DR. A. P. J. ABDUL KALAM TECHNICAL UNIVERSITY

LUCKNOW, UTTAR PRADESH

STUDY & EVALUATION SCHEME WITH SYLLABUS

FOR

B. TECH. 3rd YEAR

PLASTIC ENGINEERING

[Effective from Session: 2020-21]

Syllabus Content of B. Tech Plastic Engineering

B. Tech Plastic Engineering
Evaluation Scheme

SEMESTER-V													
S. No	Subject codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KPE 501	Plastic Materials-II	3	1	0	30	20	50		100		150	4
2	KPE 502	Plastic Processing-II	3	1	0	30	20	50		100		150	4
3	KPE 503	Testing & Quality Control of Plastics	3	1	0	30	20	50		100		150	4
4		Departmental Elective-I	3	0	0	30	20	50		100		150	3
5		Departmental Elective-II	3	0	0	30	20	50		100		150	3
6	KPE 551	Plastic Material Testing lab	0	0	2				25		25	50	1
7	KPE 552	Plastic Product Testing Lab	0	0	2				25		25	50	1
8	KPE 553	Plastic Product & Mould Design Lab	0	0	2				25		25	50	1
9	KPE 554	Mini Project or Internship Assessment*	0	0	2				50			50	1
10	NC^{+}	Constitution of India / Essence of Indian Traditional Knowledge	2	0	0	15	10	25		50			
11		MOOCs (Essential for Hons. Degree)											
		Total	17	3	8							950	22

SEMESTER-VI													
S. No	Subject codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KPE 601	Advanced Processing Techniques	3	1	0	30	20	50		100		150	4
2	KPE 602	Additives & Compounding	3	1	0	30	20	50		100		150	4
3	KPE 603	Mould & Die Manufacturing	3	1	0	30	20	50		100		150	4
4		Departmental Elective-III	3	0	0	30	20	50		100		150	3
5		Open Elective-I	3	0	0	30	20	50		100		150	3
6	KPE 651	Polymer Characterization Lab	0	0	2				25		25	50	1
7	KPE 652	Mould & Die Manufacturing Lab	0	0	2				25		25	50	1
8	KPE 653	Additives & Compounding Lab	0	0	2				25		25	50	1
9	NC^{+}	Essence of Indian Traditional Knowledge/Constitution of India	2	0	0	15	10	25		50			
10		MOOCs (Essential for Hons. Degree)											
		Total	17	3	6							900	21

Plastic Engineering Departmental Electives

Students can choose any elective horizontally from the pool of electives.

	Specialization -1	**Specialization -2**	**Specialization -3**	**Specialization -4**
Sem V Code	**KPE 051**	**KPE 052**	**KPE 053**	**KPE 054**
Departmental Elective-I	Plastic Product & Mould Design	Polymer degradation & stabilization	Plastic Packaging Technology	Polyurethane Technology
Sem V Code	**KPE 055**	**KPE 056**	**KPE 057**	**KPE 058**
Departmental Elective-II	Plastics Waste Management And Recycling Techniques	Heat & Mass Transfer	Special Processes & Techniques	Physical Chemistry of Polymers
Sem VI Code	**KPE 061**	**KPE 062**	**KPE 063**	**KPE 064**
Departmental Elective-III	Analysis and Characterisation of Polymers	Speciality Polymers	Adhesives & Surface Coating	Fibre Technology
Sem VII Code	**KPE 071**	**KPE 072**	**KPE 073**	**KPE 074**
Departmental Elective-IV	Polymer composites	Biomedical Plastics	Conducting Polymers	Polymer Structure Property relationship
Sem VII Code	**KPE 075**	**KPE 076**	**KPE 077**	**KPE 078**
Departmental Elective-V	Biodegradable Polymers	Rubber Technology	Polymer Nanomaterials	Thermoplastic Elastomers

Subject Code: KPE 501	Plastic Materials II	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand concepts of engineering plastics and their applications	K2
CO-2	Understand concepts of thermoset plastics and their specific applications	K2
CO-3	Understand knowledge of manufacturing, properties and applications of high end application plastics.	K2
CO-4	Understand the manufacturing, properties and applications of thermoplastic elastomers	K2
CO-5	Understand knowledge of manufacturing, properties and applications of speciality plastics	K2

UNIT I

Engineering Plastics

Introduction – Sources and manufacture of raw materials – basic chemistry – Methods of manufacture – Flow behaviour – General properties and applications of -Polyamides – Nylon 6, 66 etc.; Acetal-Homopolymer & Co-polymer, Polycarbonate, Thermoplastics Polyester, Polyphenylene oxide.

UNIT II

Thermosets

Introduction – Sources for raw materials – resin preparation – polymer structure, additives – curing and cross linking–agents, processing behavior, general properties and applications of Phenol formaldehyde, Urea formaldehyde, Melamine formaldehyde, Unsaturated polyesters, Polysulfones.

UNIT III

Sources and manufacture of raw materials

Basic chemistry – Methods of manufacture – Flow behaviour – General properties and applications of Fluoropolymers, Polyvinyl fluoride, Polyvinylidene fluoride, Polypheneylene oxide, Polyphenylene sulphide, Polytetrafluoroethylene, Polychlorotrifluoroethylene, Polyimidazoles, Polyetheretherketone.

UNIT IV

Thermoplastic elastomers

Basic structure, Manufacture, Morphology, Commercial grades and Applications –Thermoplastic styrene block copolymers, Polyester thermoplastic elastomers, polyamide thermoplastic elastomer, Polyurethane thermoplastic elastomers.

UNIT V

Speciality Polymers

Metallocene Polymers, High & Low Temperature Polymers, Interpenetrating Polymer Networks, Ultra-high modulus fibres, Polymeric foams.

Text Books :-

1. Plastic Materials Ed 7 - By Brydson, J A,1999.

2. Hand Book of Plastics Materials & Technology - By Rubin, Irwin, J,1990.
3. Manas Chanda, Salil.K.Roy, “Plastics Technology Hand book”, 2nd edition, Marcel Dekker, New York, 1993.
4. Matrin.T.Goosey, “Plastics for Electronics”, Elsevier, Applied Science, 1985.
5. R.W. Dyson, “Specialty Polymers”, Chapman & Hall, 2nd edition, 1998.

References :-

1. Plastics Engineering Hand Book Ed. 5 & Society of the Plastic Industry Inc - By SPI,1994.
2. Plastics Materials and Processing - By Schwartz & Goodman,1982.
3. Plastics Materials (Properties & Application) - By Birley & Scott,1982.
4. Modern Plastics Hand Book - By Harper, 2000.
5. Birley; Arthur W. and Scott; Martyn J., Plastics Materials: Properties and Applications, Leonard Hill, Blackie and Sons Ltd., 1982.
6. Biron; Michel, Thermoplastics and Thermoplastic Composites: Technical Information for Plastics Users, Elsevier, Amsterdam, 2007.
7. DuBois; P, Plastics in Agriculture, Applied Science Publishers Ltd., London 1978
8. H.F.Mark, (Ed), “Encyclopedia of polymer Science & Engineering”, John Wiley & Sons, New York, 1989.
9. Johannes Karl Fink, ‘Handbook of Engineering and Speciality Thermoplastics’, Volume
10. Water Soluble Polymers, John Wiley & Sons, New Jersy, 2011.
11. David Kaplan ,’’Biopolymers from renewable resources” ,Springer,1998.

Subject Code: KPE 502	Plastic Processing II	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the knowledge of processing of plastic by using Injection Moulding machine	K2
CO-2	Understand the process of thermoforming of plastics	K2
CO-3	Understand the process of making hollow products by using blow moulding technique	K2
CO-4	Understand the process of rotational moulding	K2
CO-5	Understand how plastics are joined and assembled	K2

UNIT I

Injection Moulding

Introduction, Historical Background, advantages, Types of Injection Moulding Machines, Screw, Moulds, Material Selection for Injection Moulding, Clamping Systems, Machine operations, Machine selection, Plastic melt behaviour inside barrel & mould, Machine operation, Process controls, Machine controls, Post moulding operations, Faults & Remedies.

UNIT II

Thermoforming Process

Various stages of thermoforming process, various methods of forming, Vacuum Forming techniques, Pressure forming techniques, Advantages and disadvantages of thermoforming, Applications of thermoforming Process, Material requirements, Thermoforming Machines, Single-stage sheet fed machine, Multiple stage sheet fed machine, In-line sheet fed machine, Continuous roll fed machine, Packaging machines, Processing Requirements, Heating methods, Temperature control, Vacuum/air pressure, Cooling, Trimming, Process Variables, Trouble Shooting.

UNIT III

Blow Moulding

History, process, material & design considerations, types of blow moulding machines, Extrusion blow moulding, Continuous & intermittent, trimming operation, parison programming, Injection blow moulding, Injection stretch blow moulding, single stage & two stage operation, Common faults & remedies. Multi layer Blow moulding.

UNIT IV

Rotational Moulding

History, process, advantages & disadvantages, material requirements, Rotational moulding machines, rotational moulding moulds, part design, process variables, common faults & remedies.

Surface treatment

Pre-treatment methods, Mechanical abrasion, Flame treatment, Chemical etching, Corona treatment, Plasma Treatment, Electrical surface treatment, Applications

Metallization

Vacuum Metallization (Vacuum evaporation, sputtering), Plating (Electroless Plating, Electrolytic Plating).

