COURSE STRUCTURE
M.E. Polymer Engineering
(2008 Course)

SEMISTER I

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Practical	Paper	TW	Oral	Practical	Total	
509115	Mathematical and Statistical Methods	3	-	100	-	-	-	100	3
509116	Principles of Management	3	-	100	-	-	-	100	3
509117	Polymer Processing and Testing	3	-	100	-	-	-	100	3
509118	Elective I	3	-	100	-	-	-	100	3
509119	Elective II	3	-	100	-	-	-	100	3
509120	Lab Practice I	-	6	-	50	-		50	3
509121	Seminar I	-	4	-	50	-	-	50	2
Total of First Term		15	10	500	100	-	**-**	600	20

SEMISTER II

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Practical	Paper	TW	Oral	Practical	Total	
509122	Polymer Physics and Characterization	3	-	100	-	-	-	100	3
509123	Polymer Structure and Properties	3	-	100	-	-	-	100	3
509124	Processing and Mechanics of Composites	3	-	100	-	-	-	100	3
509125	Elective III	3	-	100	-	-	-	100	3
509126	Elective IV (Open)	3	-	100	-	-	-	100	3
509127	Lab Practice II	-	6	-	50	-		50	3
509128	Seminar II	-	4	-	50	-	-	50	2
Total of Second Term		15	10	500	100	-	**-**	600	20

SEMISTER III

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Practical	Paper	TW	Oral	Practical	Total	
609104	Seminar III	-	4	-	50	-	-	50	2
609105	Project Stage I	-	18	-	-	-		-	-
Total of Third Term		-	22	-	50	-	**-**	50	02

SEMISTER IV

CODE	SUBJECT	TEACHING SCHEME		EXAMINATION SCHEME					CREDITS
		Lect.	Practical	Project	TW	Oral	Practical	Total	
609106	Project Stage II	-	18	200	-	50		250	18
Total of Fourth Term		-	18	200	-	50	**-**	250	18

Note- The Contact Hours for the calculation of load of teacher
Seminar- 1 Hr / week / student and
Project - 2 Hrs / week / student

Elective – I **:**
a. Polymer Reaction Engineering
b. Transport Phenomena in Polymers
c. Synthesis and Chemistry of Polymers

Elective – II **:**
a. Polymer Rheology
b. Mold and Die Design
c. Packaging Technology

Elective – III **:**
a. Science and Engineering of Fibres
b. Polymer Product Design
c. Specialty Polymer Materials

Elective –IV **:**
a. Paints And Adhesives Elective IV
b. Elastomer Technology
c. Open

509115 : Mathematical and Statistical Methods

Teaching Scheme	**Examination Scheme**
Lectures : 3 Hrs/Week	Paper : 100 Marks

Matrix & Linear Algebra

- Revision of basic concepts in Matrix algebra
- Methods to solve spare matrices (including tridiagonal)
- Solution of linear system of equations
- Solution of Eigen-value problems

Transformation

- Discrete functions and their properties
- Z - transforms and their properties
- Relation between discrete and Fourier transforms.

Advanced Numerical Methods

- Brief review of similar numerical methods
- Finite difference methods for solution of field problems, Grid generation
- Solution of IVP/BVP (ODE/PDF) with / without free, moving or periodic boundaries.
- Solution of stiff/coupled equations
- Finise element methods

Variational Calculus

- Orthogonal collocation method
- Method of Weighted Residuals

Advanced Statistical Methods

- Hypothesis Testing
- Design of experiments and Model discrimination

References :

1. Advanced Mathematical Methods for Scientists and Engineers, Bender, C.H. and Orszag S.A., McGraw Hill (1978)
2. Probability and statistics for Engineers, Miller and Ereund , 5th Ed., Prentice Hall of India
3. Mathematics for Scientists and Engineers, Scolicoff
4. Nonlinear Analysis in Chemical Engg, Finlayson, B.A., McGraw Hill (1980)
5. Modeling with Differential Equations in Chemical Engineering, Walas S.M. Butterworth - Heinemann (1991)
6. Toguchi Method, explained practical steps to robust design, Bignchi T.P., Prentice Hall, 1993
7. Taguchi Techniques for Quality Engineering Rosj Phillip J.

509116 : Principles of Management

Teaching Scheme
Lectures: 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Introduction to marketing
Difference between sales and marketing.
Marketing mix – product, price, place and promotion.

Market
Market segmentation - targeting and positioning, consumer behavior.

Product
Product lifecycle, new product – introduction.
branding, product labeling and packaging.
Advertising, direct marketing and sales promotion.

Place
Types of channel and physical distribution

Pricing
Rate of pricing, price setting methods and strategies.

Costing
Types of cost, standard costing, marginal costing, break even analysis components of balance sheet, profit and loss account, sources and utilization of funds, key profitability ratio's such as debt to equally ratio, ROI etc.

Operation research

Transportation, assignment, sequencing, game theory, queing theory.
Inventory control, economic batch calculations – deterministic & probabilistic models, PERT-CPM

References :

1. Financial management, R.P. Rastogi, 9th edition.
2. Cost accounting, Sexena and Vashistha
3. Financial management, Prasanna Chandra
4. Marketing management by Philip Kotler, Keller, Koshy and Jha – Pearson Publication, Prentice Hall Publication, 12th edition.
5. Services marketing by Groonroos – Wieley Publication
6. Global marketing management by Keegon – Prentice Hill Publication
7. Consumer relationship management by Zikmund – Wiley Publication
8. Marketing management by Rajan Sexena – Tata McGraw - Hill Publication
9. Marketing management by Namakumari and Ramaswamy – McMillan Publication
10. Marketing management by Dholakiya – Mc Millan Publication
11. Plant Design and Economics for Chemical Engineers, Peters, Timmer hous,

MacGraw-Hill.
12. Chemical Process Economics, Hapel J., Jordan D.G.
13. Cost Accounting, B.K. Bhar, Academic Publishers, Calcutta.
14. Mechanical Estimating and Costing, Kanappan D., Augustine A.G. MacGraw-Hill, New Delhi.
13. Manufacturing Cost Engineering Handbook, E.M. Malstrom, Marcel Dekker Inc New York, 1984.
14. Operation Research, Prentice Hall India, Taha H.A., 6th edition 2002.
15. Principles and Application, PERT & EPM, Srinath I.S., East West Press, 1975.
16. Operation Research, Sharma S.D., KNRN & Company, 1973.
17. Operation Research, Gupta Premkumar & Hira D.S., S. Chand Company, 2001.
18. Operation Research, Patel R.C. & Dave N.R., Mangalani A.K., C. Jamanadas & Company, 1995.

