B.S.ABDUR RAHMAN UNIVERSITY

DEPARTMENT OF POLYMER TECHNOLOGY

CURRICULUM & SYLLABI

For

M.TECH POLYMER SCIENCE AND ENGINEERING

DURATION OF THE PROGRAMME :2 YEAR (4 SEMESTER)

ELIGIBILITY CRITERIA : The candidate should possess B.E/B.Tech degree in Mechanical / Chemical / Production / Polymer science & Engineering/Polymer Technology / Rubber Technology or M.Sc. Polymer Science / Chemistry / Applied Chemistry /Material Science

CURRICULUM

SEMESTER - I

Course Code	Course Title	L	T	P	Credits	
PT606	Compounding Technology	3	0	0	3	
PT607	Polymer Processing Technology	3	0	0	3	
PT608	Mould and Product Design	3	1	0	4	
PT609	Polymer Testing & Characterization	3	0	0	3	
	Elective –II	3	0	0	3	
	Elective –III	3	0	0	3	
Practical II						
PT610	Polymer Processing, testing & product Design lab	0	0	6	2	21

SEMESTER - II

Course Code	Course Title	L	T	P	Credits	
MA	Applied Mathematics	3	1	0	4	
PT601	Applied Materials Engineering	3	0	0	3	
PT602	Polymer Science	3	0	0	3	
PT603	Polymer Materials Manufacturing	3	0	0	3	
PT604	Polymer Rheology	3	0	0	3	
	Elective IV	3	0	0	3	
Practical I						
PT605	Polymer Synthesis and Characterization Lab	0	0	6	2	21

SEMESTER -III

Course Code	Course Title	L	T	P	Credits	
PT701	**Rubber Technology**	**3**	**0**	**0**	**3**	
PT702	**Polymer Composite Technology**	**3**	**0**	**0**	**3**	
	Elective –IV	**3**	**0**	**0**	**3**	
PT 703	**Project work phase I**				*****	**9**

SEMESTER – IV

Course Code	Course Title	Credits	
PT 703	**Project Work (Phase II)**	**24***	**24**

***6 Credits of phase I are added to 18 credits of phase II**

Total credits for the programme: 75

ELECTIVES

Elective – I

PTY001 - Bio Polymers	0	0	0	3
PTY002 - Polymer Reaction Engineering	0	0	0	3
PTY003 - High Performance Polymers	0	0	0	3
PTY004 - Fibre- Technology	0	0	0	3

Elective - II

PTY005 - Polymer Degradation & Stabilization	0	0	0	3
PTY006 - Productivity Engineering and Management	0	0	0	3
PTY007 - Polymer Blends & Alloys	0	0	0	3
PTY008 - Instrumental Methods of Polymer Analysis	0	0	0	3

Elective – III

PTY009 - Adhesives & Surface coatings	0	0	0	3
PTY010 - Polymer Recycling & Waste Management	0	0	0	3
PTY011 – Polymers for Electronics	0	0	0	3
PTY012 - Tyre Technology	0	0	0	3

Elective - IV

PTY013 - Membrane Technology	0	0	0	3
PTY014 - Rapid Prototyping & Tooling	0	0	0	3
PTY015 - Nano Technology	0	0	0	3
PTY 016 - Medical polymers	0	0	0	3

MA APPLIED MATHEMATICS 3 1 0 4

UNIT I TRANSFORM METHODS 12

Laplace transform methods for one dimensional wave equation - Displacements in a string – Longitudinal vibration of an elastic bar - Fourier transform methods for one- dimentional heat conduction problems in infinite and semi-infinite rod.

UNIT II NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS 12

Solution of Laplace's and Poisson equation on a rectangular region by Liebmann's method - Diffusion equation by the explicit and Crank Nicolson - Implicit methods - Stability and Convergence criterion - Solution of wave equation by explicit scheme.

UNIT III FINITE ELEMENTS METHODS 12

One dimensional stress deformation - global and local co-ordinates, one dimentional problems, interpolation functions, relations between global local coordinates, requirements for approximation functions, stress and strain relations principles of minimum potential energy, potential energy approach for assembly.

UNIT IV PROBABILITY AND RANDOM VARIABLES 12

Probability - Random variables - Moments - Moment generating function - Standard distributions - Functions of random variables - Two dimensional R.Vs - Correlation and Regression.

UNIT V ESTIMATION THEORY 12

Principle of least squares - Regression - Multiple and partial correlations - Estimation of Parameters – Maximum likelihood estimates - Method of moments.

L = 45 hrs. T = 15 hrs Total 60 hrs

REFERENCES:

1. Fruend John, E. and Miller, Irwin , " Probability and Statistics for Engineering " , 5th Edition, Prentice Hall, 1994.
2. Jay, L. Devore, " Probability and Statistics for Engineering and Sciences ", Brooks/Cole Publishing Company Monterey, California, 1982.
3. Montgomery D.C and Johnson, L.A.," Forecasting and Time Series ", McGraw-Hill.
4. Anderson, O.D., " Time Series Analysis: Theory and practice ", I. North - Holland, Amsterdam, 1982.
5. Gupta, S.C. and Kapur, V.K." Fundamentals of Mathematical Statistics ", Sultan Chand and Sons, New Delhi, 1999.

TEXT BOOKS

1. Sneddon, I.N., Elements of partial differential equations, McGraw-Hill ,1986.
2. Spiegel , M.R., Theory and problems of complex variables with an introduction to confomal mapping and its applications, Schaum's outline series, McGraw-Hill Book Co., 1987.
3. Sankara Rao, k., Introduction to partial differential equations, Prentice - Hall of India, New Delhi, 1995.
4. Elsgolts, L., Differential equation and calculus of variations, Mir Publishers, Moscow, 1966.

PT601 APPLIED MATERIALS ENGINEERING 3 0 0 3

UNIT I. REVIEW OF ELASTIC AND PLASTIC BEHAVIOUR 9

Elasticity in metals and polymers - Mechanism of plastic deformation, role of dislocations, yield stress, shear strength of perfect and real crystals - Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviors - Super plasticity - Deformation of non crystalline

UNIT II FRACTURE BEHAVIOUR 9

Griffith's theory, stress intensity factor and fracture toughness - Toughening mechanisms - Ductile, brittle transition in steel - High temperature fracture, creep - Larson-Miller parameter - Deformation and fracture mechanism maps - Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law - Effect of surface and metallurgical parameters on fatigue - Fracture of non metallic materials – Failure analysis, sources of failure, procedure of failure analysis.

UNIT III SELECTION OF MATERIALS 9

Motivation for selection, cost basis and service requirements - Selection for mechanical properties, strength, toughness, fatigue and creep - Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

UNIT IV ADVANCED HEAT TREATMENT OF MATERIALS 9

Unconventional surface hardening techniques-Heat treatment of critical mechanical elements like gears, tools, dies, springs, shafts -Heat treatment of Al, Cu, and Ni and Ti alloys-Polymer quenchants.

UNIT V MODERN MATERIALS AND ALLOYS 9

Super alloys-Refractory materials-Ceramics-oxides/non oxides and their applications-Low melting alloys-shape memory alloys nickel–titanium alloys and copper base alloys -matrix and ceramic matrix composites.

L = 45 hrs. Total 45 hrs

REFERENCES:

1. Thomas H.Courtney, "Mechanical Behaviour of Materials ", (2nd Edition), McGraw-Hill,2000.
2. Charles J.A., Crane, F.A.A and Furness, J.A.G., " Selection and use of Engineering Materials ",(3rd Edition), Butterworth-Heiremann, 1977.
3. Flinn, R.A. and Trojan, P.K., "Engineering Materials and their Applications ", (4th Edition),Jaico, 1999.
4. Dieter - " Mechanical Metallurgy (Revised Edition) ", McGraw Hill,1989.
5. Dieter - " Engineering Design,A materials and processing approach(III Edn) ", McGraw Hill, 1999.
6. www.astm.org/labs/pages/131350.htm
7. www.applied materials.com/carrers/agu-ei.html.

PT602 POLYMER SCIENCE 3 0 0 3

UNIT I TYPES OF POLYMERIZATION 9

Functional Monomers – Initiators – catalysts – Inhibitors — Addition polymerization - Free radical and ionic – Coordination Polymerization – Metallocene catalysts – ring opening - group transfer - Metathesis polymerization - copolymerization – random, alternating, graft copolymers - Living polymerization - block copolymers – Condensation polymerization – kinetics of polymerization.

UNIT II POLYMERIZATION TECHNIQUES 9

Bulk polymerization, suspension, solution. Emulsion polymerization – Polymerization conditions – temperature, pressure, initiator concentration, polymerization time – Polymer separation techniques.

UNIT III STRUCTURE AND CONFIGURATION 9

Polymer molecular weight – Molecular weight distribution – Effect on properties – Polymer Chain structures – Chain configurations and conformations – tacticity – geometric isomerism- stereo isomerism – Conformations in biological polymers.