UNIT V

Joining & assembling

Introduction, Mechanical connection, Gluing (solvent bonding, adhesive bonding, theory of adhesion), Welding (Vibration welding, Spin welding, Ultrasonic welding, Hot-plate welding, Induction welding, Laser welding, Radio frequency welding, Resistance welding, Hot gas welding, Staking)

Text Books :-

1. Allen; W. S. and Baker; P. N., Hand Book of Plastic Technology, Volume-1, Plastic Processing Operations [Injection, Compression, Transfer, Blow Molding], CBS Publishers and Distributors, New Delhi (2004).Injection Molding Theory & Practice By Rubin, Irvin.
2. Injection Molding Hand Book By Rusto,D.V & Rosato, D.V, Plastic Engineering Hand Book, by Society of Plastic Industry Inc.,2000.
3. Plastics Material & Processing By Strong, A, Brent , Blow Molding Hand Book By Rosato, D.V & Rosato, D.V, Plastic Extrusion Technology By Hensen.

References :-

1. A Guide to Injection Molding of Plastics By Bolur, P.C.,
2. Development in Injection Molding By Whelan, A & Craft, J.L.
3. Technician's Hand Book & Plastics By Grandilli, P.A.,1990.
4. Plastics Materials & Processing By Schwartz & Goodman.,1982.
5. Injection Molding By Athalye, A.S.,1997.
6. Injection Molding Technology By V.D.I.
7. Innovation in Polymer Processing By Stevenson.,1996.

Subject Code: KPE 503	Testing & Quality Control Of Plastics	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the various testing and quality control techniques for plastics.	K2
CO-2	Apply various processes and techniques used in determining mechanical properties of plastic materials	K3
CO-3	Apply various processes and techniques used in determining thermal properties of plastics	K3
CO-4	Apply various processes and techniques used in determining permeability parameters	K3
CO-5	Apply various processes and techniques used in determining electrical properties of plastic materials	K3

UNIT I

Importance of testing

Standard and specification, National and International standards, Test specimen preparation – Preconditioning and test atmosphere. Identification of common plastics materials by simple test e.g. Visual inspection, density, effects of heat, combustion and solvents, analysis with common solvents.

UNIT II

Mechanical Properties

Density and dimensions, Hardness, tensile strength, compressive strength, flexural strength, impact strength, dynamic stress – strain Properties, creep, friction and wear, abrasion resistance test, fatigue, burst strength, folding endurance.

UNIT III

Thermal properties

Specific heat and thermal conductivity, thermal endurance, glass transition temperature, thermal yield tests, Heat deflection

Temperature, Vicat softening temperature, Marten's heat resistance test, low temperature brittle point and flexibility test, coefficient of thermal expansion, shrinkage, Thermal stability, Thermal ageing and flammability.

UNIT IV

Permeability properties

Water absorption, soluble and insoluble matter- chemical resistance, environmental stress cracking resistance, ageing, gas permeability, water vapour permeability and weathering.

Processing and flow properties, Melt flow index, Optical properties, Refractive index, light transmission, haze, clarity, gloss, colour guard and microscope.

UNIT V

Electrical properties

Insulation resistance, power factor, permittivity, dielectric strength, tracking resistance, arc resistance and antistatic test.

Product testing

pipe and fittings- film and sheets –container testing and FRP based products.

Factors affecting the quality of materials and products. Uncertainty measurement. Analysis of failure and its measurements.

Text Books :-

1. Allen; W.S and Baker; P.N, Hand Book of Plastics Technology, Volume 2, Identification, Testing & Recycling of Plastics, CBS Publishers and distributors, New Delhi (2004).
2. Brown; Roger P (Ed.), Hand Book of Polymer Testing, Marcel Dekker, Inc, New York, (1999).

References :-

1. Brown; Paul F (Ed), Hand Book of Plastics Test Methods, Longman Scientific and Technical, Harlow (1988).
2. Shah, Vishu, Hand Book of Plastics Testing Technology, John Wiley and Sons, SPE Monograph (1984).
3. Blythe; A. R., Electrical Properties of Polymers, Cambridge University Press, Cambridge (1979).

Subject Code: KPE 551	Plastic Material Testing Lab	L T P : 0 0 2	Credits: 1

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Apply contour cutting technique to prepare a specimen as per given standard	K3
CO-2	Determine basic properties of plastic materials related to nature and composition	K3
CO-3	Calculate thermal stability and melting temperature of polymers	K3
CO-4	Measure various electrical properties of plastics	K3
CO-5	Determine various mechanical properties of plastics	K3

Minimum eight experiments out of the following

1. Specimen preparation using contour cutter .
2. Determination of Ash Content of a plastic sample.
3. Determination of Moisture Content of a plastic sample.
4. Determination of Filler content of a plastic sample.
5. Determination of Melt flow index of a plastic sample.
6. Determination of Opacity of a plastic sample.
7. Determination of HDT/VST & melting temperature of a plastic sample.
8. Determination of Dielectric strength/Tracking Index of a plastic sample.
9. Study of Weathering properties of plastic materials.
10. Determination of Density of a few plastic material samples and film samples.
11. Determination of Bulk density for powder materials.
12. Determination of Mechanical properties (Tensile strength/Modulus, Flexural Strength /Modulus, Elongation at break, Young' Modulus, creep resistance, compression strength of Plastic Material.
13. Determination of abrasion resistance of a plastic sample.
14. Determination of Impact strength of a plastic sample.
15. Determination of Hardness of a plastic sample (Rockwell, Durometer)

Subject Code: KPE 552	Plastic Product Testing Lab	L T P : 0 0 2	Credits: 1

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Carryout testing of various parameters of plastic pipes	K3
CO-2	Conduct testing of plastics films, water tanks etc	K3
CO-3	Measure various quality parameters of Baby feed bottles and milk pouches	K3
CO-4	Carryout testing as per standard of Pipe fittings	K3
CO-5	Conduct testing of PVC conduits, FRP sheets etc	K3

Minimum eight experiments out of the following

1. Testing of HDPE Pipes
2. Testing of UPVC Pipes
3. Testing of Water Storage Tanks
4. Testing of Films/Sheets,
5. Testing of HDPE/PP Woven Sacks/Tapes,
6. Testing of Baby Feed Bottles,
7. Testing of Milk Packing Pouches
8. Testing of Meter box Cover.
9. Testing of UPVC Pipe Fitting
10. Testing of Irrigation Product-Lateral
11. Testing of Irrigation Product-Emitters
12. Testing of Irrigation Product-Quick Coupled Pipes
13. Testing of FRP Sheets
14. Testing of PVC Conduit

Subject Code: KPE 553	Plastic Product & Mould Design Lab	L T P : 0 0 2	Credits: 1

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Design Injection Moulds using CAD software	K3
CO-2	Design Compression Moulds using CAD software	K3
CO-3	Design Transfer & Blow moulds using CAD software	K3
CO-4	Develop the moulds using CAM/CAE software	K3
CO-5	Analyse mould flow and optimize the designs	K4

I. Mould Design using CAD

a) Injection Mould design: Design calculations for No. of cavities, Selection of injection moulding machine, shot capacity, plasticizing rate, Clamping force and 2 D / 3 D Modeling for Two plate, Three Plate and split Moulds
b) Compression Mould Design: Design calculations for No. of cavities, Flash thickness allowances, Design of loading chamber, Bulk factor, Pressure pad, Heaters and 2 D / 3 D Modeling for Compression Mould.
c) Transfer Mould Design: Design calculations for Pot, Bulk factor, Heaters and 2 D / 3 D Modeling for Pot and Plunger transfer Moulds.
d) Blow Mould Design: Design calculations for Clamping force, pinch-off, Head die design, Parison dimensions and 2 D /3 D Modeling for Blow Mould.

II. CAM Programming

Programming and Machining of mould elements (Core, Cavity, Gide Pillar and Guide Bush) using CNC Turning Center and CNC Machining Center.

III: Mould flow Analysis

a) Design Optimization of Plastic Part, Mould and Process parameters optimization using Moldflow Software
b) Modeling, Mesh Creation, Mesh Checking, Surface repair, Creating Feed system and cooling system.
c) Analysis: Gate location, Moulding window Fill, Flow, Cool, Pack, Warp, Shrinkage, Stress

Subject Code: KPE 051	Plastic Product & Mould Design	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the basics of Plastics mould design and also product design.	K2
CO-2	Acquire knowledge about various moulds for different processing techniques.	K2
CO-3	Understand the knowledge of design parameters of an Injection mould	K2
CO-4	Understand various design parameters for a split mould	K2
CO-5	Design the extrusion dies for pipes and sheets	K3

UNIT I

Design of polymeric product

Design criteria based upon product functions and geometry. Material selection by property assessment. Selection of appropriate forming processes.

Moulding considerations

Draft, radii, dimensional tolerances, wall thicknesses, ribs and bosses, inserts, sink marks, undercuts, feeding system, gate location, flow pattern, shrinkage and post moulding shrinkage.

UNIT II

Design of Plastic under static load

Design of Plastic under Dynamic load, Metal insert, hinge, fasteners.

UNIT III

Injection mould design

Single, multicavity, semi automatic and automatic moulds. Types of injection moulds, their application, detailed structure and working. Feed system, Temperature control system, Ejection System, Standard Mould base.

UNIT IV

Split Mould and types of mechanism, Unscrewing mechanism, Introduction to Hot runner mould. Design concepts for compression moulds, transfer moulds and blow moulds.

UNIT V:

Extrusion Dies

Types of extrusion dies and design characteristics. Die Design for Pipe and Sheet.

Text Books :-

1. Peter Jones, The Mould Design Guide, Smithers Rapra Technology Limited, 2008, Shawbury, Shrewsbury, Shropshire, SY4 4NR, UK
2. Injection Mould Design for Thermoplastic - By Pye, R.G.W.,2000.