509117 : Polymer Processing and Testing

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Objective
To understand polymer testing related to short term as well as long term mechanical properties, thermal as well as electrical properties. To have indepth understanding of fundamental polymer processing operations.

Introduction
Importance of Testing, Concept of Statistics, Quality Control, Standards and Standard Organizations, Preparations of test Samples and Conditioning.

Mechanical Properties - Short term and long term mechanical properties, their Significance and importance.

- Determination of Short term stress-strain properties such as Tensile strength, elongation at break, tensile modulus, compression, Flexural etc.
- Different types of Impact tests: Determination of impact tests for different polymeric materials.
- Study of creep, relaxation, set and fatigue.

Non destructive testing of finished and semifinshed products
Such as ultrasonic testing, acoustic emission or stress wave emission, radiography, optical methods, etc.

Electrical Properties
Their importance and significance, effect of temperature and humidity on electric properties.
Different types of electrical properties such as:

- Determination of dielectric strength, surface and volume resistance.
- Power factor and permittivity.
- Tracking resistance, arc resistance

Thermal Properties

- Determination of heat deflection temperature (HDT)
- Determination of vicat softening point VST)
- Determination of melting point and softening point for different polymers

Environmental Resistance Properties

- Effect of liquids and chemicals.
- Study of weathering resistance.
- Study of weathering property.
- Study of fire resistance.

Barrier Properties
Their significance and importance

- Study of Barrier properties.

Testing of plastics products such as sheet, films, laminates, and coated fabrics, plastic pipes/ fittings, tanks, buckets, dustbins, window frames, fibre reinforced plastics for mechanical, environmental resistance, etc.

Extrusion
Basic operation and analysis, solids conveying, drag induced conveying, melting mechanism, power consumption in metering zone. Overall extruder performance. Design of extrusion screws, modeling of extrusion process and computer simulation. Overall working of single screw and twin screw extruders.

Polymer Devolatilization
Basic analysis of the process, functional design considerations, screw geometry and design Devolatilization in single screw and twin screw extruders and their design.

Extruded products
Such as films, pipes, profiles, coating, foamed products, design of sizing systems, haul off systems, cooling and / or chilling units, winders, auxiliary equipments used, measurement and control of parameters. Types of dies used for the production of extruded products. Analysis of the flow through the dies. Manufacture of flat films, co extruded films, oriented films, drawing and stretching units.

Reactive extrusion
Process details, basic principles equipment used, applications.

Extrusion blow moulding
Types of blow moulding techniques, flow analysis in the die, wall thickness control, parison swell, parison sag. Continuous and intermittent blow moulding CAE of blow moulding operation.

Thermoforming
Types, various techniques, materials, heat transfer analysis of the process, effect of plugs on article thickness, continuous heating of a thin moving sheet. CAE in thermoforming.

Injection moulding
Role of rheology in injection moulding, melt flow in feed system, flow in mould cavity, mould filling. Control of politicizing and injection process.

Reaction injection moulding
Overall moulding cycle, metering system for components, mixing head design, mould construction, materials used and their applications.

References :

1. Handbook of Plastics Test Method, R.B. Brown, George Godwin Limited, 1981.
2. Handbook of Plastic Testing Technology, Brown and Vishnu Shah, A. Wiley, Inter science Publication,2007

3. Handbook of Plastics Test Methods, G.V. Eves, J.A. Mead, M.M. Riky.
4. Volume 8 of ASTM Standards, BIS Standards.
5. Polymer Extrusion, Chris Rauwendal SPE, Hanser Publishers.
6. Polymer Missing and Extrusion Technology – Nicholas Cheremisinoff, Marcel Dekker 1987
7. Modeling Of Polymer Processing, Isayav, Hanser Publishers, 1991.
8. Plastics Waste Management, Mustafa.
9. Plastics Extrusion Technology – Hanser SPE, 1996
10. Thermoforming – J.L. Throne, Hanser Publishers 1987
11. Blow Moulding Handbook – Rosato, Hanser Publishers 1987
12. Rotational Moulding Of Plastics – R.J. Crawford, Research Studies Press Ltd.
13. Engineering With Polymers - Powell.

509118 [Elective I] (a) : Polymer Reaction Engineering

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Objective
To understand the distinguishing features and challenges involved in polymer manufacturing processes as compared to monomer manufacturing processes.

Review of types and methods of polymerization MW and MWD in polymers.
Important aspects of polymers, polymerization reaction engineering as compared with monomers and their reaction engineering, the effect of mixing on kinetics and MWD.

Polymerization kinetics for both step growth as well as chain growth mechanism under ideal and real conditions. Chain growth includes free radical, anionic and cationic polymerization.

Diffusion controlled polymerization.
Tromsdorff effect in Free Radical Polymerization. Models of Tromsdorff effect. Extension of these models to step growth polymerizations at high conversions. Interfacial polymerizations in immiscible monomers case.

Review of RTD & macro and micro mixing in reaction vessels. Comparison of performance batch. Homogeneous continuously stirred tank, segregated continuous stirred tank reactor and laminar flow tubular reactor in case of ionic, free radical and step growth polymerization. Degree of polymerization and MWD.

