M.TECH POLYMER TECHNOLOGY						
Sl. No.	Sem	Name of the Subject	Core/ Elective	L	P	C
1	POL 6101	Advanced Polymer Science	C	3	0	3
2	POL 6102	Applied Mathematics	C	3	0	3
3	POL 6103	Operational Management & Management Information systems	C	2	0	2
4	POL 6104	Polymer Materials	C	2	0	2
5	POL 6105	Rubber Processing & Product Manufacture	C	2	0	2
6	POL 6106	Polymers for Bio medical applications /Polymers for Packaging/Speciality Polymers / Chemical Engineering /Material Science	E	3	0	3
7	POL 6107	Polymer Technology	C	0	2	2
8	POL 6108	Review Seminar	C	0	1	1
		Total Credit				18
1	POL 6201	Plastics Processing	C	3	0	3
2	POL 6202	Advanced Polymer Rheology	C	3	0	3
3	POL 6203	Polymer product design	C	3	0	3
4	POL 6204	Characterization and Testing	C	3	0	3
5	POL 6205	Die Mould and Design	C	2	0	2
6	POL 6206	Tyre Technology/ Polymers in Space Applications/ Polymers in Electrical and Electronics Applications/ Polymer nano composites	E	3	0	3
7	POL 6207	Polymer Technology II	C	0	1	1
		Total Credit				18
1	POL 6301	Project Work Report and Viva Voce	0	0	18	18
2	POL-6401	Project Work Report and Viva Voce	0	0	18	18

SYLLABUS FOR M TECH COURSE IN POLYMER TECHNOLOGY

(2008 Admissions)

POL 6101 ADVANCED POLYMER SCIENCE

Unit I

Different types of polymerisations like addition, condensation and ste- reoregular polymerisation. Initiators used, important steps involved, kinetics and mechanism of addition, condensation and stereoregular polymerisations. Copolymerisation and its kinetics. Important techniques of polymerisation such as emulsion, bulk, solution and suspension.

Unit II

Polymer characterization, molecular weight determination by GPC, vis- cosity, light scattering and Osmometry. Physical methods of polymer analysis such as IR, NMR, X-ray analysis etc. Thermal analysis of poly- mers using DSC, TGA, DTA, DMA etc.

Unit III

Polymer degradation and stabilization: Thermal, oxidative, photochemi- cal 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 polyethers, polyacetals, polyamides, polymers with metal in their back bone, phosphorus and sulphur-containing polymers, polymeric liquid crystals, conducting and photoconducting polymers. Polymer supported solid phase reactions, Merrifield method.

References:

1. A Text Book of Polymer Science, F.W. Billmeyer
2. Encyclopedia of Polymer Science & Engg., Vol.15
3. Handbook of Polymer Synthesis, Part A & B, Hans.R.Kricheldorf (ed)
4. Experimental Methods in Polymer Chemistry, J.F.Rabek
5. Polymer Chemistry, Paul C.Hiemenz.
6. Principle of Polymer Chemistry, P.J.Flory

POL 6102 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, GaussSeidal 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 equa- tions, 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, ho- mogeneous and non-homogeneous linear equations of first order and second order. Applications: Wave equation, one-dimensional heat flow, two dimensional heat flows.

References:

1. Erwin Kreyzig - Advanced Engineering Mathematics, John Wiley, 1993.
2. Grewal. B.S. - Higher Engineering Mathematics
3. Balaguruswamy - Numerical Methods
4. Taha. H.A - Operation Research
5. Kantiswarup - Operation Research
6. George F. Simmons - Differential Equations
7. Jan Suelddan - Elements of Partial Differential Equations
8. R.K.Jain - Numerical Method
9. Differential equation, David Lomon/James Merk, Prentice Hall, 1988.

POL 6103- OPERATIONS MANAGEMENTS, MANAGEMENT INFORMATION SYSTEMS

Unit I

Organisation and Personnel Management concept of organisation, organisational structure, organisation charts, types of organisation, author- ity and responsibility, span of control, delegation of authority, type of own- ership.