References :-

1. Injection Mould Design Fundamentals (Vol. I& II) - By Glanvill & Denton
2. Plastics Moulds & Dies - By Sors et al., Second Edition
3. Fundamentals of plastics mould design – By Sanjay K Nayak, Pratap Chandra Padhi and Y. Hidayathullah, 2012.
4. Dym J.B Injection Mould& Molding A practical manual, Springer, Second Edition.

Subject Code: KPE 052	Polymer Degradation And Stabilisation	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the thermal degradation of polymer	K2
CO-2	Understand various aspects of mechanical and Ultrasonic degradation	K2
CO-3	Acquire knowledge of degradation of plastics by the effect of light	K2
CO-4	Understand knowledge of the phenomenon of biodegradation of polymers	K2
CO-5	Understand the knowledge about Chemical methods of degradation of polymers	K2

UNIT I

Introduction and Thermal Degradation

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 Degradation and Ultrasonic Degradation

Introduction, Mechanistic Aspects, Degradation Studies, Polymer Degradation in Solution. Ultrasonic Degradation, Importance, Experimental Methods, Mechanism of Ultrasonic Degradation (Cavitation 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

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

Degradation By High Energy Radiation and Biodegradation

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 Copolymerization Bio degradation, Modes of Biological Degradation, Enzymatic Degradation in Bio Polymers (Polysaccharides, Proteins, Malice Acids)

Microbial Degradation of Synthetic Polymers, General Applications of Bio Degradable Plastics, Examples of Biodegradable Polyesters and Polyamides.

UNIT V

Chemical Degradation

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, Cationic Degradation of Polypropylene Sulphide and Polyesters.

Text Books :-

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.

Subject Code: KPE 053	Plastics Packaging Technology	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the knowledge of properties for selection of packaging materials	K2
CO-2	Understand the techniques for production of packaging materials	K2
CO-3	Acquire knowledge about various aspects of flexible packaging	K2
CO-4	Understand various forms of rigid packaging	K2
CO-5	Understand testing of plastic packaging	K2

UNIT I

Selection Criteria for Packaging Materials

Introduction to plastics packaging: functions of packaging, advantages of plastic packaging, special requirements of food and medical packaging, Packaging as a system: Elements, approach, package, design, relation criteria for packaging materials, packaging equipment checklist, case histories, major packaging plastics, Introduction - PE, PP, PS, PVC, polyesters, PVA, EVA, PA, PC, ionomers & fluoro polymers.

UNIT II

Conversion Process for Packaging Materials

Conversion process, Compression & transfer for moulding, Injection moulding, Blow moulding, Extrusion, roto moulding, thermoforming, Lamination, metallizing, decoration process, Shrink wrapping, Pallet & stretch wrapping

UNIT III

Process for flexible Packaging

Extrusion, film and flexible packaging, extrusion, cast film & sheet, Blown film, Multi layer film & sheet coatings, coextrusions, pouching, sealing, evaluation of seals in flexible packages, advantages of flexible packaging, flexible packaging products.

UNIT IV

Processes for Rigid Packaging

Thermoformed, moulded and rigid packages, Thermoforming packages: Thermoforming & wrap forming, solid phase pressure forming, scrabbles, twin sheet & melt - to- mould thermoforming, skin packaging, Polystyrene & other foams systems cushioning, plastic pallets, drums , shipping containers.

UNIT V

Testing of plastic packaging

Testing of plastic packages, barrier, migration & compatibility, Sterilization systems and health care products. Packaging hazards and their controls. Waste management act 2016.

Text Books :-

1. Susan E.M. Seleke, “Understanding Plastic Packaging Technology”, Hanser Publications – Munich.

2. A.S. Altalye, “Plastics In Packaging”, Tata Mcgraw–Hill Publishing Co. Ltd., New Delhi.
3. Mechanics’ Of Cellular Plastics By Hilyard
4. Hand Book Of Polymeric Foams & Foam Technology By Klempner

Subject Code: KPE 054	Polyurethane Technology	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand chemistry and materials of polyurethane manufacture	K2
CO-2	Understand various types of raw materials used in preparation of PU	K2
CO-3	Understand the production of flexible and rigid polyurethane foam	K2
CO-4	Explain the knowledge of production, properties and uses of solid polyurethane	K2
CO-5	Explain the knowledge of PU applications as coatings and adhesives	K2

UNIT I

Introduction to polyurethane

Chemistry and materials of polyurethane manufacture: basic reaction, cross linking in polyurethane, important building blocks for polyurethane (isocyanates, polyols, amines and additives) the manufacture of polyurethanes (the process, parameters and controls).

UNIT II

Polyurethane processing

basic design principles of polyurethane processing equipment, steps in the polyurethane processing Flexible foams-(production, properties and application slab stock foam, carpet backing, flexible moulded foams & semi rigid moulded foams. Reinforced RIM: trends in the use of RIM and RRIM.

UNIT III

Rigid polyurethane foams

chemistry of raw materials, manufacturing of rigid polyurethane (manufacturing of buns, panels, foaming of applications, moulded rigid foams), properties, relationship between production methods and properties- application of rigid polyurethane, Polyurethane skin integral foam-production, properties and applications.

UNIT IV

Solid polyurethane materials

polyurethane casting systems (cast elastomers and casting resins), thermoplastic polyurethane elastomers: productions / processing, properties and applications, polyurethane paints and coatings, adhesives builders, elastomer fibers, manufacture / processing and applications.

UNIT V

Determination of composition and testing of polyurethane

chemical compositions, detection methods, identification of functional groups, determination of properties of materials and products (Characterization, physical/mechanical, temperature dependence, chemical performance, combustibility) polyurethane and environment health and safety: making and using polyurethane safely.

Text Books :-

1. Dr. Gumter Oertal (ed.), Polyurethane Hand Book, Hanser Publication Munich.
2. George woods, The ICI Polyurethane book -published journals by ICI, John Wiley and sons NY

References :-

1. David Landel and Steve Lee, Poly Urethanes, John Wiley 2002.
2. James Henry Saunders and Kurtz Charles Frisch, Poly Urethanes: Chemistry and Technology, R. E. Krieger, 1987.

Subject Code: KPE 055	Plastics Waste Management And Recycling Techniques	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand various forms of waste and its segregation	K2
CO-2	Understand the impact of plastic waste on environment	K2
CO-3	Understand various methods of recycling of commodity plastics	K2
CO-4	Explain various aspects of recycling of engineering plastics	K2
CO-5	Acquire knowledge of various policies & legislations related to environmental issues of plastics waste.	K2

UNIT I

Plastic waste generation & separation techniques

Plastics production and consumption, Plastic waste generation, source and types, Plastic waste composition, quantities, Plastics identification methods physical, chemical and instrumental, sorting and separation technologies, disposal alternatives, Recycling methods, Primary, Secondary and tertiary recycling of plastics, Case studies of plastic waste management, success stories of various Indian cities, conversion of plastic waste into fuel, use of plastic waste in concrete and making of Plastic road, plastic waste in cement kilns, Plastic Recycling & Waste Management Guidelines.

UNIT II

Processing of Commingled Plastic Waste

Size reduction of recycled plastics, cutting / shredding, densification, pulverization and chemical size reduction processes, municipal solid waste and composition, recycling of plastics from urban solid wastes, household waste, industrial sector, density and mechanical properties of recyclable plastics, Processing of commingled / mixed plastic waste, super wood, plastic lumber.

UNIT III

Recycling of Polyolefins, Pet & PVC

Recycling of polyolefins, polyethylene films, Polypropylene battery case recycling, Recycling of HDPE fuel tanks, PET recycling methods, PET film/bottle recycling, Applications of polyolefin and PET recyclate, PVC recycling.

UNIT IV

Recycling of Engineering Thermoplastics

Engineering thermoplastics and their major areas where engineering polymers are recycled, Recycling of Polymers like PC, PBT, Nylon, PPO, ABS and polyacetals and their blends. Applications and value addition.

UNIT V

Recycling of Thermosets

Recycling of Polymer thermoset composites, regrind processes, SMC scrap, Pyrolysis and energy recovery, Types of rubber products, rubber grinding methods, tyre grinding, rubber crumb

applications, Reclaiming and de-vulcanization processes, tyre derived fuel and energy recovery, Pyrolysis of scrap tyres.

Text Books :-

1. Polymer recycling, “Science, Technology and Applications, John Scheirs, John Wiley & Sons, England 1988
2. “Recycling of Plastic Materials (Ed)”, Francesco Paolo La Mantia, Chem Tec Publishing.
3. “Plastics Waste Management (Ed)”, Nabil Mustafa, Marcel Dekker, New York,1995.

References :-

1. Degradeable polymers, Recycling and Plastic Waste Management (Eds) Ann Christine Albertson and Samuel J. Huang, Marcel Dekker, New York.
2. John Schiles, Polymer Recycling.
3. Recycling & Plastics Waste Management, Edited by Dr. J. S. Anand, CIPET, 1997.

Subject Code: KPE 056	Heat & Mass Transfer (Same as KME 501)	L T P : 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the fundamentals of heat and mass transfer.	K2
CO-2	Apply the concept of steady and transient heat conduction.	K3
CO-3	Apply the concept of thermal behavior of fins.	K3
CO-4	Apply the concept of forced and free convection.	K3
CO-5	Apply the concept of radiation for black and non-black bodies.	K3
CO-6	Conduct thermal analysis of heat exchangers.	K4

UNIT-1

Introduction to Heat Transfer (5 Hours)

Introduction of thermodynamics and Heat Transfer, Modes of Heat Transfer: Conduction, convection and radiation, Effect of temperature on thermal conductivity of different types of materials, Introduction to combined heat transfer mechanism, General differential heat conduction equation in the rectangular, cylindrical and spherical coordinate systems, Initial and system boundary conditions.