Models of Heterogeneous Polymerizations. Solution / precipitation, suspension and Emulsion polymerization. Smith Ewart Model. Application to continuous emulsion polymerization. Co-ordination polymerization in fluidized bed reactor.

Design fundaments of reactors for tailor making polymers example metalocene polyolefins. Qualitative account of control engineering considerations in operation of batch and continuous polymerization process.

References :

1. Polymerization Process Modeling, Neil A. Datson, Rafael Galvan, Robert L. Laurence, Mathew Tirrel, 1996 VCH Publishers .
2. Control of Polymerization Reactors, F.Joseph Schork, Pradeep B. Deshpande & Kenneth W. Leffew, Marcel Dekker 1993.
3. Reaction Engineering of Step Growth Polymerization, Gupta S. & Anilkumar, Plenum Press, New York 1987.
4. Encyclopedia of Polymer Science & Engg. 2nd Edition.
5. Polymer Reactor Engg. - McGreavy, Blackie Academic & Professional, Chapman & Hall, 1994.

509118 [Elective I] (b) : Transport Phenomena In Polymers

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Tensor algebra and calculus
Summary of relevance to transport phenomena in polymers

Kinematics of fluid flow and deformation
Complete overview

Stress in fluids and solids
- Body and surface forces
- Cauchy's principles
- Stress, strain and vorticity tensors
- Local balance lows - spatial / material forms

Momentum transport
- Flow phenomena in Polymeric liquids
  Non - Newtonian viscous and elastic effects.
- Applications of differential balances to Momentum transfer.
  Complete solutions and special cases.
- Complete coverage of special topics in Non - Newtonian fluid mechanics with case studies.

Mass transport
- Foundation Diffusion, convection and Dispersion Axial, Radial, Diffusion through polymers
- Mechanism and theories of diffusion through polymers.
  Different diffusion coefficient
- Permeation through polymers
- Permeability of polymers and factors affecting it.
- Diffusion through gas, liquid and solid films (Multi component)
- Models for diffusion through polymer films containing impermeable domains of various shapes
- Applications of diffusion to barrier packing, controlled release and membranes and ion exchange resins etc.

Energy transport
- Foundations conduction , convection and viscous dissipation.
- Applications of differential balances to energy transfer.
- Complete solution and special cases. Like viscous heating and chemical reactions
- Applications of integral averaging techniques to energy transfer.

References :

1. Transport Phenomena, Bird, Stewart And Lightfoot (1960). Wiley.
2. Momentum, Energy And Mass Transfer In Continua, Slattery John. C. (1972), McGraw Hill.
3. Mechanics Of Non - Newtonian Fluids, Schowalter William R. (1978), Pergamon
4. Diffusion Mass Transfer In Fluid Systems, Cussler, Cambridge (1998) 2nd Edition

509118 [Elective I] (c) : Synthesis and Chemistry of Polymers

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Introduction
Introduction to polymers, Carother's equation, molecular weight, various methods of determination of molecular weight, molecular weight distribution, Introduction to combinatorial chemistry.

Addition and condensation polymerization tech. (bulk, solution, suspension, emulsion, solid phase, gas phase, interfacial, melt polycondensation, plasma, phase transfer etc.).

Chain polymerization, free radical mechanism / polymerization.
Ionic polymerization/mechanism, group transfer polymerization. Oxidative polymerisation

Step polymerization stoichiometry, gelation and cross linking, polyaddition, polymerization, ROP.

Polymer solutions, polymer degradation, step and chain copolymerization.

Chemistry of various thermosetting polymers. Viz. phenolic, amino, epoxy, USPE, PU, silicone, Chemistry of industrial polymers.

Polymer reactions
Hydrogenation and substitution reactions, Reaction of specific groups like hydroxyl, aldehyde, ketone, carboxyl, amino, vulcanization.
Additional reactions, polymers as catalysts, polymers as substrates (Merrifield synthesis etc.) Polymer supported reactions.

References :

1. Polymer Chemistry an Introduction, Oxford University Press, M.P. Stevens,1991.
2. Principles of Polymerization, Wiley eastern, George Odian, 1991
3. Polymer Science, New age international (P) Ltd. Publishers, V.R. Gowarikar, Pearson publication,2003.
4. Text book of Polymer Science, Wiley Eastern, F.W. Billmeyer Jr, 2003.
5. Polymer Molecular Weight – Vol. I and II, Slade Jr.

509119 [Elective II] (a) : Polymer Rheology

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Objective
To understand study of flow & determination of polymeric melt while being sheared through various flow profiles during processing.

Introduction to Rheological Principals
Classifications of fluids, Newtonian and Non-Newtonian fluids, time independent and time-dependent fluids, elastic viscous fluids. Tensor notation system to fluid flow, Shear viscosity, tensile viscosity, effect of temperature & pressure on viscosity. Normal stresses, storage & loss modulus, types of polymeric fluids and Weissenburg effect. Elastic effect, extrudate swell, extrudate distortion, melt fracture. Creep, creep compliance, stress relaxation, isochroous stress strain plot.

Melt Flow Analysis
Laminar flow thru circular c/s, annulus, slit, parallel plates, irregular profiles. Flow analysis using rheological models like power law, Ellis model. Turbulent flow analysis, turbulence dampling. Rheological models for extensional viscosity. Transition between laminar & turbulent flow, Ryan Johnson criteria. Applications of Ryan Johnson criteria.

Viscoelasticity behavior
Stress relaxation, relaxation modulus, creep compliance dynamic modulus, dynamic compliance, dynamic viscosity, Mechanical models – Maxwell model, Voigt – kelvin model, Zener model, Boltzmann Principle of Superposition.

Time-temperature correspondence, time-temperature superposition, WLF equation, Glass-transition and theories of glass transition - free volume theory, thermodynamic theory and kinetic theory. Molecular theories – Reuse theory, Doi – Edward theory, Curtis – Bird model. Introduction to-non linear viscoelasticity.