UNIT IV PHYSICAL STATE OF POLYMER 9

Amorphous and crystalline state – characteristics of amorphous polymers – glass transition temperature (T_g) – theories of glass transition - factors influencing T_g - crystalline polymers – crystallinity — crystal structures lamellae and spherulites – Factors influencing crystallizability - Methods of determining crystallinity and crystal structures.

UNIT V POLYMER SOLUTIONS 9

Solubility of polymers – solubility parameters - Polymer solutions - terms and definitions, types of solutions - Hilderbrand theory - Flory Huggins theory - Thermodynamic view of miscibility, upper critical solution temperature (UCST), lower critical solution temperature (LCST) - Concentration regimes in polymer solutions - theta conditions.

L = 45 hrs. Total 45 hrs.

REFERENCES:

1. Paul C. Painter and Michael M. Coleman, Fundamentals of Polymer Science, Technomic Publishing Co. Inc., Lancaster, USA, 1994.
2. Ulf W. Gedde, Polymer Physics, Chapman & Hall, 1995
3. Joel Fried R. Polymer Science and Technology, Printice Hall 1995
4. George Odian, Principles of polymerization, Wiley Interscience, NY, 2004
5. "Encyclopedia of Polymer Science and Technology" 3rd Edition, Vol.1-12, Wiley Interscience , 2003

PT603 POLYMER MATERIALS MANUFACTURING 3 0 0 3

UNIT I MANUFACTURE OF POLYOLEFINES 9

Manufacture, properties and applications - polyethylene, polypropylene, polystyrene polyvinylchloride, polyvinyl alcohol, polyacetal, fluoroplastics.

UNIT II MANUFACTURE OF POLYESTERS 9

Manufacture, properties and applications - polyethyleneterephthalate, polybutylene terephthalate, polycarbonate, polyacrylate, liquid crystalline polyesters.

UNIT III MANUFACTURE OF POLYAMIDES 9

Manufacture,properties and applications-aliphatic polyamides-polyamide thermoplastic Elastomer-aromatic polyamides, polyimides

UNIT IV MANUFACTURE OF THERMOSET POLYMERS 9

Manufacture, properties , curing and applications- phenolics,aminoplastics, epoxy, unsaturated polyester, vinyl ester resins,BMI.

UNIT V MANUFACTURE OF SYTHETIC RUBBERS 9

Manufacture,properties and applications –NR, polybutadiene, styrene-butadiene rubber-nitrile rubber, polyisoprene, polychloroprene, silicone rubber, EPDM rubber, chlorosulfonated polyethylene, acrylic rubbers, polyurethane and fluoroelastomers.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. D.Feldman and A.Barbalata- "Synthetic Polymers-Technology, Properties and Applications" Chapman and Hall,1996
2. Olagoke Olabisis "Handbook of Thermoplastics" -Marcel Dekker,Inc,1997
3. J.M.Martin,W.K.Smith "Handbook of Rubber Technology" Vol.1 CBS Publishers,New Delhi,2004
4. Irvin .I.Rubin, "Handbook of Plastics Materials" John Wiley and Sons Inc, 1990

5. John S.Dic,Annicelli.R.A. "Rubber Technology: Compounding and Testing for Performance" Hanser Gardner Publisication,2001
6. Cornelia Vasile,ed "Handbook of Polyolefins",2nd Edition,Marcel Dekker,2000
7. Gottfried.W.Ehrenstein "Polymeric Materials : Structure-Properties-Applications" Hanser Gardner, 2001

PT 605 POLYMER RHEOLOGY 3 0 0 3

UNIT I INTRODUCTION TO RHEOLOGY 9

Types of mechanical deformations- stress & strains– stress tensor - Elastic materials – Viscous materials – Viscoelasticity – effect of rate of strain, temperature and time on mechanical behaviour of polymeric materials – creep – stress relaxation – Boltzman principle – time temperature super position principle – WLF equation.

UNIT II RHEOLOGICAL MODELS 9

Stress strain response of spring and dashpot – viscoelstic models – Maxwell element – Voigt Kelvin element – response to creep and stress relaxation – four-parameter model – SLM model- non linear viscoelasticity -dynamic mechanical properties – behavior of Maxwell element and relaxation spectra.

UNIT III FLUID FLOW BEHAVIOUR 9

Fluid flow – types of fluid flow – time dependant fluids, shear rate dependant fluids, Newtonian and Non Newtonian fluids – viscosity of polymer melts – shear thinning and shear thickening – zero-shear rate viscosity – laminar flow of Newtonian fluids – power law – general treatment of isothermal viscous flow in tubes – entrance and exit effects - elastic effects in polymer melt flow - die- swell and melt fracture – Weissenberg effect – normal stress difference –elongational viscosity.

UNIT IV RHEOLOGICAL CHARACTERIZATION 9

Measurements of rheological properties – capillary rheometers – melt flow index – cone and plate viscometer – torque rheometers – Mooney viscometer – curemeters – rheo-optical properties of polymers - rheo-optical methods as means of determining stress fields in glassy polymers.

UNIT V RHEOLOGY AND PROCESSING 9

Rheological behaviour of crystalline and amorphous thermoplastics – poly olefins - Nylons – polycarbonates – poly(vinyl chloride) - Applications of rheology to polymer processing – injection moulding – extrusion process – blow moulding – fibre spinning.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. R.J.Crawford, Plastics Engineering, Butterworth-Heinemann, Oxford, 2001.

2. Paul C. Painter and M. Michael Coleman, Fundamentals of Polymer Science, Technomic Publishing Co. Inc., Lancaster, USA 1994.
3. Richard C. Progelhof and James L. Throne, Polymer Engineering Principles, Hanser Publishers, Munnich Vienna New York, 1993
4. J. D. Ferry, Viscoelastic Properties of Polymers, John Wiley & Sons, New York. 1986.
5. J.A.Brydson, Flow Propwerties of Polymer Melts, Illfe Books London, 1978.
6. P.N.Cogswell, Polymer Melt Rheology- A Guide for Industrial Practice, George Godwin (1978)
7. B.R.Gupta, Applied Rheology in Polymer Processing, Asian Books Pvt. Ltd. 2005
8. Schwartz, S., & Goodman, S., Plastics materials and processes, New York: Van Nos Reinhold. (1982).

PT605 POLYMER SYNTHESIS AND CHARACTERIZATION LAB 0 0 6 2

Part I Polymer Synthesis

1. Preparation of polystyrene by bulk polymerization.
2. Preparation of polymethyl methacrylate by solution polymerization.
3. Preparation of polystyrene by suspension polymerization.
4. Preparation of acrylonitrile-styrene copolymer by emulsion polymerization
5. Preparation of polyethylene terephthalate
6. Preparation of unsaturated polyester resin.
7. Preparation of epoxy resin
8. Preparation of phenol-formaldehyde (Novalac) resin.
9. Preparation of phenol-formaldehyde (Resole) resin
10. Preparation of polyurethane resin.

Part II Identification of Polymers

1. Identification of Plastics
2. PE,PS,PMMA,PVC,PET,PBT,PA6,PA66,PC,Phenolics,epoxy.
3. Identification of rubbers
4. IR, IIR, SBR, NBR, EPDM, Silicone, PU elastomers

Part III Characterization

1. Determination of molecular weight by viscometry.
2. Determination of K-value of PVC resin.
3. Determination of epoxy equivalent.
4. Determination of free acid in unsaturated polyester resin.
5. Determination of reactivity ratio of a copolymer.
6. Determination of Melt flow index of thermoplastics.
7. Determination of decomposition temperature by TGA.
8. Determination of melting point and glass transition temperature by DSC.
9. Determination of dry rubber content, alkalinity, mechanical stability of NR latex.
10. Determination of Plasticity Retention Index of NR.

L = 90 hrs Total 90 hrs

REFERENCES:

1. Edward.L.Mc Caffery “Laboratory Preparation for Macromolecular Chemistry” Mc Graw- Hill Book Company ,1970.
2. W.C.Wake , “Analysis of Rubber and Rubber-like polymers” 3 rd Applied Science Publischers ,1983.
3. Billmeyer, Experiments in polymer Science, Jhon Wiley & Sons, NY 1989.

PT606 COMPOUNDING TECHNOLOGY 3 0 0 3

UNIT 1 INTRODUCTION TO COMPOUNDING 9

Compounding of plastics and rubbers – definition – basic concepts – compounding principles of thermoplastics – thermosets – rubbers – Additives for thermoplastics - technical requirements of additives, types, mechanism, limitations and advantages - antioxidants – heat stabilizers – UV stabilizers – lubricants – plasticisers – fillers – processing aids – flame retardants – colorants – anti static and anti slip agents

UNIT II COMPOUNDING OF PLASTICS 9

Compounding of Poly (vinyl chloride) – formulations for rigid and flexible PVC products – design of formulations – compounding of poly olefins – polyethylenes polypropylene, polystyrene – compounding of thermosets - unsaturated polyester resins – epoxy resins – compounding of moulding powders – phenol lformaldehyde – melamine formaldehyde.