Steady State one-dimensional Heat conduction (3 Hours)

Simple and Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation, Concept of thermal resistance, Analogy between heat and electricity flow, Thermal contact resistance and over-all heat transfer coefficient, Critical radius of insulation for cylindrical, and spherical bodies.

UNIT-2

Fins **(3 Hours)**

Heat transfer through extended surfaces and its classification, Fins of uniform cross-sectional area, Error in measurement of temperature of thermometer wells.

Transient Conduction **(3 Hours)**

Transient heat conduction, Lumped capacitance method, Time constant, Unsteady state heat conduction in one dimension only, Heisler charts and their applications.

UNIT-3

Forced Convection **(5 Hours)**

Basic concepts: Hydrodynamic boundary layer, Thermal boundary layer, Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Mixed boundary layer, Flow over a flat plate, Flow across a single cylinder and a sphere, Flow inside ducts, Thermal entrance region, Empirical heat transfer relations, Relation between fluid friction and heat transfer, Liquid metal heat transfer.

Natural Convection **(5 Hours)**

Physical mechanism of natural convection, Buoyant force, Empirical heat transfer relations for natural convection over vertical planes and cylinders, horizontal plates, cylinders and sphere, combined free and forced convection, Effect of turbulence.

UNIT-4

Thermal Radiation **(8 Hours)**

Basic concepts of radiation, Radiation properties of surfaces, Black body radiation Planck's law, Wein's displacement law, Stefan-Boltzmann law, Kirchhoff's law, Gray body, Shape factor, Black-body radiation, Radiation exchange between diffuse non-black bodies in an enclosure, Radiation shields, Radiation combined with conduction and convection; Absorption and emission in gaseous medium; Solar radiation; Greenhouse effect, Radiation network analysis.

UNIT-5

Heat Exchanger **(5 Hours)**

Different types of heat exchangers, Fouling factors, Overall heat transfer coefficient, Logarithmic mean temperature difference (LMTD) method, Effectiveness-number of transfer unit (NTU) method and Compact Heat Exchangers.

Condensation and Boiling **(3 Hours)**

Introduction of condensation phenomena, Heat transfer relations for laminar film condensation on vertical surfaces and on outside& inside of a horizontal tube, Effect of non-condensable gases, Drop wise condensation, Heat pipes, Boiling modes, pool boiling, Hysteresis in boiling curve, Forced convection boiling.

Introduction to Mass Transfer **(2 Hours)**

Introduction of Fick's law of diffusion, Steady state equimolar counter diffusion, Steady state diffusion through a stagnant gas film, Heat and Mass Transfer Analogy -Convective Mass Transfer Correlations

Reference Books:-

1. Fundamentals of Heat and Mass Transfer, by Incroperra& DeWitt, John Wiley and Sons
2. Heat and Mass Transfer by Cengel, McGraw-Hill
3. Heat Transfer by J.P. Holman, McGraw-Hill
4. Heat and Mass Transfer by Rudramoorthy and Mayilsamy, Pearson Education
5. Heat Transfer by Ghoshdastidar, Oxford University Press
6. A text book on Heat Transfer, by Sukhatme, University Press.
7. Heat Transfer by Venkateshan, Ane Books Pvt Ltd
8. Schaum's outline of Heat Transfer by Pitts & Sisson McGraw-Hill
9. Heat and Mass Transfer by R Yadav, Central Publishing House

Subject Code: KPE 057	Special Processes & Techniques	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Acquire the knowledge of various aspects of casting process	K2
CO-2	Familiarized with the process of Dip moulding	K2
CO-3	Understand the process of printing of plastics using various techniques	K2
CO-4	Understand the process of coating of plastics	K2
CO-5	Understand how plastics are machined	K2

UNIT I

Casting Process

Introduction, Types (Conventional, Solvent, Rotational, Slush), Advantages & applications.

UNIT II

Dip Moulding

Principle, Process, Materials, Inline & chain machines, Rotary machines, advanced machines, Advantages, Applications of dip moulding & dip coating, Limitations, Tooling requirements.

UNIT III

Printing of Plastics

Principles, advantages, requirements, Types (Pad printing, Screen printing, Rotogravure, Laser printing, Hot stamping, Hot transfer Printing, In mould decoration, Film insert moulding, in mould transfer decoration)

UNIT IV

Coating of Plastics

Extrusion coating, Calendar coating, Powder coating, Transfer coating, Knife or roller coating, Spray coating. Applications

UNIT V

Machining of plastics

Principle, Different types of operations, Drilling, reaming, threading, and tapping, Sawing & cutting, Milling, Turning & boring, Punching, blanking die cutting, Laser cutting, Polishing. Applications.

Text Books :-

1. Plastic Engineering Hand Book & D – 5 - By Society of Plastic Industry Inc.
2. Plastics Material & Processing- By Strong, A, Brent

References :-

1. Cheremisinoff; Nicholas P. and Cheremisinoff; Paul N. (Eds.), Handbook of Applied Polymer Processing Technology, Marcel Dekker Inc., New York (1996)
2. Plastics Materials & Processing - By Schwartz & Goodman Thermoforming - By James & Throne.

Subject Code: KPE 058	Physical Chemistry of Polymers	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Acquire knowledge about various aspects of energy states of polymers	K2
CO-2	Explain various concepts of thermodynamics of polymers	K2
CO-3	Acquire knowledge of amorphous state of polymers	K2
CO-4	Acquire knowledge about crystalline state of polymers	K2
CO-5	Understand the phenomenon of chain orientation of polymers	K2

Physical Chemistry of Polymers

UNIT I

Potential energy and conformational energy of molecules

Staggered and eclipsed states - conformations and configurations, isomeric states and isomerism in polymers - Tacticity, stereoisomerism, geometric isomerism - Unperturbed and Gaussian chains - Random coils and average end to end distance - Freely jointed and freely rotating chain models – Random flight analysis.

UNIT II

Thermodynamics

First and second law of Thermodynamics, Carnot cycle - Entropy and enthalpy - Energy driven and entropy driven elasticity - Thermoelasticity – Thermodynamic treatment of rubbers - entropic and energetic contributions to the elastic force in rubbers - Statistical mechanical theory.

UNIT III

Amorphous State

Transition temperatures - Glass transition temperature - Free volume, kinetic, and thermodynamic views of glass transition - Factors influencing glass transition temperature.

UNIT IV

Crystalline State

Crystal systems, unit cells, primitive cell, Bravais lattices, polymorphism - Polymer single crystals, lamellae, spherulites, supermolecular structures, fringed micelle model - Degree of crystallinity, factors affecting crystallinity - X-ray diffraction.

UNIT V

Chain orientation

Concept of chain orientation - orientation in amorphous and crystaline polymers - Uniaxial and biaxial orientation practical significance - Orientation processes - fibre spinning, blown film extrusion, solid state extrusion, profile extrusion - Properties of oriented polymers - Birefringence.

Text Books :-

1. S. Glasstone and D. Lewis, Elements of Physical Chemistry, Macmillan India Press, Madras, 1995.

2. Paul C. Painter and Michael M. Coleman, Fundamentals of Polymer Science, Technomic Publishing Co. Inc., Lancaster, USA, 1994.
3. Ulf W. Gedde, Polymer Physics, Chapman & Hall, 1995.

Subject Code: KPE 601	Advanced Processing Techniques	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the concepts of thermoset injection moulding.	K2
CO-2	Acquire knowledge of processes for manufacturing of different Plastic foams.	K2
CO-3	Understand the concepts of gas & water Injection moulding.	K2
CO-4	Acquire knowledge about various forms of plastics laminates.	K2
CO-5	Explain the phenomenon of sandwich moulding.	K2

UNIT I

Thermoset Injection Molding

Principle, Materials, Process description, Machine Design, Set up procedure and process parameter, Troubleshooting, Applications

Reaction Injection Moulding

Principle, Materials, Process description, Process parameters, Applications.

Resin Transfer Moulding

Principle, Materials, Additives, Process description, Process Characteristics, Troubleshooting

UNIT II

Plastic Foam Molding, Structure Foam Moulding

Principle, Materials, Process description and its types, Process Characteristic, Trouble shooting, Applications.

Expandable Bead Foam

Principle, Materials, Process description and its types, Process Characteristic, Trouble shooting, Applications.

Extruded Thermoplastics Foams

Principle, Materials, Additives, Process Description, Process parameter, Blowing Agents, Applications.

UNIT III

Gas Assist Injection Moulding

Principle, Features and Benefits of GAIM, Process description and its types, Applications.

Water Assist Injection Moulding

Principle, Process description and its types, Applications

Microcellular Plastic Technology

Principle, Process description and characteristic, Cellular and microcellular plastics.

UNIT IV

Laminates

Principle, Material used, Additives, Process Description and its types, Process Parameters, Applications

Thin Wall Moulding

Principle, Part Design, Gate Concept, Demolding Technology, Tool rigidity, Process description, Applications.

UNIT V

Co-injection or Sandwich Molding

Principle, Advantages, Process description and its types, Effects of Viscosity, Benefits of co-injection molding

Multi Component Molding

Principle, Materials, Process description and its types

Lost core moulding process

Principle, Material used and its grade, Major applications.