Rheometry Study of rotation
Rheometry & surface Rheometer. Basic concept of constant stress & constant strain, Different types of Rheometers – Oscillatory Cone and plate Rheometer, Concentric cylinder, parallel disk Rheometer, concentric rotating disk Rheometer, controlled stress rotational Rheometer, Torque Rheometers – Extruder type, sliding plate Rheometers, sliding cylinder Rheometer.

Parameters influencing polymer Rheology
Effect of temperature, activation energy, effect of on viscosity, effect of molecular wt & distribution on viscosity, molecular at dependence of zero shear viscosity, effect of slinking, crystallinity branching, copolymerization, effect of fillers, fiber filled polymer melts, effect of plasticisers, shear rate dependence of viscosity. Rheology of multiphase systems, rheology of immaculate polymer blends, phase separated block & graft copolymers. Rheology of extrusion, injection molding,

calendaring, Principles of rheology as applied to extrusion die design, calculations of pressure drop, etc.

References :

1. Rheology of filled polymer systems by Aroon V. Shenoy; Klyunner Academic Publishers,1996.
2. Polymer Advances in polymer chemical physics Yu.g.Yan ov sky and Yu.A.Bisistov.
3. The Mesoscopic theory of polymer dynamics Valadimir N. Pokrovski; Klower academic publishers.
4. Polymer & composite rheology by Rakesh K. Gupta.
5. Polymer Melt Rheology; F.N. Cogswell, George Good Ltd. John Wiley, 1981
6. Applied Rheology in Polymer Processing B.R. Gupta, Asian book, 2003.
7. Introduction to Polymer Viscoelasticity John J. Aklonis and W.J. Mackmight John Wiley & Sons.,1983
8. Melt Rheology & its Role in Plastics processing theory & applications John M. Dealy, Kurt F. Wissburn, Chapman & Hall,1995
9. Flow Properties of Polymer Melts**,** Brydson, JA, Godwin, London (1981).
10. Rheology, Principles, measurements and applications, Christopher W. Macosko, Wiley-VCH, 1994.
11. Vectors, Tensors and the Basic Equations of fluid mechanics, R. Aris, Courier Dover Publications 1989.

509119 [Elective II] (b) : Mold and Die Design

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Study of general arrangement of components of two plates and three plate injection molds.
Design of feed system, cooling and ejection system.

Study of constructional features and design of molds for components with internal and external undercuts.
Study of constructional features and design of molds for components with internal threads.

Study of general arrangement of components of compression molds and transfer molds.
Design of ejection system, feed system.

Hot runner moulds, their general arrangement, design of hot runner block, types of secondary nozzles. Heating systems used.
Design of stack molds.

Design of blow molds.

Mould fabrication techniques like spark erosion, milling, polishing procedure, costing of moulds and their maintenance

Extrusion die design : Basic considerations in die design, constructional features in pipe die, blown film die, sheet die and profile dies.

References:

1. Injection Mould Design, R.C.W. Pye,EWP Press,2000.
2. How to make Injection Moulds, Menges,Hanser Publication 1993.
3. Extrusion Dies, Walter Michaeli,Hanser,1992
4. Dies for Plastics Extrusion, M.V. Joshi.

509119 [Elective II] (c) : Packaging Technology

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Introduction – Packaging Material

Historical background, Basic concepts – Physical and Physico-chemical such as colligative properties, gas laws, surface tension, dialysis, diffusion, energy measurements, etc. Package – components, separation, clearance, support, positioning, cushioning, weight distribution, suspension and closures.
Paper – Specialty papers, paper board and corrugated / solid boards
Glass – Containers
Plastics – Rigid, semi-rigid and flexible
Metals – Black plate, GI, tinplate, TFS and aluminium
Wood and plywood
Textiles ad jute
Celluloses and laminates

Ancillary Materials and Packaging

Packaging Characteristics

- Physical characteristics of the product – physical state, weight, centre of gravity, symmetry, fragility, rigidity, surface finish, etc.
- Physico-chemical characteristics – susceptibility to water, water vapour, gases, odour, heat, light – mechanism of spoilage.
- Principles of Corrosion and its prevention.
- Compatibility – permissible plasticisers in plastics and coating media, their migration to food – can lining compounds and lacquers for containers for fruit and vegetables, fish, meat and other products.
- Package design – factors influencing design / product-package relationship.

Adhesives

- Theory and principles of adhesion and factors affecting board strength.
- Different types of adhesives – vegetable, animal, inorganic and synthetic.
- Adhesive tapes – gum tapes, pressure sensitive tapes, their manufacture and applications.

Cushioning

- Physical concepts in cushioning, energy, impact load and concept of shock as complex of deceleration and impulse time.
- Prevention of shock damage to articles by various means and their measurement.
- Types of cushioning materials and properties – space fillers-cork, paper shavings, wood-wool, saw dust, coir dust, paddy straw and dry grass.
- Resilient materials – rubberized hair, rubberized coir, polystyrene and polystyrene and polyurethane foams, springs, metal shock mounts, etc.: Non-resilient system – rigid foams, honeycomb, etc.
- Reinforcements – straps – steel, plastic, rayon-based, - wires, bailing hoops etc.

- Stitching methods - bags, paper and textiles, corrugated board boxes and stitching appliances.
- Seals and closures.
- Lining compounds and lacquers for tin containers.
- Labels and labeling including instant labels.
- Ink jet printing and bar coding.

Printing

Printing techniques, gravure, flexography, ink jet printing for coding, marking applications, surface design and sales appeal, graphic and surface design, printing inks, bar coding.

Reinforcements on distribution packages, corrosion prevention in packaging, principles of corrosion and its impact on packaging.

Adhesives tapes, their manufacture, properties and limitations

BOPP pressure sensitive tapes

Cushion design, prevention of shock damage to articles by various means and measurement of shock, cushioning materials and their applications, plastic corrugated board.