UNIT III COMPOUNDING OF RUBBERS 9

Vulcanizing agents - sulphur and peroxides – activators, accelerators, conventional and efficient vulcanization systems – retarders, promoters, antioxidants, antiozonants, processing aids, fillers – non black fillers and carbon blacks – chemical Blowing agents.

UNIT IV COMPOUNDING EQUIPMENTS 9

Single screw extruders – twin-screw extruders – internal and external mixers - High speed fluidized mixer and cooler -Mixing machineries for rubbers – two roll mill – internal batch mixers – continuous mixers –banbury mixer - operations and maintenance of mixing equipment.

UNIT V APPLICATIONS AND FORMULATIONS 9

Compounding formulation for Pipes, flooring, wire and cable compounds – mixing and design of formulations for footwear , hose, seals, O-rings, tyre and inner tubes.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. Richard F.Grossman, The mixing of Rubbers, Chapman & Hall, 1997.
2. Chris Rauwendaal Polymer Mixing, A self-study Guide, Hanser Publisher, ed.1998.
3. David B Todd, Plastic Compounding, Hanser Gardener publication, 1998.
4. Maurice Morton, Ed Rubber technology, Third Edition, Van Nostrand Reinhold,
5. New York, 1987
6. John S.Dic,Annicelli.R.A. “Rubber Technology: Compounding and Testing for

7. Performance" Hanser Gardner Publisication,2001.
8. C.M.Blow and Hepburn, - Rubber Technology and Manufacture, 2nd edition, 1982.

PT607 POLYMER PROCESSING TECHNOLOGY 3 0 0 3

UNIT I INTRODUCTION TO POLYMER PROCESSING 9

Plastics processing techniques – Selection of plastic materials – Selection of additives - General considerations in formulation – Methods of incorporation of additives - Mixing and compounding equipment.

UNIT II INJECTION MOULDING 9

Terminology – Process description- Theory of injection moulding – Design and consideration -moulding cycle —Trouble shooting operations. Types Injection unit & Elements of plasticating process – Classification of screw – Screw design – Process control – Clamping unit – Classification of Machine Hydraulics – Ancillary equipment – Computer operation

UNIT III BLOW MOULDING 9

Terminology – Basis in blow moulding - Process variables – Injection & stretch blow moulding – Single and multi layer. Extrusion blow moulding – Extrusion heads, moulding process controls for blow moulding – Machine, process and product controls. Thermoforming –Thermoforming machinery – Heating of sheet – Heating cycle - Stretching – Concept – Heat balance – Shrinkage –Trimming operations.

UNIT IV EXTRUSION 9

Principle – Types of Extruders – Single screw and twin-screw extruders – Metering – Screw design - process control variables – Types of dies – Die design –Extrusion of Pipes- Extrusion profiles – Extrusion line for cable industry – Blown films – Flat film- Cast film - sheet film – Filament – Fibre extrusion.

UNIT V COMPRESSION MOULDING 9

Types and procedure machinery and equipment moulding of thermoplastics – moulding of thermosets and rubber Automatic compression molding- Transfer moulding advantages – Limitations-Rotational moulding – types of machines moulds – materials – part design.
FRP- Processing – moulding - reaction and resin transfer moulding design review feature and benefits – Finishing and Machining of plastics – Joining and assembling of plastics.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. V. Rosato Kluwer, Injection moulding handbook. - Academic Publishers Boston 2nd edtion 1995.
2. Richard C. Progelhof James. L. Throne, Polymer Engg. Principles, Hanser Publisher Munich 1993.

3. N.P. Charemisinoff & P.N. Chere, Handbook of applied Polymer processing Tech, Marcel Dekker, inc, NY 1996.
4. Herbert Rees, Understanding of Injection moulding Tech., Hanser Pub., Munich 1994

PT 608 MOULD AND PRODUCT DESIGN 3 1 0 4

UNIT 1: POLYMER PRODUCT DESIGN 12

Product design - steps - material selection - aesthetics - undercuts - fits and tolerance - shrinkage - warpage - wall thickness - taper - fillets - sharp corners - ribs and bosses - holes - moulded threads - inserts and fasteners - integral hinges - snap fits - moulded lettering - surface finish - tooling aspects on product design - safety aspects on product design.

UNIT 2: INJECTION MOULD DESIGN 12

Introduction-Methodical approach to mould design -Selection of machines - Number of cavities - lay out of impressions - mould venting - mould alignment - mould clamping - Parting surface -Feed system - Ejection system - Mould temperature control - Calculation of strength of cavities, guide pillars and support blocks.

UNIT 3: TYPES OF INJECTION MOULDS 12

Standard mould systems- two plate mould - multi daylight mould - stack mould - Moulding external undercuts - Splits - sliding splits - angled lift splits - side cores and side cavities - moulding internal undercuts - form pin - split cores- stripping internal undercuts -moulds for threaded components - Runnerless moulds - Nozzle types - hot runner moulds- insulated runner moulds.

UNIT 4: COMPRESSION AND TRANSFER MOULD DESIGN 12

Types of compression moulds - flash mould -landed plunger mould - Loading shoe mould - Positive mould - Semi positive mould -Special mould classifications -sub cavity gang mould - removable plate mould -remoable plunger mould -swing mould -spring box mould - double knock out rod mould - unit mould - clamping pressure- pressure pads - depth of loading chamber - heating systems - types of heaters - calculation of heat requirement and heater capacity -
Types of transfer moulds - pot transfer mould - top & bottom plunger transfer mould - loose plate mould -clamping pressure - transfer pot design - Advantages and disadvantages of compression and transfer moulds.

UNIT 5: BLOW MOULD DESIGN AND EXTRUSION DIE DESIGN 12

Types of blow moulds - extrusion, injection and stretch blow moulds - blow ratio - blow pin and neck ring design - Pinch off design - parting line - clamping force - mould venting - mould cooling
Extrusion die design -process characteristics of polymer melt - die geometry - die head pressure - characteristics of land length to profile thickness - extrudate die swell -

classification of dies - dies for solid sections -dies for hollow profiles - blown film dies - flat film dies - parison dies - wire and cable coating dies.

L = 45 hrs. T=15 hrs. Total 60 hrs.

REFERENCES:

1. Ronald D.Beck, Plastics Product Design, Van Nostrand Reinhold Co – 1985.
2. R.G.W.Pye, Injection Mould Design, 4th Edition, Longman Group UK Ltd., England - 1989.
3. M.V.Joshi, Dies for Plastics Extrusion, Macmillan India Limited, New Delhi –1984.
4. Dubois and Pribbles, Plastics mold engineering hand book, 5th Edition, Chapman and Hall, A division of International Thomson Publishing Inc. New York -1995.
5. P.S.Cracknell and R.W Dyson, Hand Book of Thermoplastics - Injection Mould Design, Chapman & Hall, 1993.
6. Laszlo Sors and Imre Balazs, Design of Plastics Moulds and Dies, Elsevier, Amsterdam - Oxford - Tokyo - NY, 1989.

PT609 POLYMER TESTING & CHARACTERIZATION METHODS 3 0 0 3

UNIT I INTRODUCTION TO TESTING METHODS 9

A brief review on various available for polymers- Viscosity MFI & K-value, Acid value - hydroxyl value - isocynate index - epoxy equivalent - spiral flow test - cup flow test - gel time & peak exothermic temperature , Plasticity – elasticity – PRI - Mooney viscosity, scorch time & cure characteristics ,Mechanical – thermal – rheological – electrical – optical - chemical & permanence properties testing methods.

UNIT II MECHANICAL & PROCESSABILITY TESTING 9

Introduction – Hardness - stress – strain properties and testing. concepts of compression, shear & flexural stress – strain. Tear & impact testing. General comments on short term stress - strain properties - Static & dynamic property behaviour - creep – stress relaxation – Fatigue testing. Introduction to viscoelastic properties of polymers – conventional viscometers – capillary rheometer – Applications of capillary rheometer to processing predictions – principle of Torque rheometry. The oscillating disc rheometer.

UNIT III FLAMMABILITY & NON DESTRUCTION TESTING 9

Concept of flame & retardancy. Flammability test for non rigid & self-supporting plastics – Ignition properties - oxygen index test – surface burning characteristics of materials - Flammability of cellular plastics - smoke generation tests - UL – 94 Flammability testing – Meeting flammability requirements - Non destructive testing to polymers - Theory of ultrasonic testing -Pulse – echo technique - Transmission technique - Resonance technique - Application of ultrasonic NDT in plastics – Gammback scatter – Betta transmission – scanning laser - X-ray fluorescence – Hall effect

UNIT IV MOLECULAR CHARACTERIZATION, THERMAL ANALYSIS AND VIBRATIONAL SPECTROSCOPY 9

Characteristics of Molecular weight and molecular weight distribution – Determination of Number Average Molecular weight – Determination of Molecular size – Characterization of molecular weight distribution.-thermal analysis of polymers – Thermal behaviour properties – Measurement technique, instrumentation, Interpretation and analysis of DTA – DSC - TGA –TMA –DMA (DMTA) Dielectric thermal analysis & thermal conductivity measurement, Infra red and Raman spectroscopy – Experimental techniques – Instrumentation – Interpretation and analysis of data – Application to polymers – Recent developments - A brief on UV – visible spectroscopy.