Text Books :-

1. Plastic Engineering Hand Book & D – 5 - By Society of Plastic Industry Inc.
2. Plastics Material & Processing- By Strong, A, Brent

References :-

1. Cheremisinoff; Nicholas P. and Cheremisinoff; Paul N. (Eds.), Handbook of Applied Polymer Processing Technology, Marcel Dekker Inc., New York (1996)
2. Plastics Materials & Processing - By Schwartz & Goodman Thermoforming - By James & Throne.
3. Welding of Plastics - By New Man

Subject Code: KPE 602	Additives & Compounding	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand various aspects of polymer additives	K2
CO-2	Understand the use of fillers, stabilizers and pigments	K2
CO-3	Acquire knowledge of Plasticizers, antistatic agents and their merits & demerits.	K2
CO-4	Understand various compounding methods used in the manufacturing of compounded thermoplastics and thermosets.	K2
CO-5	Acquire knowledge about various selection criteria for polymeric additives and their characterization	K2

Additives & Compounding

UNIT I

Introduction, Technological requirements, Classification, Chemistry and Mechanism, Selection Criteria, General effect on Properties, Evaluation and functions of additives.

UNIT II

Fillers, Stabilizers, Pigments: Fillers and Reinforcement, Antioxidants, Metal de-activators, Thermal Stabilisers, Ultraviolet stabilizer, Impact Modifiers/ Toughening agents, Colourants, Fire retardants, Coupling agents, blowing-agents.

UNIT III

Plasticizers, Antistatic agents, Anti blocking agents, Slip and anti slip agents, processing aids, Lubricants, mould releasing agents, Additives for recycling, conductive additives, antimicrobial additives

UNIT IV

Mixing and mixing equipments: Mixing Methodologies: Types of Mixing, Dispersive/Distributive, Agglomerates, mixing of solid additives, mixing of liquid additives, Difference between mixing and compounding.

Principles, Operating characteristics, Machine construction, Specifications, Process control systems and working details of Batch mixers and continuous mixers, High speed mixer, Two roll mill, Banbury Mixer, Ribbon blender, Planetary mixers, Twin screw extruders [co rotating / counter rotating.

UNIT V

Separation & analysis of additives in Polymers: Extraction techniques, Solvent dissolution, centrifugation, Precipitation, filtration and ashing. Identification and estimation of additives by using spectroscopy, chromatography, spectrometry and titrimetry.

References :-

1. R. Gachter , H. Muller, Plastics additives handbook: Stabilizers, processing aids, plasticizers, fillers, reinforcements, colorants for thermoplastics, Hanser Publishers, Munich, 1987.

2. Murphy; John, Additives for Plastics Handbook, 2nd Edition, Elsevier Advanced Technology, Oxford.
3. Al – Malaika; S. Golovoy; A and Wilkie(Eds), Chemistry and Technology of Polymer Additives, Black well Science Ltd, Oxford (1999)
4. Mascia; L., The Role of Additive in Plastics, Edward Arnold Publishers Ltd., U. K. (1974).

Subject Code: KPE 603	Mould & Die Manufacturing	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand mould making process	K2
CO-2	Understand the Electro discharge machining process	K2
CO-3	Acquire knowledge in surface texturing of mould	K2
CO-4	Understand polishing technology in mould making	K2
CO-5	Understand the concept of computer aided manufacturing for polymers	K2

UNIT I

Mould Making

Introduction of mould parts, Mechanism of metal cutting, types of tools, influence of tool angles, Cutting fluids, Tool materials used including coated tools. Mould material, Material selection for mould making, Properties of steels for moulds. Nonferrous metals for moulds - Zinc base alloys and aluminium alloys, Beryllium Copper, Polyesters, Epoxies, Silicones. Review of various machining operations.

UNIT II

Jig boring, Pantograph, Profile grinding, Electrical discharge machining Characteristics, physical processes, special technological features, types of EDM, design consideration & functions and technological planning. Applications of wire cut EDM in mould making. Electroforming for mould manufacturing - discussion of the process, materials for electroforming, machining for electroformed blanks

UNIT III

Heat Treatment Processes, Various Types of Furnaces.

Hobbing for mould making – Discussion of the hobbing process & its advantages, elements of hobbing like hobbing punch, shape of the hob, materials used for cavity, lubrication, and depth of hobbing, Hobbing presses, Hobbing operations & its economy with examples.

UNIT IV

Polishing technology in mould making

Definition of surface roughness, basis of polishing technology, Effect of mould materials on polishability, Types of polishing tools, Methods of polishing. Basic information on electrosonic polishing. Principles of electro-deposition in damaged moulding surfaces. Surface Texturing of moulds - Process description, types of moulds, types of patterns and mould shapes, metals that can be etched, mould preparation, limitations of chemical texturing.

UNIT V

Computer aided Manufacturing and Measurement. Introduction to CAM; Automated Manufacturing system; Need of automation, Basic elements of automation, Levels of automation, Automation Strategies, Advantages &disadvantages of automation, classification of NC machine tools, NC Part Programming.

Manual (word address format) programming- SIMPLE Examples: Canned cycles, Subroutine, and Macro. APT programming. Geometry, Motion and Additional statements, Macro- statement Open and closed loops. Control of point to point systems-Incremental open loop control, Incremental close loop, Absolute close loop; Control loop in contouring systems; Adaptive control.

References :-

1. "Injection Mold Design" R.G.W.Pye, East West Press Pvt. Ltd., New Delhi.
2. "Mold making handbook for Plastic Engineers", KlusStokhert (Edt.),Hanser Publishers, NY,1983
3. "Computer Aided Engineering Design" Anupam Saxena & B. Sahay, Anamaya Publishers
4. "CAD/CAM" HP Groover & EW Zimmers, Jr. Prentice Hall India Ltd.
5. "CAD/CAM" Theory and Practice Ibrahim Zeid & R Sivasubramaniam McGraw Hill
6. "A New Technology", Bhattacharya, IB Publishers, 1984
7. Stoeckhert "Menning, Mold making handbook", 2nd edition, Hanser Publishers, Munich.
8. "Workshop Technology", Vol I & II, W.A.J Chapman, ELBS.
9. "Mold Engineering", Herbert Rees, Hanser Publishers, NY. George Menges & Paul Mohren
10. "How to Make Injection Molds", Hanser Publishers.
11. "Plastics Mold Engineering", DuBois; J. Harry and Pribble; W. I. (Eds.),SPE Polymer Technology

Subject Code: KPE 651	Polymer Characterization Lab	L T P : 0 0 2	Credits: 1

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Carryout thermal characterization of polymeric sample using DSC & TGA	K4
CO-2	Analyze a sample using X Ray Diffractometry (XRD)	K4
CO-3	Analyze the data acquired through characterization of polymeric sample by various spectroscopic methods	K4
CO-4	Interpret the topography of a sample using SEM	K4
CO-5	Carryout the study of biodegradability of plastics	K4

Study of the following techniques with analysis & interpretation of results : (Minimum 08)

1. Differential Scanning Calorimetry (DSC)
2. Thermo Gravimetric Analysis (TGA)
3. Dynamic Mechanical Analysis (DMA)
4. Mass spectrometry
5. Scanning Electron Microscopy (SEM)
6. X Ray Diffractometry (XRD)
7. Gas Chromatography
8. CHNSO analyser
9. UV visible spectroscopy
10. Fourier transform infrared spectroscopy (FTIR)
11. Inductively Coupled Plasma (ICP) Spectroscopy
12. Biodegradability tests

Subject Code: KPE 652	Mould & Die Manufacturing Lab	L T P : 0 0 2	Credits: 1

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Demonstrate various types of cutting tool	K3
CO-2	Demonstrate mould manufacturing on EDM	K3
CO-3	Attain skills for mould assembly	K3
CO-4	Acquire skills for manufacture of Guide pillars	K3
CO-5	Demonstrate the use Wire cut EDM	K3

Study of the following techniques (Minimum eight)

1. Study of different types of Cutting tools.
2. Letter writing on Pantograph milling
3. Study of EDM,
4. Study of Wire cut EDM
5. Study and Detailing of mould assembly
6. Manufacturing of Guide Pillar
7. Manufacturing of Pocket by Milling
8. Gas assisted & Water assisted Injection mould and Hot runner mould
9. Hand compression mould design – positive, semi positive, displacement type mould, and design with split cavities
10. Transfer mould design (pot type & top plunger type)
11. Automatic unscrewing mould
12. Study of Mould for Rotational Moulding
13. Study of Mould for Thermoforming Moulding
14. Study of Mould design for industrial component

Subject Code: KPE 653	Additives & Compounding Lab	L T P : 0 0 2	Credits: 1

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Demonstrate the working of various types of mixing devices and compounders	K3
CO-2	Perform PVC compounding using high speed mixer	K3
CO-3	Prepare various composites using Twin screw extruder	K3
CO-4	Carryout mixing of thermoplastics with rubber using two roll mill	K3
CO-5	Analyse the effect of various fillers in common plastic materials	K4

Study of the following (Minimum eight)

1. To study operating characteristics, machine construction, specifications, process control systems and working details of various batch and continuous mixers and other equipments.
2. To study the functioning of two roll mill.
3. To carry out compounding of PP with various additives for specific applications.
4. To do PVC compounding using high speed mixer.
5. Preparation of plasticized polyvinyl chloride (PVC) compound using two roll mill.
6. Preparation of phenolic moulding compound using two roll mill.
7. Preparation of filled polymers using twin screw extruder.
8. To study compounding and dispersion of carbon black filled compositions.
9. To carry out mixing of thermoplastics with rubber materials on two roll mill. To analyse mixing time v/s speed of rolls, study effects using microscope on morphology.
10. To study effects of additives on properties of PP.
11. To study effects of additives on properties of LDPE.
12. Mixing characteristics of sigma mixer and preparation of Dough Moulding Compound formulations using sigma mixer.