Containerization, containerization and multimodal transport system, containerization concept, intermodal containers – its impact on packaging.

Packaging of accessories and spares – skin, blister and shrink packaging, stretch warpping systems, strip packaging, blister packaging.

Form – fill – seal machine (systems), developments in packaging of stand – up pouches, blow moulding machines, high flow PEs – a new trend in injection moulded containers.

Packaging of processed food products, dehydrated, ready to use foods, packaging of meat, fish and poultry, packaging of fresh foods, packaging of diary products, packaging of biscuits, bread and confectionery, packaging of fruit juices, aseptic packaging – sterilization of packaging materials, using aseptic system, aseptic packaging, sterilization by lrradiation, radiation sterilization – process norms, guidelines and applications, packaging of horticultural crops.

specifications and performance requirements of fibreboard boxes, packaging quality control, testing methods for evaluation of transport packages.

- For packaging materials – physical, physico – chemical, resistance to light, insect and mould/fungus.
- For packaged goods – Unit package: compatibility studies, shelf-life studies –with
- reference to flexible, rigid packs, different types of seals, closures etc. Bulk packages – Evaluation of transport – worthiness of filled packages – physical and climatic hazards.
- Standards for packaging material – rigid, non – rigid and ancillary material.
- Standards for export packages – labeling and marketing regulation.
- Packaging quality control criteria.
- Sampling, variables and attributes,
- Implication of ISO – 9000.
- Eco Packaging and regulation.

Packaging management, package design, an important marketing tool, systems approach to packaging, systems packaging, scientific packaging and loss prevention, packaging needs for export, basic concepts in standardization, packaging standardization and physical distribution, standards – basic concepts, packaging materials, rigid and ancillary material and export packaging, packaging economics maximizing the container utility in relation to the product, packaging cost, cost reduction in packaging, inventory control, value analysis and value engineering, packaging laws, consumer protection in food packaging, marketing and labeling, eco-friendly packaging for exports.

References :

1. Food packaging and preservation, Edited by M. Mathlouthi.
2. Foods and Packaging Materials-Chemical Interactions Edited by Faul Actarmann.
3. Food Packaging Technology Hand Book, By NIIR.
4. Package Engineering, Honlon J F, McGraw Hill,1984
5. Packaging Handbook, Intel,1992.
6. Packaging With Plastics, Bruins Paul F, Gordon and Breach,1974.
7. Plastics Packaging, Turtle Ivor, Pira,1990.
8. Active Packaging for food application by Aaron L. Brodel. , Eugene R. Strupinstes, Lauri R.Kline.
9. Advances in Plastic Packaging Technology, by John Briston.
10. Plastic Films by J.H. Briston.
11. Hand Book on Modern Packaging Industries, by NIIT.

509120 : Laboratory Practice – I

Teaching Scheme
Practicals : 6 Hrs/Week

Examination Scheme
T.W. : 50 marks

Each student should perform at least 8 experiments/ assignments from the list given below and submit the journal which will form the term-work for the subject.

1. Compounding of PP with fillers and rheological characterization of compound.
2. Compounding, moulding and testing of PVC.
3. Injection moulding of PET with different mould temperatures and studying properties of moldings.
4. Blown film extrusion and studying effects of changing processing parameters on the properties of the film.
5. Thermoforming at different temperatures and studying product properties such as shrinkage on heating and environment stress cracking of products.
6. Use of Flow Analysis software for balanced filling of an injection mould cavity.
7. Use of Flow Analysis software for runner balancing.
8. Use of Flow Analysis software for studying cooling and warpage.
9. Modeling a cavity and deciding gate location using Flow Analysis software.
10. Study of volume & surface resistivity.
11. To find out environmental stress crack resistance for polyethylene samples.
12. To determine the izod impact strength for various polymer.
13. To determine the tensile strength at break & yield & % elongation of dumbbell shaped specimens of various polymers.
14. To determine the heat deflection temperature.
15. To determine the vicat softening temperature.

509121 : Seminar – I

Teaching Scheme
Practical : 4 Hr/Week

Examination Scheme
T.W. : 50 marks

Each student is required to deliver a seminar in first semester on the state of the art of the topic of his/her choice, preferably the topic of his/her dissertation and submit it in form of a short report.

Semester II

509122 : Polymer Physics and Characterization

Teaching Scheme	**Examination Scheme**
Lectures : 3 Hrs/Week	Paper : 100 Marks

Solution properties – molecular configurations in solutions, solubility parameter, light scattering measurements, phase diagrams, viscosity of polymer solutions, thermodynamics of polymer solutions and melts, solubility parameter, theta solvents.

Solid state properties - DMA creep, ultimate properties, thermal relaxations, optical, electrical and mechanical properties.

Surface properties, contact angle measurements.

Thermal analysis by DTA, DSC. Use of DSC for determination of kinetics of crystallization. TGA, TMA. Pyrolysis techniques, polymer degradation.

Dynamic viscoelasticity measurements for characterization of different relaxations. Molecular motions responsible for different relaxations.

Dielectric measurements, conductivity, resistivity.

Separation techniques – GPC, HPLC, mol. wt and mol. wt distribution measurements.

X – ray studies for polymers.

Microstructure evaluation by scanning electron and optical microscopes.

Structure evaluation by FTIR, NMR, C-13 NMR, UV.
Elemental analysis – qualitative and quantitative.

Material functions for polymeric liquids such as shear flows, shear less flows (Elongational flows), viscosity, normal stress differences, steady state shear flows, complex viscosities, dynamic viscosity, complex modulus, storage modulus, loss tangent, stress relaxations, elongational viscosity, effect of temp, concentration and mol. wt on materials functions. Relationship between viscoelastic properties and viscometric functions.