UNIT V NMR, GC-MASS, X-RAY AND POLYMER MICROSCOPY 9

Principles of magnetic resonance – Experimental techniques – Instrumentation – Interpretation – of NMR spectra and analysis – Applications of NMR to polymers – NMR polymers in the solid state- GC & Mass spectrometer-Usefulness of GC & Mass combination – Experimental setup – Instrumentation – operational details - interpretation of data and output analysis – Application to polymers - X-ray diffraction – Instrumentation – Experimental technique – X-ray absorption – Application to polymers -Introduction to light microscopy – Refractive index – Birefringerence- interpretation & analysis of data - Introduction to electron microscopy – Scanning Electron microscopy & Transmission Electron Microscope – principle – Instrumentation – Layout of SEM / TEM – Resolution limitation – Design and operation – operating conditions and procedure – observation of polymers – Examples of SEM / TEM application with polymers.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. Handbook of plastics testing technology – Vishu Shah, John Wiley and sons, New York(1998)
2. Handbook of polymer testing edited by Roger Brown, Marcel Dekker, Inc. New York(1999)
3. Product Design and Testing of Polymeric materials, Nicholas p chermisonoff, Marcel Dekker, inc. New York(1990).
4. Rubber Technology handbook, Haffman, Hanser publisher, Munich(1996)
5. Physical Testing of Rubber, Roger Brown Interscience, New york (1996).
6. Polymer characterization D Campbell & JR white, Chapman & Hall, London (1989)
7. Polymer characterization, Hunt & James, Chapman & Hal, London(1993)

PT610 POLYMER PROCESSING AND TESTING LAB 0 0 6 2

1.(a) Injection moulding of thermoplastic test specimen using various processing parameters

(b) Testing moulded test specimen for mechanical, thermal and electrical properties after conditioning. Interpretation and analysis of test results.

2.(a) Compression moulding of rubber test specimen under various moulding conditions and recepies.

(b) Testing the moulded test specimen after conditioning for evaluation and analysis of mechanical and electrical properties.

3.(a) Compression moulding / casting of thermoset specimen using various fabricating conditions & formulations.

(b) Testing the moulded specimen for evaluating and analyzing mechanical, rheological and electrical properties

4.(a) Moulding of FRP sheets and preparing specimen using different gel time resins or formulations

(b) Testing the moulded specimen for mechanical and electrical properties.

5. Producing filament wounded products and evaluating their properties

6. Extruding thermoplastics with varied quantities of additives / fillers, moulding the specimen and evaluating selected properties.

7. Blow moulding polyethylene to obtain good quality products by optimizing its moulding parameters.

8. Thermoforming HIPS sheets by optimizing its processing parameters to get good quality product.

REFERENCES:

1. ASTM – 8.01, 8.04, 9.02.
2. ISO Handbook. on Plastics

PT701 PRODUCTIVITY & REENGINEERING 3 0 0 3

UNIT I INTRODUCTION 5

Productivity concepts - Macro and Micro factors of productivity, Productivity benefit model, productivity cycle.

UNIT II PRODUCTIVITY MODELS 12

Productivity measurement at International, National and Organisational level, Total productivity models.Productivity management in manufacturing and service sector. Productivity evaluation models, Productivity improvement models and techniques.

UNIT III ORGANISATIONAL TRANSFORMATION 8

Principles of organisational transformation and re-engineering, fundamentals of process reengineering, preparing the workforce for transformation and reengineering, methodology, guidelines, DSMCQ and PMP model.

UNIT IV RE-ENGINEERING PROCESS IMPROVEMENT MODELS 10

PMI models, Edosomwan model, Moen and Nolan strategy for process improvement, LMICIP model, NPRDC model.

UNIT V RE-ENGINEERING TOOLS AND IMPLEMENTATION 10

Analytical and process tools and techniques - Information and communication technology - Enabling role of IT, RE-opportunities, process redesign - cases. Software methods in BPR - specification of BP, case study - Order, processing, user interfaces, maintainability and reusability.

L= 45 Hrs Total 45 Hrs.

REFERENCES:

1. Sumanth, D.J., " Productivity engineering and management ", TMH, New Delhi, 1990.
2. Edosomwan, J.A., " Organisational transformation and process re-engineering ",
British Library cataloging in pub. data, 1996.
3. Rastogi, P.N. " Re-Engineering and Re-inventing the enterprise ", Wheeler pub. New Delhi, 1995.
4. Premvrat, Sardana, G.D. and Sahay, B.S, " Productivity Management - A systems approach ",
Narosa Pub. New Delhi, 1998.

PT702 POLYMER COMPOSITE TECHNOLOGY 3 0 0 3

UNIT – I INTRODUCTION 9

Need for the composite materials, Matrices for composites – thermoplastics and thermosetting resins; Types of reinforcements – fibers – natural and synthetic fibers classification - Glass, carbon and aramid ; Commonly used additives and fillers ; applications of composites – automotive, aerospace , marine, construction , electrical

UNIT – II PROCESSING OF COMPOSITES 9

Important processes like hand lay up, spray up, resin transfer molding , vacuum bag and pressure bag molding, centrifugal casting , pultrusion, filament winding – Moulding compounds DMC , SMC,TMC – Nano technology – POSS (Polyhedral Oligomeric silsesquioxanes) technology

UNIT – III MECHANICS OF PERFORMANCE **9**

Basic concepts – Hooke's law for orthotropic and anisotropic materials - Characteristics of fibre- reinforced laminates- interlaminar stresses – static mechanical properties – fatigue and impact properties – environmental effects – fracture behaviour and damage tolerance

UNIT – IV ANALYSIS OF LAMINATED COMPOSITES **9**

Governing equations for anisotropic and orthotropic plates ; Angle ply and cross ply laminates ; Stress analysis of laminated composite beams, plates , shells ; static. Dynamic and stability analysis for simpler cases of composite plates ; FEM and introduction to composite analysis using software

UNIT – V REPAIR OF COMPOSITES **9**

Failure predictions - Joining and repair - evolution of design of joints – mechanical fastening- adhesively bonded joints – advanced designs for joints – welding – repair of composites

L = 45 hrs. Total 45hrs.

REFERENCES :

1. Mallick P.K. "Fiber reinforced composites : Materials ,manufacturing and design" Marcel Dekker Inc 1993
2. Encyclopedia of Polymer Science and Technology 3rd Edition, Vol. 2, Wiley Interscience , 2003
3. T.G.Gutowski "Advanced composites Manufacturing" , John Wiley & Sons, NY, 1997
4. Hatsuo Ishida , "Controlled interfaces in composite materials" Elsevier Science Publishing Co, Inc 1990
5. Halpin J.C "Primer on composite materials, Analysis" Technomic Publishing Co 1984
6. Agarwal B.D and Broutman L.J "Analysis and performance of fibre composites" John Wiley and Sons , New York 1990
7. Mallick P.K and Newman S, "Composite materials technology: Processing and properties" Hansen Publisher, Munich, 1990.
8. C.A.Happer "Handbook of plastics, elastomers, composites", McGraw Hill , Ny, 1996
9. G.Lubin "Handbook on fibre glass and advanced plastic composites" Van Nostrand Co, NY 1989

ELECTIVES

ELECTIVE – I

PTY001 BIO POLYMERS 3 0 0 3

UNIT I CHEMISTRY AND BIOCHEMISTRY OF POLYMER DEGRADATION 9

-Introduction, enzymes – enzyme nomenclature – enzyme specificity – physical factors affecting the activity of enzymes – enzyme mechanism, Chemical degradation initiates biodegradation, Hydrolysis of synthetic biodegradable polymers.

UNIT II PARTICULATE STARCH BASED PRODUCTS 9

Development of Technology, Current objectives, relative starch technology, Manufacture of master batch, Conversion technology – processing precautions – moisture and temperature – rheological considerations, cyclic conversion process, physical properties of products – sample preparation – physical testing methods – test results, Quality control testing of degradation – auto oxidation measurement – biodegradation assessment – soil burial test.

UNIT III BIOPOLYESTERS 9

Introduction, History, biosynthesis, Isolation – solvent extraction - sodium hypo chloride digestion, enzymatic digestion, Properties – crystal structure – nascent morphology, degradation - Intracellular biodegradation - extra cellular biodegradation – thermal degradation – hydrolytic degradation – environmental degradation – effects of recycling, applications, economics, future prospects.

UNIT IV RECYCLING TECHNOLOGY FOR BIODEGRADABLE PLASTICS 9

Introduction, conventional recycling – economic incentive – recycling problems, degradable complicate recycling – polyethylene/starch film, reprocessing polyethylene/corn starch film scrap – learning to reprocess PE/S - Calcium oxide moisture scavenger – temperature control – accounting for pro-oxidant – handling PE/S repro – economics of in-plant recycling, Using PE/S repro – comparative study of PE/S repro on film properties, recycling other degradables.