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 pro- motion, 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 ap- proaches, product line determination, decision making, need for manage- ment 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 sys- tems, computer application in finance accounting, booking and other op- erations, 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 : Koopez & Konnel
2. Financial Management : Prasanna Chandran, Tata McGraw Hill
3. First step in book keeping : T.P.Batliboi
4. Industrial organisation and Management : P.P.Khanna
5. Industrial organization and Management : Bethel et al, Mc Greev Hill
6. Management Information systems : Gordan B Devis, Margrethe II Otson, Mc Greeve Hill

POL 6104 - POLYMER MATERIALS

Unit I

General Introduction to individual polymers:

Manufacture, structure, properties and applications of styrenebutadiene rubber, polyisoprene rubber, comparative evaluation of these different unsaturated rubbers, comparison of polyisoprene rubber with natural rubber with respect to structure, properties and applications. Acryloni- trile 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, fluorocar- bons, ethylene vinyl acetate copolymers etc. Manufacture, properties and applications of different thermoplastic elastomers.

Unit III

Preparation, general properties and end use of polyolefins viz. Polyeth- ylenes, PVC, polyvinyledene chloride, PTFE, PP, polystyrene, olefin copolymers viz. Copolymers of acrylonitrile, styrene, butadiene and vi- nyl chloride and their terpolyrners. Polyacrylics, polyvinyl acetate and polyvinyl alcohol.

Unit IV

Preparation, properties and uses of Polyamides like Nylon 6 and Nylon
66, aromatic polyamides like Kevlar. Polyimides-their structure, prepa- ration and uses. Silicone resins and fluids. Important polyesters in com- mercial application. 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 differ- ent PF, UF and MF resins, their structure properties and applications, moul- ding powders from these resins. Study of preparation, structure and curing of epoxide resins. Their important applications and advantages over other adhesives.

References:

1. Rubber Technology - Maurice Morton
2. Rubber Technology and Manufacture - Blow C.M.
3. Plastics Materials - H.A Brydson
4 Synthetic Rubber - Whitby G.S.
5. Introduction to Industrial polymers - Henri Ulrich
6. Man made fibres – Moncriff

POL 6105 - RUBBER PROCESSING AND PRODUCT MANUFACTURE

Unit I

Processing of field latex into various forms like (a) preserved field latex (b) latex concentrate by-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 rotor cure, 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 articles, latex thread etc.

References:

1. Natural Rubber Handbook - R.R.I.I Kottayam
2. Rubber Technology and Manufacture - C.M.Blow
3. High Polymer Latices -D.C.Blackley, Vols.III
4. Polymer Processing - Mortin Jones.
5. Rubber Technology Hand Book - Hofmann
6. Rubber Processing - Freakly
7. Applied Science of Rubber - W.J.

POL 6106 A - 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, polyglocolic 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 6106 B - POLYMERS FOR PACKAGING

Unit I

Major polymers used for packaging, Evaluation of the following polymers for packaging application polyethylene , EVA, EAA, lonomers, HDPE, LLDPE, Metallocene polymer, PP,PVC, PVDC, PS, PVOH, EVOH, nylon, polyester, polycarbonate, fluoropolymers, ABS, acrylonitrile copolymers, thermoplastic elastomer, cellophane and cellulose plastics, polymer blends.

Unit II

Adhesives, heat sealing types, sealing method, Extrusion Blown film and cast film and sheet co extrusion, surface treatment testing and evaluation of films, flexible packaging, pouches, bulk and heavy duty bags, thermoforming, thin sheet thermoforming, Blow moulding, extrusion and injection blow moulding, foams, cushioning and distribution packaging.

Unit III

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

Asceptic packaging of foods, Sterilization of packaging materials, Packaging of microwavable foods, Active and intelligent packaging, Modifies atmospheric packaging, Packaging of fresh foods, Packaging of horticultural products. Packaging of dairy products, Packaging of cereal, 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.

References:

1. Food Packaging – Gordon.L Robertson, Taylor and Francis (2006)
2. Plastics packaging RJ Hernandez /Susan EM Selhe John D Caller , Hauer Publishers

POL 6106 C – 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 polypyrole, 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- ex- change, 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, polyelectro- lyte 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 App ied Science Publishers (1985)

POL 6106 D - 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 Poiseuillie 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, radiation heat transfer, 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 Maltson, John Wileyl & Sons (1978)
3. Unit operations of Chemical Engineering, W.L.Mc-Cabe & J.C.Smith, Mc-Graw Hill (1983)
4. Chemical Engineering, J.M.Coulson and J.M.Richardson, Pergamon press (1979) relevant volumes.

