, 1984.

6. Propellants manufacture, Hazards and Testing, Boyars C and Klager K., Advances in Chemistry Series, American Chemical society, Vol.88, Washington D.C., 1969.

POL 3206 POLYMERS FOR ELECTRICAL & ELECTRONICS APPLICATIONS

Unit I

Organic semiconductors – phthalocyanines, microcyanine, (SN)x, chlorophyll. Difference between inorganic semiconductors and organic semiconductors.

Conjugated polymers- Historical development, basic structural characteristics of conjugated polymers. Important properties of conjugated polymers- electrical conductivity, photoconductivity, charge storage capacity, photoluminescence, and electroluminescence.

Applications of conducting polymers- electro active applications-polymer rechargeable batteries, sensors, electrochemical actuators, electro luminescent applications. Conductivity applications: antistatic coatings, conducting adhesives, artificial nerves. Electronic applications: EMI shielding, frequency selective surfaces, satellite communication links etc.

Unit II

Electrically conducting polymers- Chain growth polymerisation, step growth polymerization, electrochemical polymerization, Metathesis polymerization [Ring opening metathesis polymer (ROMP)]. Advantages and disadvantages of conducting polymers, methods to enhance the processability of conducting polymers.

Unit III

Synthesis and properties of conducting polymers-polyacetylene, poly p-phenylene, polyheterocyclic and polyaromatic conducting polymers like polythiophene, poly vinyl carbazole, polypyrene, polyaniline, polypyrrole, poly phenylene vinylene, polypyridine.

Unit IV

Valance band theory- basic concepts of band model, band model of conductor, semiconductor and insulator. Carrier mobility, intrachain conductivity, interchain conductivity.

Concept of doping- Charge carriers: polarons, bipolarons and solitons. Types of dopants, oxidative dopants and reductive dopants, mechanism of doping, p-type doping and n-type doping, inorganic and organic dopants, effect of doping on the dielectric properties of conducting polymers

Dielectric properties of conducting polymers in the high and very high frequency fields (a.c field), ultra high frequency field (Microwave field). Dielectric constant, dielectric loss and absorption property of conducting polymers in the a.c and microwave fields.

References

1. Hand book of conducting polymers, T.A. Skotheim, R.L. Elsenbaumer, J.R. Reynolds, 2ed. Marcel Dekker, New york, vol.1-2., (1998).
2. Organic conductive molecules and polymers, H.S. Nalwa, John wiley and sons; vol. 2, England (1977).
3. Conjugated polymers, J. L. Bredas, R. Silbey, Kluwer, Dordrecht, (1991).
4. Encyclopaedia of Polymer science and Engineering, second edition, Vol.5, Mark Bikales over Berger Menges John Wiley and Sons Inc., (1986).
5. Electroactive polymers, M.E.O.Lyons, Ed;Plenum Press; New York, PP 1-65, (1994).
6. Conducting Polymers and Plastics, J. Margolis, Chapman and Hal, London 1993.

POL 3206. POLYMER NANOCOMPOSITES

Unit I

Introduction to composite materials – Classification, Introduction to polymer composites – nano, micro and macro scales. Reinforcements – short fibre, long fibre and particulate fillers. Matrices – thermoplastics, thermosets and rubbers. Nano and micro composites. Short and long fibre composites, treatment of reinforcements, polymer-filler interactions, use of coupling and bonding agents.

Unit II

Incorporation of reinforcements in polymer: Solution mixing, latex stage mixing, melt mixing and in-situ polymerization and precipitation. Dispersion and nucleating effects, intercalation and exfoliation. Application of layered and nonlayered nano and micro particles in polymer modification. Preparation of long fibre and short fibre composites. Different methods of preparation of composites.

Unit III

Carbon nanotubes- single walled and multi walled- preparation, treatment and functionalization. Salient features of polymer modification with carbon nanotubes, nano silica and nano clay. Organically modified layered clays. Various methods used for the incorporation of nano fillers in polymer matrix like solution mixing, latex stage mixing and melt mixing.

Unit IV

Characterization and testing of polymers and polymer composites- Thermal, mechanical and electrical properties- tribological characteristics, fracture behavior, creep and fatigue behavior, composite material rheology. Long term effects, applications of composites.

References:

1. Handbook of composites, G. Lubin, Van Nostrand, (1982)
2. Polymer Engineering Composites, M.O.W. Richarson (Applied Science Publishers,1995)

3. SPIE Handbook of Technology and Engineering of Reinforced Plastics/Composites, J. G. Mohr (Van Nostrand,1998)
4. Polymer nanocomposites: Synthesis characterization and modeling, R. Krishnamoorti and R.A. Vaia (Americal Chemical Society, 2002)
5. Polymer Clay Nanocomposites, Pinnavaia T.J. and Beall G.W. (John Wiley 2000)

POL 3207 - POLYMER TECHNOLOGY (LAB) II

1. Compounding and moulding of rubbers: Compounding and moulding of NR, SBR, CR, NBR and BR as per ASTM standards.
2. Estimations of:
   a) Iodine value of NR
   b) Acrylonitrile content of NBR
   c) Chlorine content of CR
3. Estimation of:
   a) Percentage purity of MBT, ZnO, Sulphur and PPD
   b) Iodine number of carbon black.
4. Specification tests for latex and dry rubber.
5. Preparation of dry rubber products: play ball, Hawai sheet, M.C sheets, chappel straps, sponge, hand-made hose, rubber-to-metal bonded articles.
6. Preparation of latex based rubber products - household and surgeons gloves, latex foams, latex thread, latex casted articles and latex based adhesives.
7. Determination of physical and mechanical properties of rubber vulcanizate: TS, modulus, EB, tear strength, abrasion resistance, resilience, heat build up, flex resistance and ageing resistance.

References:

1. ASTM 9.01 and 9.02
2. BIS 3400
3. High polymer Latices, D.C. Blackly, Vol. II.

POL 3301 & POL 3401 - PROJECT WORK, REPORT AND VIVA VOCE

Each student will have to undertake a research project for a period of 1 year either in a leading Industry/research Institution or in the Department. The research work will be guided by one supervisor from the respective industry /Institution and one supervisor from the Department .The student will have to submit an interim report (2 copies) at the end of third semester and make a presentation in the Department. The student will have to pursue the study and submit the final thesis (2 copies) at the end of the fourth semester. The final evaluation will be made based on the thesis, the presentation and the viva voce.