UNIT V TEST METHODS & STANDARDS FOR BIODEGRADABLE PLASTICS 9

Introduction, defining biodegradability, criteria used in the evaluation of biodegradable polymers, tiered systems for evaluating biodegradability, choice of environment, choosing the most appropriate methodology, description of current test methods – screening test for ready biodegradability, tests for inherent biodegradability, tests for simulation studies, other methods for assessing biodegradability – petri dish screen – environmental chamber method – soil burial tests, Test method developments for the future.

L = 45 hrs. Total =45 hrs.

REFERENCES:

1. G.J.L Griffin Blackie(ed.), Chemistry & Technology of biodegradable polymers Academic & Professional London 1994.

2. Yoshiharu Doi , Kazuhiko Fukuda(ed.) Biodegradable plastics & Polymers Elsevier 1994
3. Abraham J.Donb & others(ed.) Handbook of Biodegradable polymers
4. Harvard academic publishers Australia 1997.

PTY002 POLYMER REACTION ENGINEERING 3 0 0 3

UNIT – I INTRODUCTION TO CHEMICAL KINETICS 9

Representation of expression for reaction rate, performance equations for batch and flow reactors, Heat effects in reactors- Catalytic Reactions, Rate controlling steps

UNIT II KINETIC MODELS 9

Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Analysis of non-ideal reactors.

UNIT III KINETICS OF POLYMERIZATION 9

Kinetic analysis of Polymerisation – Molecular weight distribution – Smith and Ewart theory of Emulsion polymerization – Fitch thery for dispersion polymerization - copolymerization – chain growth coplymerisation – graft coplymerisation. – pearl polymerization – solution polymerization

UNIT – IV REACTOR DESIGN 9

Principles of reactor design - analysis of polymerization reactions - Reactor types – Anionic – free radical polymerization – reactor dynamics – reactor selection – Average molecular weight in different reactors.

UNIT – V PROCESS CONTROL AND MODELING 9

Process control of batch polymerization – continuous polymerization – process modeling – step testing – pulse testing – application to polymerization reactors.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. Octave Levenspiel, Chemical Reaction Engineering, Wiley Eastern Ltd.
2. J .M. Smith, Chemical Engineering Kinetics, Mc-Graw Hill, 1975.
3. .H. Scott Fogler, Elements of chemical reaction engineering, PHI, 1992
4. Fundamentals of Polymerscience and Engineering – Anilkumar – Tata McGrawhill
5. Handbook of Polymer Reaction Engineering, wiley publications
6. Control of polymerization reactors , F.Joseph Schork, Pradeep B Deshpande& Kenneth W Leffew

PTY003 HIGH PERFORMANCE POLYMERS 3 0 0 3

UNIT I IONIC POLYMERS 9

Ionic Polymers, synthesis, physical properties and applications, Ion-exchange, Hydrophilicity, lonomers based on polyethylene, elastomeric ionomers. Ionomers based on polystyrene, ionomers based on PTFE, ionomers with polyaromatic backbones, polyelectrolytes for ion exchange, polyelectrolytes based on carboxylates, polymers with integral ions, polyelectrolyte complexes. Biological and inorganic ionic polymers. Polymer supported synthesis, polymer supported catalysts and reagents.

UNIT II CONDUCTING POLYMERS 9

Conducting polymers, polyacetylene, polyparaphenylene polypyrrole, organometallic polymers, photo conducting polymers, polymers in non-linear optics, polymers with piezpelectric Ferroelectric and pyroelectric properties, photoresists for semi conductor fabrication – liquid crystalline polymers.

UNIT III HIGH TEMPERATURE RESISTANT POLYMERS 9

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, polyphenylene sulphide, polysulphones, polyesters, polyamides, polyketones, Heterocyclic polymers.

UNIT IV POLYMERS IN AEROSPACE 9

Polymers used in aerospace – polymer binders for solid propellants, requirements of a polymer to be used as propellant binder, types of polymer binders, their energetics and combustion characteristics, high energy propellant binders, ablative plastics.

UNIT V POLYMERS IN TELECOMMUNICATIONS 9

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

L = 45 hrs. Total 45hrs.

REFERENCES:

1. H.F.Mark, (Ed), Encyclopedia of polymer Science & Engineering, John Wiley & Sons, New York, 1989.
2. Matrin.T.Goosey, Plastics for Electronics, Elsevier, Applied Science, 1985.
3. R.W. Dyson, Specialty Polymers, Chapman & Hall, 2nd edition, 1998.
4. Manas Chanda, Salil.K.Roy, Plastics Technology Hand book, 2nd edition, Marcel Dekker, New York, 1993
5. Sanjay Palsule, Aerospace Polymers and composites, Fundamentals and Aerospace Applications, John Wiley & Sons, NY, 1995**.**
6. G.F.DAlelio, J.A.Parker (Eds), Ablative Plastics, Marcel Dekker, 1971.

PTY004 FIBRE TECHNOLOGY 0 0 3

UNIT I POLYMERIC FIBRE MATERIALS 9

Development of synthetic fibres – commercial synthetic fibres – Raw materials – DMT –TPA – MEG – caprolactum – adipic acid – hexamethylene diamine – acrylo nitrile — types of polymers – criteria for fibre forming polymers – production of polyethylene terephthalate polymer , polyamides (nylon 66 , nylon 6), Polyacrylonitrile, PP

UNIT II FIBRE MANUFACTURING 9

Production of PVC fibres – PVA fibres – Aramid fibres -Melt spinning – Polymer feed – melt spinning equipment – high speed spinning – spin draw processes – cyrstallisation method – melt spinning of PET & PP staple fibres – wet and dry spinning – comparison.
Spin finishes – functions of spin finish – methods of application of spin finish – spin finish for polyester staple fibres – spin finish for texturing process – effect of spin finish on dyeing.

UNIT III POST PROCESSING 9

Stretching or drawing – conditions of drawing – machines for draw warping – texturing – false twist process – draw texturing – other methods – staple fibre production – melt spinning – drawing – heat setting – crimping in fibre line –polyester tops for wool blending – Mass coloration and tow dyeing – polyester – nylon – acrylic – polypropylene – dyeing in loose fibre and yarn forms – of polyester, nylon – acrylic – PP – loose fibre dyeing.

UNIT IV FIBRE TESTING 9

Measurement system in fibres – Direct System – Indirect System – Modified Synthetic fibres – modified polyester, Nylon, PP, analysis – Hydrophilic – Hollow – Low pilling – flame retardant.

UNIT V QUALITY CONTROL MEASURES 9

– testing raw material – testing polymers – testing yarns & fibres – waste utilisation of polyester – nylon 6 – 66 – acrylics – PP ; Energy conservation during polymerization and fibre production – pollution control measures.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. A.A. Vaidya, Production of synthetic fibres, Prentice Hall of India Pvt. Ltd., New Delhi, 1988
2. R.W.Moncrieff , Man made fibres , 6th Ed , Hey wood Books, UK 1975
3. Encyclopedia of Polymer Science and Tech Vol 1-12 John Wiley and Sons 2003

ELECTIVE – II

PTY005 POLYMER DEGRADATION AND STABILIZATION 3 0 0 3

UNIT I INTRODUCTION AND THERMAL DEGRADATION 9

Definition - Modes of Polymer Degradation - Mechanistic Aspects - Single Step Process and Chain Reactions - Auto Oxidation - Random and Specific Site Attack - Thermal Degradation: Introduction - Methods for Evaluation of Heat Resistance (DTA, DSC, TGA, TMA) - Mechanistic Aspects - Heat Resistance Polymers - Ablation –Stabilization – Thermal Degradation and Recycling - Heat Effect in Bio Polymers.

UNIT II MECHANICAL AND ULTRASONIC DEGRADATION 9

Introduction - Mechanistic Aspects - Degradation Studies - Polymer Degradation in Solution. Ultrasonic Degradation - Importance - Experimental Methods - Mechanism of Ultrasonic Degradation (Cavitations and Direct Effects) - Degradation Studies (Detection of Transient Species and Molecular Weight Distribution) Application of Mechanical Degradation: Stress - Induced Chemical Alterations of Polymers- Mastication of Natural and Synthetic Rubber - Mechano Chemical Synthesis of Block and Craft Copolymers.

UNIT III PHOTO DEGRADATION 9

Introduction - Mechanistic Aspects (Excited States, Free Radicals and Ionic Species, Energy Transfer and Energy Migration) - Degradation in the Absence of Oxygen (Norrish Types I & II Reactions) - Photo Oxidation (Auto Oxidative Process, Sensitized Degradation) - Stabilization - Application: Polymers with Predictable Life Time, Photo resists.