Subject Code: KPE 061	Analysis And Characterization Of Polymers	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Have knowledge about various aspects of X-ray diffractometry	K2
CO-2	Attain knowledge about various types of microscopy	K2
CO-3	Have understanding of various spectroscopic methods	K2
CO-4	Analyze various methods of molecular characterization of polymers	K3
CO-5	Analyze the data taken by thermal characterization of polymers	K3

UNIT I

Molecular Characterization of Polymers

Determination of molecular weight, viscometry, end group analysis, colligative property, osmometry, light scattering technique, determination of molecular weight and molecular weight distribution, gel permeation chromatography (GPC)**.**

UNIT II

Thermal Analysis Techniques

Differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), thermomechanical analysis (TMA), dynamic mechanical thermal analysis (DMTA).

UNIT III

X-ray diffractometry

X-ray diffraction analysis, experimental methods, applications-Chain conformations, chain packing, disorder in the crystal, degree of Crystallinity, micro structural parameters, degree of orientations.

UNIT IV

Principles of microscopy

Optical**,** SEM, TEM, AFM; Morphology of polymers, Crystallization behavior, phase separation and applications

UNIT V

UV/Visible Spectroscopy

Introduction, principle, Lambert law, Beer's law, theory, instrumentation, procedure, advantages, disadvantages, interpretation of spectrogram, applications-qualitative analysis, quantitative analysis; purity, cis- and trans- conformation.

Fourier transform infrared (FTIR) spectroscopy, Introduction, principle, theory, instrumentation, ATR attachment, methods of sample preparation, advantages, disadvantages, interpretation of spectra, applications, establishment of chemical structure of polymers, reaction kinetics, polymer linkage, hydrogen bond formation, purity, copolymerization, qualitative and quantitative results, gas chromatograph (GC) - Mass spectrometer.

Nuclear Magnetic Resonance(NMR) spectroscopy, (1H NMR and 13C NMR)**,** Introduction, Principle, theory, Spin-spin coupling, coupling constant – chemical shifts - instrumentation, procedure, method of sample preparation - applications – chemical structures, purity, tacticity, Solid state NMR – applications.

Text Books :-

1. Nicholas P. Cheremisinoff, Polymer characterization – Laboratory Techniques and Analysis, Elsevier Books.
2. Hunt & James, Polymer characterization – Chapman & Hall, London, 1993

References :-

1. ASTM – Volume: 8.01, 8.02 & 8.03, 2000
2. G. Kämpf, Characterization of plastics using physical methods, Experimental techniques and practical applications. Hanser Publishers, Munich, 1986
3. D. Campbell & J.R. White, Polymer Characterization, Chapman & Hall, 1989.

Subject Code: KPE 062	Speciality Polymers	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand about the properties of fire resistant and high temperature polymers	K2
CO-2	Acquire knowledge about polymers with electrical properties	K2
CO-3	Acquire knowledge of ionic polymers and their applications	K2
CO-4	Understanding of polymer concrete and its applications	K2
CO-5	Understand various application of speciality polymers in telecommunication and transmission	K2

UNIT I

High temperature and fire resistant polymers improving low performance polymers for high temperature use – polymers for low fire hazards – polymers for high temperature resistance – Fluoropolymers. Aromatic polymers, polyphenylene sulphide, polysulphones, polyesters, polyamides, polyketones, Heterocyclic polymers.

UNIT II

Polymers with electrical and electronic properties - Conducting polymers, conducting mechanisms, polyacetylene, polyparaphenylene, polypyrrole, organometallic polymers, photo conducting polymers, polymers in non-linear optics, polymers with piezoelectric and pyroelectric properties, photoresists for semi conductor fabrication – liquid crystalline polymers.

Types of electroactive polymers; Dielectric, Ferroelectric (Electrostrictive and liquid crystalline) and ionic (electrorheological fluid and ion-metal composite) EAP‘s; Comparison of electronic and ionic behaviors

UNIT III

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.

UNIT IV

Polymer concrete, polymer impregnated concrete ultra high modulus fibres, polymers for biomedical applications, polymeric binders for rocket propellants, polymer supported reagents. Definition, classification, synthesis, characterization and application of polymer gels.

UNIT V

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. Photoactive polymers their design, synthesis, characteristic properties and its application.

Text Books :-

1. R.W. Dyson, Specialty Polymers, Chapman & Hall, 2nd edition, 1998.

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. Manas Chanda, Salil.K.Roy, Plastics Technology Hand book, 2nd edition, Marcel Dekker, New York, 1993

Subject Code: KPE 063	Adhesives And Surface Coatings	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand various adhesives and their specific applications	K2
CO-2	Understand various concepts of speciality and their applications	K2
CO-3	Acquire knowledge of surface coatings and their uses	K2
CO-4	Acquire knowledge about various types of paints	K2
CO-5	Acquire knowledge of various aspects of paint properties and their evaluation	K2

UNIT I

Adhesives, concepts and terminology, functions of adhesives, advantages and disadvantages of adhesive bonding, criteria for selection of adhesives.

Types of adhesives, structural adhesives, Urethane structured adhesives, Modified acrylic structural adhesives, phenolic adhesives and modifiers, anaerobic adhesives, cyanoacrylate adhesives, Hot melt adhesives, pressure sensitive adhesives, RTV Silicone adhesives, sealants, water based adhesives.

UNIT II

Specialty adhesives, adhesives in aerospace, adhesive in automobile industry, conductive adhesives, adhesives in building construction, adhesive in electrical industry.

Joint design, stress, types of joints, selection of joint detail, joint criteria, surface preparation of adherend -metals, plastics and rubbers. Adhesive bonding process- methods for adhesives application and bonding equipment, testing and quality control.

UNIT III

Introduction to surface coatings

Components of paints. Pigments, pigment properties, different types, extenders, solvents, oils, driers, diluents, lacquers, varnishes, paint preparation, formulation, factors affecting pigment dispersion, preparation of pigment dispersion.

UNIT IV

Different types of paints

classification based on polymeric resin, emulsion, oil and alkyd paints, acrylic paints, epoxy coatings, polyurethane, silicones, chlorinated rubbers. Classification based on application, fluro polymers, vinyl resins, appliance furnishes, automotive finishes, coil coatings, can coatings, marine coatings, aircraft coatings. Surface preparation and paint application.

UNIT V

Paint properties and their evaluation, mechanism of film formation, factors affecting coating properties, methods used for film preparation, barrier properties, optical properties, ageing properties, rheological properties and adhesion properties of coatings.

References :-

1. Handbook of Adhesives – Skeist, Irvind, Van Nistrand, New York, 1990, 3rd Edition 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. Sheilds, Hand book of adhesives, Butterworths, 1984.

Subject Code: KPE 064	Fibre Technology	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand about various aspects of fibres	K2
CO-2	Understand various methods of fibre production	K2
CO-3	Understand different processes of formation of fibres	K2
CO-4	Acquire knowledge of various aspects of modified synthetic fibres	K2
CO-5	Acquire knowledge for testing and quality control of fibres	K2

UNIT I

Criteria for fibre forming Polymers

Development of synthetic - commercial synthetic fibres, Raw materials manufacture. DMT, TPA, MEG, Caprolactum, Adipic acid, Hexamethylene Diamine, Acrylonitrile, Polymerisation - types of polymers - criteria for fibre forming polymers - production of polyethylene terephthalate polymer -polyamides - production of Nylon 66 polymer, Nylon 6 polymer.

UNIT II

Fibre Production Methods

Production of acrylic fibres - polypropylene - production of other fibres - PVC fibres - PVA fibres - Aramid fibres - Melt spinning - Polymer feed - melt spinning equipment - high speed spinning - spin draw processes - crystallization method - melt spinning of PET & PP stable 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

Fibre Drawing Processes

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

UNIT IV

Modified Synthetic Fibres

Modified synthetic fibres - modified polyester, Nylon, PP, acrylics - Hydrophilic -Hollow –Low pilling - flame retardant- bicomponent fibres - Dyeability of synthetic fibres

UNIT V

Testing of Yarn and Fibres

Quality control - testing raw material - testing polymers - testing yarns & fibres - waste utilisation of polyester - Nylon 6, 66 - acrylics - PP- Energy conservation - pollution control.

Text Book:-

1. A.A. Vaidya, Production of synthetic fibres, Prentice Hall of India Pvt. Ltd., New Delhi, 1988.

References :-

1. Fourne, Franz, “Synthetic Fibres, Machines and Equipment, Manufacture, Properties”, Hanser Publishers, 1999.
2. Corbman Bernard P., “Textiles: fibre to fabric”, Sixth Edition, McGraw Hill, 1983.

B. Tech Plastic Engineering
Evaluation Scheme
Effective in Session 2021-22 (Yet to finalized)

MESTER- VII

Sl. No.	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1		HSMC-1/HSMC-2	3	0	0	30	20	50		100		150	3
2		Departmental Elective-IV	3	0	0	30	20	50		100		150	3
3		Departmental Elective-V	3	0	0	30	20	50		100		150	3
4		Open Elective-II	3	0	0	30	20	50		100		150	3
5		Lab-1	0	0	2				25		25	50	1
6		Mini Project or Internship Assessment*	0	0	2				50			50	1
7		Project	0	0	8				150			150	4
8		MOOCs (Essential for Hons. Degree)											
		Total	**9**	**0**	**12**	**21**						**850**	**18**

*The Mini Project or internship (5 - 6 weeks) conducted during summer break after VI semester and will be assessed during VII semester.