POL 6106 E - MATERIAL SCIENCE

Unit I

Crystal symmetry: Crystal systems, crystal planes, X-ray and neutron diffraction from crystals - strucionic, 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.Haja Choudhury (India Book Dis- tributing Company)
1. A first course in materials science - V.Raghavanture determination. Bonding in crystals
3. Materials Science - I.C.Anderson & K.D.Leaver
4. Introduction to solid state Physics - C.Kittel
5. Introduced materials science - M.J.Starfird & A.M.Sharanger

POL 6107 - 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. K.J.Saunders, The Identification of Plastics and Rubbers - Chapman and Hall
2. Rabek : Experimental Methods in Polymer Chemistry
3. Analysis of Rubber like Materials - D.C.Blackely

POL 6201 PLASTICS PROCESSING

Unit I

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

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 Crawford, C.J.Pergamon Press.
2. Plastics Engineering Handbook - Edited by Joel Fradis, Vail Nostrand Reinhold Company.
3. Polymer Processing - D.H.Morton Jones, Chapman and Hall.
4. Polymer mixing Technology - George Mathews, Applied Science Publishers.

POL 6202 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, pseudo plastic, 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, Rabinowitch 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. Crowford.R. - Plastic Engineering, Pergamon
2. Brydson, JA. - Flow properties of polymer melts-Godwin
3. Cogswell, F.N. - Polymer melt rheology-Godwin

POL 6203 - POLYMER PRODUCTS DESIGN

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

Dynamic load response of polymers, effects of cyclic loading, other forms of stress applied to polymer parts, design for stiffness, processing limitations on polymer product design. Material and process interaction and the effects on the performance of plastic parts and the resulting design limitations, performance in service and environmental exposure.

Unit III

Design procedure for plastic parts, design of plastic structural parts for static loads, design of dynamically loaded plastic parts, design of plastic parts for electrical applications, design of plastic parts for optical applications.

Unit IV

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 V

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.

References:

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

POL 6204 – CHARACTERISATION AND TESTING

Unit I

Introduction to testing of polymers and polymer products, standards organisations in the field like BIS, ASTM, BS, DIN, ISO etc. Prepara- tion 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, 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. Measurements 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, footwear and cables and wires.

References:

1. Hand Book of Plastic Test Methods, R.P.Brown.
2. Physical Testing of Rubbers, R.P.Brown.
3. ASTM, BS, BIS, ISO and DIN Standards.
4. Hand Book of Plastic Test Methods. Iver, Mead and Riley.
5. Highpolymer Latices Vol I&II. D.C. Blackley
6. Hand Book of Plastic Testing Technology, Vishu Shah

POL 6205 - INTRODUCTION TO MOULD AND DIE DESIGN

Unit I

Introduction: Common machine tools and processes employed for mould making, materials for mould making, CAD/CAM

Unit II

Injection Moulds, general mould construction, cavities and cores, bol- sters, ancilliary items, ejection techniques.

Unit III

Feed System, runners, gates, venting, mould cooling, three plate moulds.

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, features, introduction to moulds for transfer moulding, rotational moulding, reaction processing, blow moulding.

References:

1. Injection Mould Design, R.C.W. Pyre, George Godwin
2. Extrusion of Plastics, E.G. Fisher, Newnes Butter worths.
3. Plastic Mould Engineering Handbook, J.Harry Don Bois and Wayne
4. . Pribbh, Van Nostrand Reinhold Company.

POL 6206 A - TYRE TECHNOLOGY

Unit I

A historical introduction on the design and development of tyres of various kinds and type the current status of tyre industry in India and its future prospects, tyre sizing and marking on the tyres, different types of tyres bias-belted tyre, tube 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, 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 and failure mechanism of cord reinforced rubber. Mechanics of tyre pavement interaction. Tyre forces on dry and wet road surface. 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 affect- ing friction and sliding. Tyre stresses and deformation, tyre noise, mechanism of noise generation, effect of tread pattern, vehicle speed etc. on

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 tubeless 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, their 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, trac- tion, 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, 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', Adam Higher, New York.
3. Tyre Mechanics & Testing (Sponsored Course, Feb. '83) Roorke....
4. Mechanics of Pneumatic Tyres, Samuel C Lark, US Department of Transportation Washington.