UNIT IV HIGH ENERGY RADIATION AND BIODEGRADATION 9

Introduction - Aspects of Radiation - Mechanistic Aspects - Simultaneous Cross Linking and Degradation - Radiation Stability and Protection Radiation Effects in the Bio Polymers - Application: Lithography, X - ray Resists in Contact Microscopy- Graft and Block Copolymerisation Bio degradation

UNIT V CHEMICAL DEGRADATION 9

Introduction - Solvolysis - Polymer Characterization by Solvolysis - Stability of Polymer Against Solvolytic Agents - Commercial Applications - Ozonisation - Oxidative Degradation - Auto Oxidation of Polymers. Ionic Degradation: Alkaline Degradation of Poly Saccharides Acidic Degradation of Polyaldehydes and Polyacetals and Cationic Degradation of Polypropylene Sulphide and Polyesters.

L = 45 hrs. Total 45hrs.

REFERENCES:

1. W. Schnabel, Polymer Degradation - Principles and Practical Applications Hanser Publishers, New York, 1992.
2. Ann - Christine Albertsson , Samuel J. Huang , "Degradative Polymers Recycling and Plastic Waste Management" Marcel Dekker , New York , 1995.
3. Norman S. Allen, Michele Edge., "Fundamentals of Polymer Degradation and Stabilisation" Elsevier Science Pub Co., 1992
4. Gerald Scott "Mechanisms of Polymer Degradation and Stabilisation" Kluwer
5. Academic Publishers, 1990.

PTY007 POLYMER BLENDS & ALLOYS3 0 0 3

UNIT I INTRODUCTION TO POLYMER BLENDS 9

Miscible and immiscible blends-thermodynamics of polymer blends-principle-single component systems-liquid mixtures-phase separation-crystallization-morphological structure and melting –fundamentals of polymer mixing-blending methods and equipment-non-mechanical methods-reactive processing.

UNIT II INTERPHASE AND COMPATIBILISATION OF BLENDS 9

interface, determination of interfacial parameters-compatibilisation-reactive compatibilisation –characterisation of immiscible blends-reactive compatibilisation by different methods.

UNIT III RHEOLOGY OF POLYMER BLENDS AND ALLOYS 9

Rheological models for miscible blends,immiscible blends-morphology-–crysatllisation from single phase mixture,melt blending of highly immiscible polymers,structure in single phase polymer mixtures-morphological studies by optical microscope,SEM and TEM.

UNIT IV PROPERTIES AND PERFORMANCE 9

Low and high speed mechanical properties,miscibility and solubility,thermal properties. Aging and degradation: physical aging,chemical aging and weathering.

UNIT V COMMERCIAL BLENDS AND THEIR APPLICATIONS 9

Polyolefinic blends,styrenic blends,vinyl resin blends, acrylic blends, polyamide blends ,polycarbonate blends, thermoplastic polyester blends. Applications of blends in automotive, electrical and electronics,medical,building and construction and packaging.

L = 45 hrs. Total = 45 hrs.

REFERENCES:

1. L.A.Utracki., “Polymer Blends Handbook”, Kluwer Academic Publishers, 2003.
2. D.R.Paul and C.B.Bucknall, “Polymer Blends”, Vol.1 & 2, John Wiley and Sons, Inc.2000.
3. D.R.Paul and Seymour Newmann “Polymer Blends” Vol.1 & 2, Academic Press, 1978.
4. Warren E.Baker, Chris.E.Scott and Guo-Hua,eds “Reactive Polymer Blending” Hanser Gardner,2001.
5. George.P.Simon “Polymer Characterization Techniques and their Application to Blends” American **Chemical Society, 2003.**

PTY008 INSTRUMENTAL METHODS OF POLYMER ANALYSIS 3 0 0 3

UNIT I: MOLECULAR CHARACTERIZATION AND THERMAL ANALYSIS 9

Instrument details, equation and methods of analysis of Ebbuliometry, cryoscopy, osmometry, light scattering for molecular weight determination.
Instrumentation- DSC, TGA, DTA, TMA, DMA DETA, Measurement of thermal conductivity and thermal diffusivity.

UNIT II OPTICAL METHODS 9

Ultraviolet and visible spectrometer: Instrumentation Double beam spectrophotometers – single beam spectrophotometers sources of radiation – Detectors – Instrumentation – operational procedure – qualitative and quantitative analysis – polymer applications.
Instrumentation – optical materials – sources detectors – Typical spectrophotometers – Fourier – Transform – Spectrophotometers – calibration & standardization – sample preparation quantitative analysis – principle of polymer identification and characterization of polymers using IR & Raman spectroscopy – Case studies.
Scanning Electron Microscopy : (SEM) – Sample imaging in the SEM – sample preparation
Transmission Electron Microscopy : Direct Examination – indirect examination

UNIT III X-RAY DIFFRACTION & NEWTON SCATTERING 9

Principle & basic concept of absorption of X-rays monochromatic X-ray sources – X-ray detectors – Experimental technique – Instrumentation – Analysis by X-ray absorption. Absorption apparatus – X-ray diffraction – Diffraction apparatus. Application to polymers.
Small angle neutron scattering – Theory – Foam factors and scattering laws – Experimental – Applications of small angle neutron scattering.

UNIT IV CHROMATOGRAPHY 9

size extension chromatography(SEC) or gel permeation chromatography (GPC) – High pressure liquid chromatography (HPLC) – Thin layer chromatography (TLC0- Gas chromatography(GC) – Key components in various analysis – sample preparation chromatographic process and instrumentation – compositional separation and detectors – various types – Analyses – The uses and applications of various chromatographic technique – pyrolysis gas chromatography.

UNIT V NMR AND MASS SPECTROMETRY 9

NMR spectroscopy – Fundamental concepts – chemical shift – spin –spin- coupling. Instrumentation for NMR Equipment, data acquisition & spectral interpretation. Application of NMR – FT NMR – NMR characterization of polymers in solution – proton & carbon studies – NMR studies of other nuclear – solid state NMR studies of polymers
Mass spectrometry- Instrumentation – Ion sources mass analysers – Double focus instruments – Quadrupole Mass analyzers – FTMS – MS detectors – Data recording and analysis – Qualitative and quantitative analysis applicable to polymers- GC/ Mass – Instrumentation – Factors to be considered in design – modes of operation – Analysis – Application to polymer.

L = 45 hrs. Total = 45 hrs.

REFERENCES:

1. Instrumental methods pf chemical analysis Galen W. Euring, McGraw Hill International editions, New York(1985)
2. Polymer Characterisation edited by B.J. Hunt & MI Jones Blackie, Academic professional, London(1997)
3. Handbook of Plastic analysis , Hubert Lobo , Jose V.B.Bonilla, Marcel Dekker inc, New York(2003)
4. Modern techniques for polymer characterization RA pethrick & JV Daukins , John Wiley & sons Chichester, UK(1999)
5. Polymer characterization, D. Campbell and R.white, Chapman & Hall, London(1989)

ELECTIVE –III

PTY009 ADHESIVES AND SURFACE COATINGS3 0 0 3

UNIT I ADHESIVE CONCEPTS AND TERMINOLOGY 9

Functions of adhesives, advantages and disadvantages of adhesive bonding, theories of adhesion-Requirements for a good bond, criteria for selection of adhesives-Types of adhesives.

UNIT II JOINT DESIGN 9

Stress, types of joints, selection of joint detail, joint criteria, surface preparation of adherents-metals, plastics and rubbers. Adhesive bonding process- methods for adhesives application and bonding equipment, adhesives for specific substrates, testing of adhesives, adhesive specifications and quality control

UNIT III SURFACE PREPARATION 9

adherends for adhesive bonding-plastic surface preparation-metal surface preparation-anodised treatments for adhesive bonding of aluminium-conversion coatings-abrasion-electrochemical methods.

UNIT IV PAINTS 9

Components of Paints, Paint Preparation, Formulation, Factors Affecting Pigment Dispersion, Preparation of Pigment Dispersion, Manufacture, Pigments, Pigment Properties, Different Types, Selection, Dispersion and Color Matching of Pigments, Extenders, Solvents, Different Types, Solvent Properties, Oil, Driers, Resins, Dilutents, Additives Affecting: Viscosity Interfacial Tensions, Chemical Reaction, Living Micro-Organisms.

UNIT V PAINT PROPERTIES 9

Mechanism of Film Formation, Physical Drying, Oxidation Drying, Chemical Drying, Factors Affecting Coating Properties, Film Thickness, Film Density, Internal Stresses, Pigment Volume Concentration (PVC). Different Methods used for Film Preparation, Barrier Properties, Mechanical Properties and Optical Properties of Coatings, Color, Gloss, Hiding Power, Ageing Properties, Factors Affecting Viscosity of Paints, Effect of Rheological

Behavior on paint Performance. Adhesion Properties of Coatings, Factors Affecting Adhesive Bond, Thermodynamics of Adhesion, Destructive Methods, Non Destructive Methods.

L = 45 hrs. Total =45 hrs.