References :

1. Introduction to Physical Polymer Sciences, L.H. Sperling, J. Wiley N.Y, 1993.
2. Molecular Motions in High Polymers, R.T. Crompton, Pergmon Press N.Y., 1989.
3. Analysis of Polymers, T.R. Crompton Pergmon Press N.Y., 1989.
4. Mechanical Properties Of High Polymers, I.M. Ward, John Wiley, 1979.

509123 : Polymer Structure and Properties

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Effect of following factors on various properties like mechanical, thermal, electrical, barrier and rheological properties.

- Chemical composition and types of bonds; in the structure.
- Influence forces and molecular flexibility.

Effect of orientation and crystallinity on polymer properties.

- Orientation of amorphous and crystalline zones and study of its effects on properties. Difference between orientation and crystallinity.
- Study of spherulites, factors affecting their growth and thus effect on properties.

Structural requirements of polymers for formation of films, fibers and multiphase systems.

- Molecular Weight, Molecular Weight distribution and structural parameters required.
- Morphology and behaviour of multiphase systems and composite materials on structure and properties.

Different transitions in polymer and effect of molecular and sub-molecular factors on transitions.

- Effect of different transitions on various properties like mechanical, electrical, optical etc.
- Effect of Molecular Weight, filler, additives on these transitions and the methods to measure these effect.

Structural development during processing techniques like injection, blow moulding, rotational moulding etc.

- Molecular structure required for above processing techniques.
- Effect of various processing parameters on properties and morphology of polymers..

Thermodynamics and kinetic forces affecting polymer properties.

- Effect of chemical groups of adhesion.

References :

1. Polymer Structure, Properties and Applications, R.D. Deanin,1972
2. Introduction to Polymer Crystallization, Allan Sharples, St. Martin's Press, N.Y., 1966.
3. Macromolecular Physics, Berhard Wunderlich, Academic Press, N.Y.

4. Properties and Structure of Polymers, A.V. Tobolsky, John Wiley and Sons, New York, 1960.
5. Structure and Properties of Polymers, H.V. Boenig, J.Wiley and Sons, N.Y., 1973.
6. Handbook of Plastic Testing Technology, Brown and Vishu Shah, A. Wiley, Inter science Publication,1984
7. Handbook of Plastics Test Methods, G.V. Eves, J.A. Mead, M.M. Riky,second edition,1981
8. Introduction to Physical Polymer Science by L.H. Sperling,John Wiley,2001.
9. Commercial Polymer Blends, Utraci L.A.,Chapman Hall,1998.

509124 : Processing and Mechanics of Composites

Teaching Scheme | **Examination scheme**
Lectures : 3 Hrs/Week | Paper : 100 marks

Study of different types of matrix materials, thermoplastic and thermosetting, study of various reinforcements – long, shot fibers, particulate fillers, flakes.
Review of processing techniques like hand lay up, filament winding, resin transfer molding, fultrusion. Effect of processing parameters on properties.

Extrusion of Thermosets
Pultrusion, application to pultruded products. Advantages and limitations of process.

Macromechanics
Macromechanical behaviour of a lamina : Stress strain relations for anisotropic materials, Engineering constants for orthotropic materials, Restrictions on elastic constants, Invariant properties of an orthotropic lamina, Biaxial strength theories for an orthotropic lamina, Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai-Wu tensor theory

Micromechanical behaviour of a lamina
Mechanics of materials approach to stiffness, Elasticity approach to stiffness, Particulate composites Mechanics of materials approach to strength

Macromechanical behaviour of a laminate
Classical lamination theory ,Symmetric laminates, Antisymmetric laminates, Nonsymmetric laminates, Inversion of stiffness equations, cross-ply laminate stiffnesses, Theoretical and experimental cross-ply laminate stiffness, Angle-ply liminate stiffnesses, Theoretical and experimental angle-ply laminate stiffnesses, Strength of laminates, Interlaminar stresses, Design of laminates

Bending, Buckling, and vibration of Laminated plates
Governing equations for bending, buckling, and vibration, Deflection of simply supported laminated plates under distributed lateral load, Buckling of simply supported laminated plates under in-plane load

References :

1. Fibre-glass Reinforced Plastics, N.P.Cheremisinoff (Ed), Noyce Pub. 1988.
2. Fibre Reinforced composites, P.K.Malik, Marcel Deckar, 1988.
3. Design Data for Reinforced Plastics, N.L.Hancex, R.M.Mayer, Chapman Hall, 1994
4. Reinforced Plastics : Properties and Applications,Raymond Seymour , The Materials Information Society, 1991.
5. Composite materials in Maritime Structures, R.A.Shenoi, J.F.Wellicome, Vol-I and II, Cambridge University Press,1993.
6. Mechanics of Composite Material, Robert Jones, McGraw Hill company,second edition,1999.

509125 [Elective III] (a) : Science and Engineering of Fibers

Teaching Scheme **Examination Scheme**
Lectures : 3 Hrs/week Paper : 100 marks

Definition, Classification and Spinning techniques of fibers

- Definition of fibers, denier, tex, yarns, filament, staple etc.
- Classification of fibers with advantages and disadvantages.
- Stages involved in production of synthetic fibers like PET, nylon, acrylics, PP, etc.
- Polymerization methods for PET, nylon, acrylics, PP, etc.
- Melt spinning, wet spinning, solution spinning, dry jet wet spinning, etc.
- Modified synthetic fibers.

Various sources of obtaining natural fibers

Raw materials and techniques used to obtain natural fibers like.

- Regenerated protein fibers
- Regenerated cellulosic fibers
- Analysis of melt spinning parameters, and their effects on structure and properties of fibers.
- Effect of orientation and crystallinity on properties.
- Structural changes during various methods like.
- High speed spinning.
- Drawing
- Heat setting
- Staple fiber production with steps

Mass coloration and its advantages and disadvantages

- Dyeing of synthetic fibers in loose and yarn form.
- Carrier dyeing, high temperature dyeing, thermosol process, acid and base dyeing, etc.