SEMESTER- VIII

Sl. No	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1		HSMC-2/HSMC-1	3	0	0	30	20	50		100		150	3
2		Open Elective-III	3	0	0	30	20	50		100		150	3
3		Open Elective-IV	3	0	0	30	20	50		100		150	3
4		Project	0	0	18				100		300	400	9
5		MOOCs (Essential for Hons. Degree)											
		Total	**9**	**0**	**18**	**27**						**850**	**18**

Subject Code: KPE 071	Polymer Composites	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the concepts of polymer composites and their applications	K2
CO-2	Understand of theories of composite formation and mechanism of load transfer	K2
CO-3	Acquire knowledge of various techniques for compounding of thermoplastics.	K2
CO-4	Understand the process of manufacture of fibre reinforced plastics	K2
CO-5	Acquire knowledge of testing & characterisation of composites	K2

UNIT I

Introduction to composite materials

classification - advantages - polymer composites. Thermosetting and thermoplastic matrix materials – Reinforcements-Types and Forms-particulate, flake, fibrous etc.- coupling agents-Principles of composite reinforcement. Effect of reinforcement on composite properties.

UNIT II

Theory of composite materials

calculation of composite properties- mechanism of load transfer,
minimum and critical fibre content, critical fibre length- Rule of mixtures – Halpin -Tsai - equation.

UNIT III

Compounding of Thermoplastics

Twin screw extrusion, compression moulding- compounding of
polyolefins, polystyrene and styrene copolymers, engineering polymers, wood floor and natural fiber filled plastics, compounding lines, post compounding operations.

UNIT IV

FRP processing

important methods - hand layup, spray up, filament winding, compression moulding, injection moulding, resin, transfer moulding, reaction injection moulding, pultrusion,

miscellaneous methods

machinery, operation, advantages and disadvantages.

UNIT V

Characterization of Composites

Control of particle/fibre and porosity content, particle/fibre distribution, Interfacial Reaction of matrix-reinforcing component, Coating of reinforcing component, Strength analysis

Testing Quality control & end use of Composites

Testing for mechanical, electrical, thermal, optical and chemical properties, Determination of shelf life and gel time – Non-destructive testing methods.

Application of composite

marine, chemical, railways, electrical and electronic industry, space structures, Robotics.

Text Books:-

1. J.A.Brydson, "Plastics materials", Butterworth- Heinemann - Oxford, 6th Ed., 1995.
2. S.T.Peters, “Handbook of Composites”, Chapman & hall, 2nd Edition 1998.

References:-

1. G Lubin, “Hand Book of Composites”, 2nd Ed, Van Nostrand Reinhold, New York, 1982.
2. F.L. Matthews and R.D. Rawlings, 'Composite materials: engineering and science', Chapman and Hall, 1994.
3. P.K. Mallick, 'Composites Engineering Handbook', Marcel Dekker Inc.NY., 1997.
4. D. Hull and T. W. Clyne, "An introduction to Composite Materials 2nd Ed", Cambridge, 1996
5. Astrom; B.T, Manufacture of Polymer Composites, Chapman and Hall, London(1997).

Subject Code: KPE 072	Biomedical Plastics	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Acquire knowledge of nature and application of biomedical plastics	K2
CO-2	Understand various aspects of natural biomedical polymers	K2
CO-3	Acquire knowledge about various applications of polymers in biomedical devices	K2
CO-4	Understand the various aspect of application of polymers in soft lenses	K2
CO-5	Understand the various aspect of biopolymers in dental field	K2

UNIT I

Introduction to biomedical applications of polymers;

contemporary biomedical materials, Their advantages over other materials in use.

Biomaterials

Biomaterials, Bio-Compatibility, Stabilization, Inflammation and Wound Healing, Blood Clotting System, Kinn System, Biological response to Implants, Implant Design and Applications.

UNIT II

Biomedical Polymers

Natural biomedical polymers (natural rubber, representative biopolymers) Biodegradation and biodegradable polymers like polylactides, polyglycolides and their copolymers; polydioxanones etc., Criteria for the Selection of Biomedical Polymers, Physicochemical Aspects of the Blood Compatibility of Polymeric Surface. Biomedical Polymers from biological source, Poly hydroxy Alkanoic Acids, Microbial polysaccharides, Silk, Collagen, Microbial Cellulose, Hyaluronic Acid, Synthetic Polymers such as PTMA, Silicon Rubber, Polyethylene, Natural Rubber, Hydrogels.

UNIT III

Biomedical Applications of Polymers

Permanent implants For Function- Orthopaedics, Cardio Vascular, Respiratory Patches and Tubes, Digestive System, Genitourinary System, Nervous System, Orbital (Corneal And Lens Prosthesis) – Permanent Implant For Cosmoses, Other Applications of Engineered Material In Clinical Practices, Silicone Implants, Polymer Membranes, drug delivery systems, Polymer Skin, Polymeric Blood substitute. Properties and applications of various polymers used for biomedical polymers Synthetic biomedical polymers [Polyolefins; PVC, Polyacrylates, Polystyrenes and its copolymers, Polyesters, Polyamides (Nylons), Fluorocarbon polymers, Polyacetals, Polycarbonates, Polysulphones, Epoxy resins]

UNIT IV

Polymeric Lenses

Contact Lenses, Hard Lenses, Gas Permeable Lenses, Flexible Lenses, Soft Lenses, Hydrogels, Equilibrium Swelling, Absorption and Desorption, Oxygen Permeability, Types of Soft Lenses, Manufacture, Cleaning And Disinfection.

UNIT V

Dental Polymers

Dental applications, denture bases, dentate reliners, crown and bridge resins, plastic teeth, mouth protectors, maxillofacial prosthetic materials, restorative material, polyelectrolyte based restoratives, sealants, adhesives, dental impression and duplicating materials, agar, algometer elastomers.

Reference Books:

1. H.F. Mark (Ed), Encyclopedia of polymer science and engineering, John Wiley and Sons New York, 1989.
2. Galin and M. Ruben Ed., Soft compact Lenses clinical and applied Technology. John Wiley and Sons, Inc. New York, 1978.
3. HR Allcock, FW Lampe and JE Mark. Contemporary polymer chemistry (3rd edition). Pearson Education, Inc (Pearson/Prentice Hall)
4. Manas Chanda, Salil K. Roy (Ed) Plastic Technology Hand Book Marcel Dekker, Inc. New York, 1993.

Subject Code: KPE 073	Conducting Polymers	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understanding of the basics of conducting polymers and their conduction mechanism	K2
CO-2	understand various types of conducting polymers and their properties	K2
CO-3	Aquire knowledge about various mechanisms and techniques used in synthesis of conducting polymers	K2
CO-4	Understand various characterisation techniques for conducting polymers	K2
CO-5	Acquire knowledge of various applications of conducting polymers	K2

UNIT I

Introduction

need of conducting polymers, Classification of conducting polymer, Concept of doping,n-Type, p-Type, Electrochemistry of electronically conducting polymers-source of electronic conduction in polymers, polaron, bipolaron, conduction mechanism.

UNIT II

Properties of conducting polymers

Structure-property relationship, Types of conducting polymers, e.g. Polyaniline (PANI), Polypyrrole (PPy), Polythiophene (PTh), Discovery of polyacetylene

UNIT III

Synthesis of conducting polymer-Chemical synthesis, electrochemical synthesis, template synthesis, precursor synthesis, soluble polymers (Colloid and dispersion), advantage and disadvantage of various synthesis methods. General Methodology; Synthesis and processability of selected conducting polymers like – Polyacetylene, Polyaniline, Polypyrrole, Polythiophene and Poly-para – phenylene

UNIT IV

Analytical Techniques for Characterization of Conducting polmers

IR ,UV, Impedance spectroscopy, Fourier Transform Infra red spectroscopy, X-ray photoelectron spectroscopy**,** Scanning Electron microscopy **(**SEM)**,** Transmission electron microscopy(TEM), Electrochemical quartz crystal micro balance(EQCM), Four Probe conductivity measurement, Galvanostat/Potentiostat

UNIT V

Applications

Rechargeable batteries, o-LED, Gas sensors, Bio sensors, Photovoltaic energy device, Micro electronics, PCB fabrication, Electro catalyst. Application proposed antistatic coating, electrochemical mechanical device, super capacitor, Telecommunication system, Electromagnetic screening material, Analytical sensor.

Recent trend in conducting polymer, functionalized conducting polymer (Second generation polymer), Super conductor (Inorganic, organic hybrid structure), Conducting polymer based on nano composite.

Text book :-

1. Electrochemical science and technology of polymers -1 & 2 ed., R.G Linford, Elsevier applied sciences, London 1987 and 1989.

Reference Books:

1. Hand book of Conducting Polymers: Terje A. Skotheim (Vol.l), Dekker (668.42)
2. Hand book of Polymer Synthesis (Part B): Hans Kricheldorf, Dekker (668.9).
3. Sensors: Principles and Applications: Peter Hauptmann, Prentice Hall
4. Polymer Science and Technology: Premamoy Ghosh, Tata McGraw Hill (668.42).
5. Hand book of organic conductive molecules and polymers, Hari singh Nalwa (ed.), 4-Volume set, John wiley and sons, England 1997.

Subject Code: KPE 074	Polymer Structure And Property Relationship	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the basics of structure and properties of polymers.	K2
CO-2	Acquire knowledge about effect of polymer structure on various properties of polymers.	K2
CO-3	Acquire knowledge of different thermal transitions in polymers	K2
CO-4	Understand various electrical and optical properties of polymers	K2
CO-5	Understand various chemical properties of polymers	K2

UNIT I

Structure of polymers

Linear, branched, cross-linked and network polymers – Homochain and hetero atomic chain polymers-Co-polymers-Linear and cyclic arrangement – Prediction of polymer properties, group contribution techniques, topological techniques- Volumetric properties-molar volume, Density, Vander Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion – Pressure volume temperature (PVT) relationship.

UNIT II

Stress-strain properties of polymers

Effect of polymer structure on modulus of elasticity, tensile strength, flexural strength, impact strength, yield strength, fracture toughness –Crazing in glassy polymers - Ductile brittle transition. Effect of additives on mechanical properties of polymers - Creep, stress relaxation and fatigue.