REFERENCES:

1. Gerald L. Schreberger, Adhesive in manufacturing, Marcel Dekker Inc., New York, 1983
2. W.C. Wake, Adhesion and the formulation of adhesives. Applied Science Publishers, London, 1976.
3. Swaraj Paul, Surface Coatings, John Wiley & Sons, NY, 1985.
4. George Mathews, Polymer Mixing Technology, Applied Science Publishers.
5. Sheilds, Hand book of adhesives, Butterworths, 1984.

PTY010 POLYMER RECYCLING AND WASTE MANAGEMENT 3 0 0 3

UNIT I PLASTIC WASTE SEPARATION TECHNIQUES 9

Introduction-sources of plastics waste –-density based sorting –optical sorting-spectroscopic sorting-electrostatic sorting-melting temperature—sorting by size reduction-selective dissolution.

UNIT II PLASTICS WASTE MANAGEMENT 9

4R's approach-reduction – reuse-repair-recycling-recycling classification-code of practice-primary-secondary-tertiary-quaternary recycling with examples.

UNIT III RECYCLING 9

Recycling of Polyolefins -PVC, PET, Polystyrene, Nylon, Polyurethanes,polyacetals-mechanical process-applications of recycled materials.

UNIT IV RECYCLING OF POLYMER COMPOSITES 9

Recycling of thermoset composites-thermoplastic composites-rubber, tyre recycling-tyre size reduction-Applications of recycled rubber

UNIT V RECYCLING OF PLASTICS BY SURFACE REFURBISHING 9

Surface coating application-influence on plastics- properties by coating –polishing of the plastics surface-commercial process-plastics aging-environmental aging-thermal aging-weathering –mechanical degradation-energy from waste-incinerators.

L = 45 hrs. Total =45 hrs.

REFERENCES:

1. John Scheirs., - "Polymer Recycling" John Wiley and Sons,1998.
2. Nabil Mustafa – "Plastics Waste Management" John Wiley and Sons,1998.
3. Muna Bitter, Johannes Brandup, Georg Menges "Recycling and Recovery of plastics" 1996.

4. Attilio.L.Bisio,Marino Xanthos, " How to manage plastics waste: Technology and market Opportunities" Hanser Publishers, 1994.
5. Francesco La Mantia., " Handbook of Plastics Recycling" Chem Tec Publishing,2002

PTY011 POLYMERS IN ELECTRONICS 3 0 0 3

UNIT I INTRODUCTION TO SEMI CONDUCTORS 9

Electrons and Holes in Semiconductors - Energy Bands - PN Junction, Diode Characteristics – Photo diode – photo transistors – Optical polymers – semiconducting polymer LEDs – characteristics of LED polymers – polymer displays – polymer solar cells – Electronic injection and conduction processes for polymer devices

UNIT II POLYMERIC MATERIALS AND PROCESSES 12

Inorganic Polymers as IC Passivation and Interlayer Dielectric Materials - Thermal CVD, Plasma Processes and Plasma Enhanced CVD - High Performance Organic Polymers for Electronic Coating, Passivation and -Interconnects - (Silicones, Epoxies, Polyimides, Silicone-Polyimides, Parylenes, BCB, Silicon-carbons, Polyesters, Liquid-crystal Polymers, Conductive Adhesives (ICA, ACA/F for lead-free Interconnects) and Embedded Passive Materials - Polymers for Ferroelectric, piezoelectric, non-linear optics - electroluminescent polymers, ladder polymers

UNIT III SEMICONDUCTOR PACKAGING 9

Purpose of electronic packaging – interconnects levels and processing technique – wire bonding- flip-chip, TapAutomated bonding(TAB). Beam leaded , Polymer interconnects , Ball Grid Array (BGA), Chip size / scale packaging (CSP), FC etc

UNIT IV MICROELECTRONIC ENCAPSULATION 9

Techniques - Coatings, Moldings, Potting, Chip-on-Board, Glob-tops, BGA, CSP, Flip-chip Underfills and Recent Advances in Low-cost Flip-chip packaging -Photonic Packaging - The fundamentals and Recent Advances
Conductive Adhesives, Microvias HDI, SOP and Embedded Passives

UNIT V CHARACTERIZATION OF PACKAGING 6

Prepackaging Cleaning and Control Methods - Interfacial Surface Analyses, Contact Angle, XPS, Electronic Corrosion Mechanism and Lotus Effect Materials

L = 45 hrs. Total =45 hrs.

REFERENCES:

1. C. P. Wong, Ed., "Polymers for Electronic and Photonic Applications," Academic Press (1993).
2. Encyclopedia of Polymer Science and Technology, Vol.3 , Wiley Interscience 2003
3. J. Lau, C. P. Wong, J. Prince, W. Nakayama," Electronic Packaging: Design, Materials, Process and Reliability", McGraw Hill, NY, (1998).
4. Semiconductor Physics & Devices, 2nd Edition by Donald A. Neamen, Irwin, 1997.

5. Physics of Semiconductor Devices by S. Sze, 2nd edition, Wiley, 1984.
6. Microelectronic Devices by E.S. Yang, McGraw-Hill, 1988.

PTY012 TYRE TECHNOLOGY 3 0 0 3

UNIT I FUNDAMENTALS OF TYRE 9

A historical introduction on the design and development of tyres of various kinds and types. Tyre classification – sizes & speed rating. Different types of tyres – bias, bias belted radial, tube type abd tubeless tyres their basic features and performance comparison. Different components of a tyre, its geometry, basic functions. Functions of a pneumatic tyre – load carrying, vibration and noise reduction, the tyre function as a spring, contribution to driving control and road adhesion, the tyre friction contribution to driving control, steering control and self aligning torque.

UNIT II MATERIALS AND PROCESSES 9

Principles of designing formulations for various tyre components. compounding and mixing of rubber. Tyre reinforcement materials (Textile, steel, glass etc.). Criteria of selection - textile treatment - adhesion promoters. Tyre mould design

UNIT III TYRE DESIGN AND TYRE MECHANICS 9

Tyre friction and wear hydroplaning. Caracas design, contour shape, tyre cord and their characteristics. Cord tension. Load capacity of tyre. Stresses in Tyre. Tread design, Bead design – bead tension, 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 level, Tyre in plane dynamics. High frequency properties, basic yaw and camber analysis.

UNIT IV TYRE MANUFACTURE 9

Manufacturing techniques of various tyres like two wheeler and car tyres, truck tyres, OTR, Farm tyres, aircraft tyres - different styles and construction - 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 and bladders. Different types, their feature and operation of tyre building machines, bead winding machine, wire/glass processing machines, bias cutters, curing presses.

UNIT V MEASUREMENT OF TYRE PROPERTIES 9

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 concentricity and ply steer. Type balance, mileage, evaluations, tyre flaws and separations, X-ray holography etc., Foot print pressure distribution. BIS standards for tyres, tubes and flaps.

L = 45 hrs. Total =45 hrs.

REFERENCES:

1. Samuel K. Clark, Mechanics of pneumatic Tires, National Bureau of standards, Monograph, US Govt. printing office, 1971.
2. Tom French, Tyre Technology, Adam Hilger, New York, 1989.
3. F.J. Kovac, Tire Technology, 4th edition, Good year Tire and Rubber company, Akron, 1978.
4. E. Robecchi, L.Amiki, Mechanics of Tire, 2 Vols, Pirelli, Milano, 1970

ELECTIVE –IV

PTY013 MEMBRANE TECHNOLOGY 3 0 0 3

UNIT I INTRODUCTION 9

Membranes-types-membrane process. membrane transport theory, solution –diffusion model, structure-permeability relationships. pore-flow membranes

UNIT II TYPE OF MEMBRANES 9

Membranes and modules-isotropic membranes- anisotropic membranes-metal membranes and ceramic membranes-liquid membranes-hollow fibre membranes, membrane modules.

UNIT III CONCENTRATION POLARIZATION 9

Liquid separation process-gas separation process-cross flow-co-flow and counter flow. Reverse osmosis: Theoretical background –membrane selectivity-module –fouling.

UNIT IV ULTRACENTRIFUGATION 9

Characterization of ultra filtration membranes –modules-System design. Micro filtration: Background and Applications. Pervaporation-membrane materials- process design. Ion-exchange membrane:chemistry of ion-exchange membranes-transport in electro dialysis membrane-system design

UNIT V MEDICAL APPLICATIONS 9

Heamodialysis-Blood oxygenators-control drug delivery-membrane processes: dialysis, donan dialysis and diffusion dialysis-charge mosaic membranes and piezo dialysis-membrane contractors and membrane distillation-membrane reactors.

L = 45 hrs. Total = 45 hrs.

REFERENCES:

1. Richard.W.Baker “Membrane Technology and Applications” 2 nd Edition Wiley Interscience, 2004.
2. Marcel Mulder “Basic Principles of Membrane Technology”, Kluwer Academic publishers, 1996.
3. Wolf R.Vieth “Membrane Systems: Analysis and Design: Applications in Biotechnology, Biomedicine and Polymer Science” Wiley Interscience, 1994.