References :

1. Fundamentals of Fiber Formation, A.Ziabicki, John Willey , New York 1976
2. High Speed Fiber Spinning, A.Ziabicki and H.Kawari, John Willey, New York 1985.
3. Production of Synthetic Fibers, A.A.Vaidya, Prentice Hall Of India, 1988.
4. Artificial fibers by R.W. Moncrieff, Richand Clay and Company Ltd.

509125 [Elective III] (b) : Polymer Product Design

Teaching Scheme | **Examination Scheme**
Lectures : 3 Hrs/week | Paper : 100 marks

Product Design
Procedure and steps, Flowchart in product design. Structural foam product design, Mechanical properties, Short term and long term properties. Relaxation, Recovery of plastics, Maxwell model, Kelvin model, Zener model for visco elastic deformation. Design methods using deformation data, Pseudo - Elastic design methods for plastics, load bearing products; Stress concentration, Intensity factor, Fracture behavior of plastics, Energy approach to fracture. Creep failure of plastics, Fatigue, Impact behavior of plastics.

Parallel Engineering approach to product design.

Design of extruded products like pipes, profiles for various applications, blow molded products, thermoformed product, and rotational molded products like storage tanks.

Assembly of Parts
Various techniques of assembly like-mechanical fasteners, welding of thermoplastics, press fit and snap fit assemblies adhesive bonding.

Computer Aided Engineering
Study of development of flow analysis software :

a. Study of filling phase
b. Study of packing phase
c. Study of cooling
d. Study of shrinkage
e. Study of warpage

Finite element analysis for product design, modeling and meshing for computer simulation.

References :

1. Plastics Product Design, Beck, Van Nosrand Reinhold Publishers,1980.
2. Flow Analysis Of Injection Moulds, Peter Kennedy, Hanser Publishers 1995.
3. Plastics Materials Properties and Applications, A.W. Birley, M.J. Scott
4. Designing With Plastics and Composites, D.V. Rosato, Van Nostrand.
5. Product Design With Plastics, Dym J.B. Industrial Press,1983.
6. Plastics Product Design Handbook, E.D. Edward Miller, Marcel Dekkar
7. Plastics Engineering, R.J. Crawford Pergamon Press, 1982.

509125 [Elective III] (c) : Specialty Polymer Materials

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Study of structure property relationship of engineering plastics, effect of cross-linking on different polymer properties. Correlation between polymerization process and the structure of polymer obtained.

Liquid crystalline polymers
Thermo tropic polymers, their synthesis and properties of these polymers and applications, self reinforced composites.

Conductive polymers
Polyheterocyclic and polyacetylenes, their synthesis and recent advances, theory of conduction, field of application, conjugated polymers, sensors.

Heat resistant polymers
Preparation, curing reactions, their properties and applications.

Membranes : Cellulosics, polysulphones, PPS, polyacrylates and polyhyadrizes, methods, of manufacture, casting and applications. Polyurethanes membranes and IPNS. Reverse osmosis, applications.

Bio polymers
Polymers in medicines, drug carriers and controlled drug release, polymers in human body, silicones etc.

Materials for communication systems.
Polymers in construction and agriculture
Hydrogels, synthesis and characterization and water absorbing polymers.

Polymer Blends
Solution thermodynamics, theories of polymer miscibility. Flowry Huggins theory and other theories. Various commercial blends and their applications.

References :

1. Handbook Of Thermoplastics, Olagoke Olabisi, MARCEL, DEKKER INC.
2. Polymers For High Technology, Electronics And Photonics, M.J. Bowden and S.R. Turner. American Chemical Society 1987.
3. High Modulus Polymer, A. Zachariades and R.S. Porter,Decker Publication,1988.
4. Powder Coating – Chemistry and Technology, T.A. Miser J.Wiley NY 1991
5. Polymers For Space Research, C.L. Segal, F.N. Kelly, Marcel Dekker NY
6. Engineering polymers, R.W. Dyson Chapman Hall NY 1990

509126 [Elective IV] (a) : Paints and Adhesives

Teaching Scheme
Lectures : 3 Hrs/Week

Examination Scheme
Paper : 100 Marks

Introduction to paints, raw materials (vegetable oils, solvents, additives etc.). Manufacture of resins – alkyl, polyester, amino, phenolic, polyurethane, epoxy, silicone, acrylic.

Paint manufacture, formulating principles, architectural coating, industrial coating, automotive coatings, lacquers, varnish, powder coatings, water based coatings. printing inks,

Quality control, viscosity, gloss, various environmental resistance factors, mechanical properties, colour, coverage, volatile organic content, impact resistance, adhesion, chalking, chemical resistance. Safety measures.

Guidelines for good adhesion various theories of adhesion :
Diffusion, electrostatics, mechanical interlocking, merits and demerits of adhesive joint. Equilibrium contact angle, spreading prepare, work of cohesion and adhesion thermodynamics of coating spreading surface tension and surface energy critical surface tension.

Types of adhesives classification chemistry of epoxy, acrylic, elastomer modified, PU adhesives, pressure sensitive adhesives, hot melt adhesives solvent and emulsion based adhesives formulations of various adhesives health and safety aspects in adhesives industry.

Surface characteristics of various surfaces and pretreatments, mechanical testing of adhesives, properties of adhesives such as tack, viscosity cure time, etc.

References :

1. Organic coating Technology, Vol. I & I H.F. Payne.
2. Paints and Surface coatings, Lambourne (new),second edition,Woodhead Publication House,2004
3. Oil Colour Chem. Association, Surface Coatings, Vol. I & II.
4. Paint Technology Manuals, Vol. I to VI.Chapman And Hall,1974.
5. Encyclopedia of Chemical Technology, Vol. I page no. 445 – 446,Kirk and Othmer,Fourth Edition.
6. Encyclopedia of Chemical Technology Vol. VI page no. 669 – 760, Vol. XVII page no. 1049 – 1082, Kirk and Othmer, Fourth Edition
7. Oil & Colour Chemists Association, Surface coatings Vol. I, Champman & Hall, 1984.
8. Oil & Colour Chemists Association, Surface coatings Vol. II, Champman & Hall, 1984.
9. Surface Engineering Fundamentals of coatings, Datta P.K. & Gray J.S. Vol.I Londan. Royal Society of London, 1993.