. (a) Year Book, (b) Engineering Design Informations, The Tyre & Rim Association.

6. Tyre, Valve & Rim data, ITTAC, New York.
7. LJK Setright. "Automobile Tyres". Chapman & Hall, London.
8. Tyre Technology, F.J.Kovac, GOODYEAR Tyre and Rubber Com- pany, USA.

POL 6206 B - 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 containing 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 depending 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, anti-symmetric 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- solids, liquids, hybrid, 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 glycol nitrates.

References:

1. S-C Lin, E.M. Pearce, High Performance Thermosets, Chemistry, Properties and Applications, Hanser Publictions NewYork, 1993
2. C. A. Dostal etal. Engineered Materials Handbook vol 3 Adhesives and sealants, 1990.
3. S.K. Mazundar Composites manufacturing materials, product and process engineering CRC press, Boca Ratun 2002
4. K. Friedrich Polymer composite, from nano to macro scale, Springer, NY 2005
5. Urbensky, Chemistry and Technology of Explosives, Vol.2, Vol.3 and Vol.4, Pergamon Press, New York, 1985.
6. Boyars.C and Klager. K., Propellants manufacture, Hazards and Testing, Advances in Chemistry Series, American Chemical society, Vol.88, Washington D.C., 1969.

POL 6206 C - POLYMERS FOR ELECTRICAL & ELECTRONICS APPLICATIONS

Unit I

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

π conjugated polymers - Historical development,Basic structural characteristics of π conjugated polymers. Important properties of π 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.

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

Unit V

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. T.A. Skotheim, R.L. Elsenbaumer, J.R. Reynolds, *Hand book of conducting polymers*, 2ed. Marcel Dekker, New york, vol.**1-2**. , (1998).
2. H.S. Naiwa, *organic conductive molecules and polymers*, John wiley and sons; vol. **2**, England (1977).
3. J. L. Bredas, R. Silbey, *conjugated polymers*, 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. M.E.O.Lyons, *Electroactive polymers*, Ed;Plenum Press; New York, PP 1-65, (1994).
6. J. Margolis, *Conducting Polymers and Plastics*, Chapman and Hal, London 1993.

POL 6206 D- 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 behaviour- Creep and Fatigue behaviour- Composite material rheology. Long term effects- Applications of composites.

References

1. G. Lubin - Handbook of composites – (Van Nostrand, 1982)
2. M.O.W. Richarson - Polymer Engineering Composites – (Applied Science Publishers,1995)
3. J. G. Mohr - SPIE Handbook of Technology and Engineering of Reinforced Plastics/Composites – (Van Nostrand,1998)
4. R. Krishnamoorti and R.A. Vaia – Polymer nanocomposites: Synthesis characterization and modeling (Americal Chemical Society, 2002)
5. Pinnavaia T.J. and Beall G.W. – Polymer –clay Nanocomposites (John Wiley 2000)

POL 6207 - POLYMER TECHNOLOGY (LAB) II

1. Compounding and molding of Rubbers: Compounding and mould- ing of NR, SBR, CR, NBR and BR as per ASTM standards.

2. Estimation of Polymers:
   a) Iodine value of NR
   b) Acrylonitrile content of NBR
   c) Chlorine content of CR

3. Estimation of compounding ingredients:
   a) Percentage purity of MBT, ZnO, Sulphur, anit-oxidant 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 etc.

6. Preparation of latex based rubber products - household and surgeons gloves, latex foams. Latex thread, latex casted articles, latex based adhesives etc.

7. Determination of physical and mechanical properties of rubber vulcanizate: TS, modulus, EB, tear strength. Abrasion resistance, resilience, heat build up, flex resistance, ageing resistance etc

References:

1. ASTM 9.01 and 9.02

2. BIS 3400

3. High polymer Latices, D.C. Blackly, Vol. II.

POL 6301 & POL 6401 - 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 for the department. The student will have to submit an interim report (2 Nos) 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 Nos) at the end of the fourth semester. The final evaluation will be made based on the presentation and viva voce.