4. Serge.F.Timashev., Kemp.T.J, "Physical Chemistry of Membrane Process", Prentice Hall, 1991
5. Rautenbach.R, Albrecht., "Membrane Process", John Wiley and Sons, New York,v 1989.

PTY014 FATIGUE AND FRACTURE MECHANICS 3 0 0 3

UNIT 1 ELEMENTS OF SOLID MECHANICS 9

Analysis of stress-strain - constitutive equations - energy principles - Incremental and deformation theories of plasticity - Properties of slip lines
Fatigue of Structures - S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Neuber's stress concentration factors – plastic stress concentration factors – Notched S-N curves.

UNIT 2 STATISTICAL ASPECTS OF FATIGUE BEHAVIOR 9

Low cycle and high cycle fatigue – Coffin-Manson's relation – Transition life – Cyclic Strain hardening and softening – Analysis of load histories – Cycle counting techniques – Cumulative damage – Miner's theory – other theories.
Physical Aspects Of Fatigue - Phase in fatigue life – Crack initiation – Crack growth – Final fracture – Dislocations – Fatigue fracture surfaces

UNIT 3 ENERGY BALANCE AND CRACK GROWTH 9

Griffith analysis - Linear Fracture Mechanics - Crack opening displacement - Dynamic energy balance - crack arrest
Linear elastic crack tip fields - stress intensity factor - energetics of cracked bodies - fracture toughness (Kic) – testing - R-curve – estimation - Elastic - plastic fracture mechanics.

UNIT 4 THEORIES AND MECHANISM OF FAILURES 9

Plastic crack tip fields - J integral testing – CTOD - J dominance, J controlled crack growth - Tearing modulus - Quasi static crack growth - Fatigue crack propagation - Basic considerations in prediction of fatigue crack growth and life estimation – Paris law
Mechanism of fatigue failure - Effect of after loading crack closure on Fatigue Crack Propagation (FCP) – Environment assisted cracking – corrosion fatigue – stress and strain controlled fatigue – crack closure measurement - FCP in plastics ceramics and composites – fracture surface morphology

UNIT 5 ELEMENTS OF APPLIED FRACTURE MECHANICS 9

Examples of crack growth Analysis for cyclic loading - leak before break - crack initiation under large scale – yielding thickness as a Design parameter - crack instability in Thermal or Residual - stress fields - Applications of the concept of fracture mechanics to mechanical design such as pressure vessels - boilers - case studies
Failure Analysis - Failure during manufacture - Damage and criteria for fracture

L = 45 hrs. Total = 45 hrs.

REFERENCES:

1. Lawn.B.R. and Wilshaw.T.R, Fracture of Brittle Solids, Cambride Univ. Press, 1974.
2. Hellan.K, Introduction to Fracture Mechanics, McGraw-Hill, 1984.
3. Parker.A.P, The Mechanics of Fracture and Fatigue - An Introduction, E &F.N.Spin, London, 1981.
4. Knott.J.F, Fundaments of Fracture Mechanics, Butterworths, 1979.
5. Brock.D, Elementary Engineering Fracture Mechanics, 3 ed. Martinus, Nijhoff, The Hague, 1982.
6. J.F.Knott, "Fundamentals of Fracture Mechanics", Butterworth & Co., (Publishers) Ltd., London, 1983.

PTY015 RAPID PROTOTYPING AND TOOLING 3 0 0 3

UNIT 1 MANUFACTURING ENGINEERING 9

recent developments – robotics – FMS – CAD/CAM- Concurrent engineering - Rapid prototyping - benefits of rapid prototyping – Classification of rapid prototyping techniques – based on state of raw material – based on shape building approach
Steps in rapid prototyping – Pre processing – issues related to CAD - STL files - slicing – support design – part orientation - processing - post processing.

UNIT 2 TWO DIMENSIONAL LAYER BY LAYER TECHNIQUES 9

Stereo Lithography apparatus (SLA) - Selective Laser Sintering (SLS) - Solid Ground Curing (SGC) - Laminated Object Manufacturing (LOM) - Fused Deposition Modeling (FDM) – Selective powder binding (three dimensional printing TDP) – Ballistic particle manufacturing – Repetitive masking and depositing.

UNIT 3 DIRECT THREE DIMENSIONAL TECHNIQUES 9

Beam interference solidification – 3d Ballistic particle manufacturing – Holographic interference solidification – Programmable moulding.
Building metallic objects by RP Techniques – laser based deposition head for FDM – FDM using electrochemical discharge.
Comparison of RP process characteristics – Comparison of materials, activation sources, post processing, performance characteristics, accuracy and surface finish of different techniques – Considerations for adopting RP Technology

UNIT 4 RAPID TOOLING 9

Indirect Methods of Rapid Tooling - RTV Silicone Rubber Molds – Epoxy tooling - Vacuum Casting – RIM - Wax Injection Molding - Spin Casting - Cast Resin Tooling - Spray Metal Tooling - Sprayed Steel Rapid Solidification Process - Plaster Molds -Electroforming - Cast Aluminum and Zinc Kirksite Tooling - Investment Cast Tooling - 3D Keltool

UNIT 5 DIRECT METHODS OF RAPID TOOLING **9**

Direct tooling using stereo lithography - SLS Rapid Steel - Copper Polyamide Tooling - Direct Metal Laser Sintering - Laminated Tooling - Laser Engineered Net Shaping (LENS) - Controlled Metal Build-up (CMB) – Prometal
Trends In Rapid Prototyping And Tooling - Future development - Rapid prototyping and tooling in Indian scene - advances in rapid prototyping.

L = 45 hrs. Total = 45 hrs.

REFERENCES:

1. Amitabha Ghosh, Rapid Prototyping – A Brief Introduction, Affiliated East –West Press Private Limited, New Delhi, 1997.
2. Marshall Burns, Automated Fabrication: Improving Productivity in Manufacturing,
3. PTR Prentice Hall - Englewood Cliffs, New Delhi, 1993.
4. Lamont Wood, Rapid Automated Prototyping: An Introduction, Industrial Press Inc., New York. Copyright 1993.
5. Paul F. Jacobs, Rapid Prototyping and Manufacturing Fundamentals of Stereo Lithography, I Edition, Society of Manufacturing Engineers, Dearborn, Michigan, 1992.
6. Philip Dickens, Richard Hague and Terry Wohlers, - Methods of Rapid Tooling Worldwide, Department of Engineering & Technology at De Montfort University,1993.

PTY016 NANO TECHNOLOGY 3 0 0 3

UNIT I INTRODUCTION TO NANO TECHNOLOGY **9**

Elementary quantam mechanics- atomic structures and types of bonding.- Solid state physics- electronic and optical properties of materials- sensors electronic , magnetic and optical behaviour of nano materials – self assembled organized systems – Dentrimers, liposones, vesicles , supermolecular complexes

UNIT II PROCESSING TECHNOLOGY **9**

Processing of materials – chemical synthesis – powder coating –sintering – Photo lithography – Thin film technology - sputter deposition – spin coating- stamping lithography- thin films by chemical vapor deposition – types of CVD - Ablation- Electro spinning into nanofibers – carbon nanotubes – structures – properties - sensors of ceramics , Al2O3, TiO2, MgO and BaTi - sensor fabrication and applications- Nanophosphors development – Processing of nano fillers containing polymers and their characteristcs

UNIT III ANALYTICAL INSTRUMENTATION TECHNIQUES **9**

Low energy electron diffraction (LEED), Scanning Probe Microscopy, Auger, SEM, TEM, XRD (Powder / single crystal), AFM, STM, EDAX, ESCA, Optical microscope, UV Photo electron spectroscopy, Ellipsometry

UNIT IV NANO STRUCTURES AND APPLICATIONS 9

effect of environment on nanostructures – corrosion – oxidation – biological attack - Industrial applications of nanosized materials- Paints, catalysis, membranes , mesoporous materials , phosphor materials, Laser materials , water purifications ; Polymer nano composites

UNIT V NANO BIOTECHNOLOGY 9

Nano particles and microorganisms- nano materials in bone substitutes and dentistry- Nano particles in food and cosmetic applications- drug delivery and its applications – Biosensors , biochips and analytical devices

L = 45 hrs. Total = 45 hrs.

REFERENCES :

1. Nadin Malot, Introduction to Nanotechnology, (Artech House Library), Artech House, ISBN : 0890065810 Dec 1999
2. R.Edwards , Nano : the emerging science of Nano Technology , remaking of world molecule by molecule, Little Brown , Boston, 1995
3. Scgey Edward Lyshevski , Nano mechanical systems, Fundamentals of Nano engineering CRC Press; ISBN 0849309166 ,2000
4. Bernald R.Glick, Jack J.Pasternak, Molecular Biotechnology: Principles and applications of DNA , ISBN :1555811361 , 1998
5. Stephen D.Senturia, Klower Micro system design , Academic Publishers ISBN : 0792372468
6. Skotheim T.A , Electroresponsive molecular and polymeric systems Vol 1 & 2 , Dekker