10. Surface Engineering Fundamentals of coatings, Datta P.K. & Gray J.S. Vol.II Londan. Royal Society of London, 1993.
11. Surface Engineering Fundamentals of coatings, Datta P.K. & Gray J.S. Vol.III London. Royal Society of London, 1993.

509126 [Elective IV] (b) : Elastomer Technology

Teaching Scheme
Lectures : 3 Hrs/week

Examination Scheme
Paper : 100 marks

Objective
Elastomers are an important area of Material Science where polymeric materials are exclusively used. These materials find wide spread applications in automotive, aviation, marine, electrical industries. In this course the details pertaining to raw materials, formulations, processing, testing, applications have been presented. A sound understanding of these polymeric materials would equip the students for careers in rubber industry.

Revision of basic concepts
Rubber Elasticity: Physics of raw and vulcanized rubber. Kinetic and thermodynamics theory of rubber elasticity. Stress strain relationships for vulcanized rubber. Molecular basis for material to act as a rubber.

Stages in raw rubber and latex rubber technology such as mastication, mixing and compounding and vulcanization.

Study of various additives like peptizers, antioxidants, accelerators, activators, fillers, carbon black reinforcement, chords and fabrics, blowing agents, colorants, Processing aids like tackifiers, plasticizers, softeners, extender oils, their function, level of addition and stage of addition.

Characterization of compounds, rheological behaviour of compounds, properties influenced by compounding ingredients.

Processing of rubbers by extrusion, calendaring and injection moulding.

Manufacturing techniques for products such as tyres, belts, hoses, foot wears, cellular products and cables. Manufacture of latex based products such as dipped goods, foams and threads.

Testing of rubber products.

Study of major elastomeric materials like natural rubber SBR, NBR, IIR, CR, BR, with respect to synthesis, compounding considerations, cure characteristics.

Study of thermoplastic elastomers with respect to compounding, properties and applications.

Vulcanization of rubbers: Vulcanization by Sulphur and by other methods.
Chemical reactions, factors affecting rate of vulcanization.

Determination of cure rate of rubbers. Testing and analysis of raw rubber, compounds and vulcanizates. Testing finished rubber products, test methods and fundamentals.

References :

1. Science and Technology of Rubbers, J.E.Mark, B.Ermas, F.R.Eirich,"Academic Press 1994
2. Rubber Processing Technology, Materials and Principles, J.Lwhite, Hanser Publishers 1995
3. W.Hofmann "Rubber Technology Handbook, Hanser Publishers 1989
4. Rubber Technology and Manufacture C.M.Blow, C.Hepburn, Butterworth Publishers 1985.
5. Thermoplastics Elastomers, N.R.Legge, G.Holden, H.E.Schroedar Hanser Publishers 1987.
6. Rubber Technology Handbook, C. Hoffman, Hanser Pub. 1989.
7. Synthetic Rubbers: Chemistry and Technology, D.C. Blackley,Applied Science Publisher,1983.

509127 : Laboratory Practice - II

Teaching Scheme	**Examination Scheme**
Practicals : 6 Hrs/Week	T.W. : 50 Marks

Each student should perform at least and experiments / assignments form the list given below and submit the journal which will form the term – work for the subject.

1. Study of G.P.C. to determine MW and MWD of polymer and analysis of a result sheet obtained from GPC instrument.
2. Study of IR and FTIR for characterization of the structure of the polymers and interpretation of an IR spectrum obtained from the instrument.
3. Study of X-Ray scattering and X-Ray diffraction methods to determine crystallinity and orientation in polymers and analysis of a X-Ray diffraction pattern.
4. Study of optical microscopy and interpretation of an optical micrograph.
5. Study of scanning electron microscopy and interpretation of a SEM photograph.
6. Study of differential scanning calorimetry to determine thermal behavior of polymers and interpretation of a melting curve.
7. Interpretation of a crystallization (cooling) curve on DSC.
8. Interpretation and analysis of a DSC scan taken for isothermal crystallization.
9. Determination of intrinsic viscosity and viscosity average molecular weight of polystyrene / polyamide – 6 / polypropylene.
10. Study of dynamic mechanical analysis of polymers and interpretation of a typical graph obtained on DMA instrument.
11. Preparation & characterization by actual testing of single layered configurations of isotropic, orthotropic lamina.
12. Preparation and characterization of by actual testing symmetric laminates.
13. Preparation and characterization by actual test of anti symmetric laminates.
14. Preparation & characterization by actual test of non-symmetric laminates.
15. Preparation of Natural Fiber Reinforced Thermoplastics or Thermoset Composites.
16. Preparation of Thermoplastic fiber Reinforced Composites.

509128 : Seminar – II

Teaching Scheme	**Examination Scheme**
Practical : 4 Hr/Week	T.W. : 50 marks

Each student is required to deliver a seminar in second semester on the state of the art of the topic of his/her choice, preferably the topic of his/her dissertation and submit it in form of a short report.

609104 : Seminar – III

Teaching Scheme
Practical : 4 Hr/Week

Examination Scheme
T.W. : 50 marks

Each student is required to deliver a seminar in third semester on the state of the art of the topic of his/her choice, preferably the topic of his/her dissertation and submit it in form of a short report.

609105 : Project Stage I

Teaching Scheme **Examination Scheme**

Practicals : 18 Hrs/Week

Students are required to prepare a report based on project of their choice.

609106 : Project Stage II

Teaching Scheme	**Examination Scheme**
Practical : 18 Hrs/Week	T.W.:50marks / Project 200 Marks

Students are required to prepare report on project of their choice. They are required to submit project report and appear for the oral examination.