UNIT III

Thermodynamic and transition properties

Transition temperature in polymers, glass transition (Tg), melt transition (Tm), relationship between Tg and Tm – other transitions like ß-transitions, upper and lower glass transition temperatures-Prediction of Tg and Tm of polymers by group contributions.

Calorimetric properties – Heat capacity, specific heat, latent heat of crystallization and fusion, enthalpy and entropy – Calculation of heat capacities of polymers.

UNIT IV

Electrical and optical properties

Effect of polymer structure on Dielectric constant, power factor, dissipation factor and loss factor effect of frequency of voltage and temperature on dielectric properties - Prediction of molar polarization and effective dipole moment. Effect of additives on electrical properties of polymers. Optical properties- Effect of polymer structure on optical properties-clarity, transparency, haze, transmittance, reflectance and gloss – Prediction of refractive indices of polymers by group contributions.

UNIT V

Chemical Properties

Cohesive energy, cohesive energy density, solubility parameter, determination of solubility parameter of polymers – Prediction of solubility parameter- Effect of polymer structure on solubility in solvents and oils - Influence of structure in prediction of flame retardancy, water repellency – Chemical resistance of polymers - Polymer toxicity.

Reference :-

1. D.W. Van Krevelen And P.J. Hoftyzen, "Properties Of Polymer , 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford - Newyork . 1990.
2. J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt, 1996.

Subject Code: KPE 075	Biodegrdable Polymers	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand various methods of biodegradation of polymers	K2
CO-2	Understand various aspects of starch based products	K2
CO-3	Acquire knowledge of bio-polyesters and their applications	K2
CO-4	Acquire knowledge of the recycling of biodegradable polymers	K2
CO-5	Acquire knowledge about various test methods and standards for biodegradable polymers	K2

UNIT I

Chemistry and Biochemistry of Polymer Degradation

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

UNIT II

Particulate Starch Based Products

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. Introduction

UNIT III

History of Bio-polyesters

Biosynthesis, Isolation – solvent extraction - sodium hypo chloride digestion, enzymatic digestion, Properties – crystal structure and morphology.

UNIT IV

Recycling Technology for Biodegradable Plastics

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

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 – composting methods - soil burial tests.

Reference Books:

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, Harvard academic publishers Australia 1997.

Subject Code: KPE 076	Rubber Technology	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Acquire knowledge about various aspects of Natural Rubbers	K2
CO-2	Apply the knowledge of compound design and vulcanisation	K2
CO-3	Understand various aspects of synthetic elastomers	K2
CO-4	Understand various thermoplastic elastomers	K2
CO-5	Understand various applications of Rubbers	K2

UNIT I

Natural Rubber

Tapping latex, Processing of Latex - Dry rubber production (Smoked sheet, air dried sheet, Crepe etc.) - Grading of rubbers - Modified natural rubber, Reclaimed rubber - process of reclamation – applications.

UNIT II

Compounding Design and Vulcanization

Sulphur vulcanization and non-sulphur vulcanization, vulcanization systems - accelerators, activators, promoters, antioxidants, antiozonants, processing aids, fillers and effect of fillers, Blowing agents etc.

UNIT III

Synthetic Elastomers

Manufacturing, structure, properties, compounding, curing and applications - Polyisoprene, Polybutadiene, SBR, EPDM, Butyl rubber, Neoprene, Nitrile rubber, Silicone rubber, Fluoroelastomer, Polysulphide rubber, polyurethane rubber, Acrylic rubber.

UNIT IV

Thermoplastic Elastomers

Basic structure, Manufacture, Morphology, Commercial grades and Applications – Thermoplastic styrene block copolymers, Polyester thermoplastic elastomers, polyamide thermoplastic elastomer, Polyurethane thermoplastic elastomers.

UNIT V

Rubber Product Manufacturing

Manufacturing of Belting, Hoses, Footwear, Rubber metal bonded items, sports goods, cellular rubber, tyres etc.

Text Books:-

1. C.M.Blow and Hepburn, - Rubber Technology and Manufacture, 2nd edition, 1982.
2. Hoffman, Rubber Technology Handbook - Hanser Pub. Munich – 1996

References :-

1. Anil .K. Bhowmic, Howard L. Stephens (Edt), Handbook of Elastomers – New Developments & Technology, Marcel Decker Inc. New York 1988.
2. Maurice Morton, Rubber Technology,1998.

Subject Code: KPE 077	Polymeric Nanomaterials	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand basics of Polymeric nanoparticles	K2
CO-2	Understand various types of nanocomposites of polymers and inorganic particles	K2
CO-3	Understand various aspects of carbon nanomaterials	K2
CO-4	Acquire knowledge of various applications of nanomaterials	K2
CO-5	Acquire knowledge about various methods of characterisation of nanomaterials	K2

UNIT I

Polymeric nanoparticles

Introduction, synthetic routes for polymeric nanoparticles, super critical fluid based particle production, droplet and aerosol techniques, gas atomization approaches dendrimers, hyper branched polymers or star polymers, molecular imprint polymers, applications of polymeric particles. Nano clays, nano oxides, nanowires, nanotubes and nanofibres, polymer nanofilm, nanostructured polymers with special architectures.

UNIT II

Nanocomposites of polymers and inorganic particles

Introduction, preparation of nanocomposites, characterization and properties of Nanocomposites, structure of clay and its modification with surfactants, preparative methods and structure of polymer/clay nanocomposites, types of polymers used for polymer/clay nanocomosites preparation, material properties of polymer/clay nanocomposites, processing operations of nanocomposites.

UNIT III

Carbon nanomaterials

Structural aspects, preparation of nano tubes: carbon arc process, catalytic assisted pyrolysis, laser technique, electro chemical method, purification of carbon nano tube, properties of nano tubes, Single walled nano tubes, multi walled nano tubes, application of nanotubes, CNT-polymer-matrix composites – processing of polymer nano composites - properties of polymer nanocomposites.

UNIT IV

Applications of Nanoparticles

Introduction, features of polymeric materials, preparation and characterization of nanoparticles, recent developments in nanoparticles technology, nanoparticles for some specific applications.

UNIT V

Characterisation of Nanomaterials

Introduction, Morphological characterisation, Physico-chemical characterisation, Atomic Force Microscopy, Small angle X-ray scattering, Raman Spectroscopy, Dynamic light scattering,

Brunauer-Emmett-Teller-Method, Nanoparticle Tracking Analysis, Ultra Centrifugation, Electrophoresis.

Reference Books:-

1. Y.C. Ke, P. Stroeve and F.S. Wang**,** Polymer layered silicate and silica nano composites, Elsevier, 2005.
2. B. K. G. Theng. Formation and properties of clay-polymer complexes. Elsevier, Amsterdam, 1979.
3. B.K.G. Theng. Chemistry of clay-organic reactions. Wiley, New York, 1974.
4. V.Chirala, G.Marginean, W.Brandl and T.Iclanzan, Vapour grown carbon nanofibres-polypropylene composites and their properties in Carbon nanotubes edited by V.N. Popov and P.Lambin, Springer (2006), Netherlands.
5. Recent Advances in Polymer Nanocomposites; Editors: S. Thomas, G.E. Zaikov and S.V. Valsaraj, CRC Press, 2009

Subject Code: KPE 078	Thermoplastic Elastomers	L T P : 3 0 0	Credits: 3

Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand various classifications of thermoplastic elastomers	K2
CO-2	Understand different thermoplastic elastomers from conventional polymers	K2
CO-3	Understand various aspects of Polyurethane elastomers	K2
CO-4	Acquire knowledge of various aspects of Polyamide and Polyether based Elastomers	K2
CO-5	Acquire knowledge of various Thermoplastic elastomer from Blends	K2

UNIT I

Classification of Thermoplastic Elastomers

Introduction to Thermoplastic Elastomers (TPE) Polyolefin based thermoplastic elastomers – Block copolymer, Random Block polymers, Graft copolymers, Polyolefin blend TPE's, preparation, properties, processing and applications.

UNIT II

Thermoplastic Elastomers from Conventional Polymers

Polyvinylchloride based Thermoplastic Elastomers – PVC/Nitrile Rubber blends, PVC/Polyurethane blends. Styrenic Thermoplastic Elastomers – Manufacture, Properties and applications.

UNIT III

Polyurethane Elastomers

Thermoplastic Polyurethane Elastomer – Raw materials, Synthesis, Properties, Processing, Blends and their applications.

UNIT IV

Polyamide and Polyether based Elastomers

Polyamides based Thermoplastic Elastomers – Polyamide thermoplastic elastomers, Preparation, properties, and applications. Thermoplastic Polyether ester elastomers – Synthesis, Properties and applications.

UNIT V

Thermo Plastic Elastomers from Blends

Introduction - Preparation of Elastomer – Plastic blends by dynamic vulcanization, properties and applications. Ionomeric Thermoplastic Elastomers: Synthesis, Properties and applications of ionomeric elastomers.

References :-

1. Anil K. Bhowmick, Howard L. Stephens, Hand Book of Elastomers, New Developments and Technology, Marcel Dekker, Inc., New York, 1988.
2. Benjamin M. Walker, Hand Book of Thermoplastic Elastomers, Van Mostrand Reinhold Company, New York, 1979
3. G.Holden, N.R. Legge, R. Quirk, H.E. Schrolder, Thermoplastic Elastomers – 2nd Edition, Hanser Publishers, Munich, 1996.
4. S.K. De, Anil K. Bhowmick, Thermoplastic Elastomers from Rubber – Plastic Blends, Ellis Horwood, New York, 1990.