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

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<th>Code</th>
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# B. Tech Plastic Engineering
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Plastic Engineering Departmental Electives

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<td>CO-1 Understand concepts of engineering plastics and their applications</td>
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<td>CO-2 Understand concepts of thermoset plastics and their specific applications</td>
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<td>CO-3 Understand knowledge of manufacturing, properties and applications of high end application plastics.</td>
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<td>CO-4 Understand the manufacturing, properties and applications of thermoplastic elastomers</td>
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<td>CO-5 Understand knowledge of manufacturing, properties and applications of speciality plastics</td>
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UNIT I
Engineering Plastics

UNIT II
Thermosets

UNIT III
Sources and manufacture of raw materials

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 :-

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

Course Outcomes: The students will be able to

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<th>Understand the knowledge of processing of plastic by using Injection Moulding machine</th>
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<td>Understand the process of thermoforming of plastics</td>
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<td>CO-3</td>
<td>Understand the process of making hollow products by using blow moulding technique</td>
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<td>CO-4</td>
<td>Understand the process of rotational moulding</td>
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<tr>
<td>CO-5</td>
<td>Understand how plastics are joined and assembled</td>
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UNIT I
Injection Moulding

UNIT II
Thermoforming Process

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 :-

References :-
1. A Guide to Injection Molding of Plastics By Bolur, P.C.,
6. Injection Molding Technology By V.D.I.
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

| CO-1 | Understand the various testing and quality control techniques for plastics. | Blooms Taxonomy | 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 :-

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

**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.
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.
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

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

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

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Description</th>
<th>Blooms Taxonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO-1</td>
<td>Design Injection Moulds using CAD software</td>
<td>K3</td>
</tr>
<tr>
<td>CO-2</td>
<td>Design Compression Moulds using CAD software</td>
<td>K3</td>
</tr>
<tr>
<td>CO-3</td>
<td>Design Transfer &amp; Blow moulds using CAD software</td>
<td>K3</td>
</tr>
<tr>
<td>CO-4</td>
<td>Develop the moulds using CAM/CAE software</td>
<td>K3</td>
</tr>
<tr>
<td>CO-5</td>
<td>Analyse mould flow and optimize the designs</td>
<td>K4</td>
</tr>
</tbody>
</table>

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
    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

<table>
<thead>
<tr>
<th>CO-1</th>
<th>Understand the basics of Plastics mould design and also product design.</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO-2</td>
<td>Acquire knowledge about various moulds for different processing techniques.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3</td>
<td>Understand the knowledge of design parameters of an Injection mould</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4</td>
<td>Understand various design parameters for a split mould</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5</td>
<td>Design the extrusion dies for pipes and sheets</td>
<td>K3</td>
</tr>
</tbody>
</table>

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 :-

References :-
1. Injection Mould Design Fundamentals (Vol. I & II) - By Glanvill & Denton
2. Plastics Moulds & Dies - By Sors et al., Second Edition
Subject Code: KPE 052  |  Polymer Degradation And Stabilisation  |  L T P : 3 0 0  |  Credits: 3

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

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

UNIT II

Mechanical Degradation and Ultrasonic Degradation

UNIT III

Photo degradation

UNIT IV

Degradation By High Energy Radiation and Biodegradation
UNIT V
Chemical Degradation

Text Books :-
Course Outcomes: The students will be able to

| 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

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

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

Text Books: -
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

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
<th>Blooms Taxonomy</th>
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</thead>
<tbody>
<tr>
<td>CO-1</td>
<td>Understand chemistry and materials of polyurethane manufacture</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2</td>
<td>Understand various types of raw materials used in preparation of PU</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3</td>
<td>Understand the production of flexible and rigid polyurethane foam</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4</td>
<td>Explain the knowledge of production, properties and uses of solid polyurethane</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5</td>
<td>Explain the knowledge of PU applications as coatings and adhesives</td>
<td>K2</td>
</tr>
</tbody>
</table>

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:–
2. George woods, The ICI Polyurethane book -published journals by ICI, John Wiley and sons NY
References :-
Subject Code: KPE 055  |  Plastics Waste Management And Recycling Techniques  |  L T P : 3 0 0  |  Credits: 3

<table>
<thead>
<tr>
<th>Course Outcomes: The students will be able to</th>
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</thead>
<tbody>
<tr>
<td>CO-1  Understand various forms of waste and its segregation</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2  Understand the impact of plastic waste on environment</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3  Understand various methods of recycling of commodity plastics</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4  Explain various aspects of recycling of engineering plastics</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5  Acquire knowledge of various policies &amp; legislations related to environmental issues of plastics waste.</td>
<td>K2</td>
</tr>
</tbody>
</table>

UNIT I
Plastic waste generation & separation techniques

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 :-

References :-
2. John Schiles, Polymer Recycling.
The students will be able to

| 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 to Mass Transfer**  
(2 Hours)  

**Reference Books:-**  
1. Fundamentals of Heat and Mass Transfer, by Incroperra& DeWitt, John Wiley and Sons  
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  
7. Heat Transfer by Venkateshan, Ane Books Pvt Ltd  
**Subject Code: KPE 057 | Special Processes & Techniques | L T P : 3 0 0 | Credits: 3**

<table>
<thead>
<tr>
<th>Course Outcomes: The students will be able to</th>
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</thead>
<tbody>
<tr>
<td>CO-1 Acquire the knowledge of various aspects of casting process</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2 Familiarized with the process of Dip moulding</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Understand the process of printing of plastics using various techniques</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Understand the process of coating of plastics</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Understand how plastics are machined</td>
<td>K2</td>
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</tbody>
</table>

**UNIT I**
**Casting Process**
Introduction, Types (Conventional, Solvent, Rotational, Slush), Advantages & applications.

**UNIT II**
**Dip Moulding**

**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 :-**
2. Plastics Material & Processing- By Strong, A, Brent

**References :-**
Subject Code: KPE 058  |  Physical Chemistry of Polymers  |  L T P : 3 0 0  |  Credits: 3

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>CO-1 Acquire knowledge about various aspects of energy states of polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2 Explain various concepts of thermodynamics of polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Acquire knowledge of amorphous state of polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Acquire knowledge about crystalline state of polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Understand the phenomenon of chain orientation of polymers</td>
<td>K2</td>
</tr>
</tbody>
</table>

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, supramolecular 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 crystalline 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 :-
Subject Code: KPE 601  |  Advanced Processing Techniques  |  L T P : 3 1 0  |  Credits: 4

**Course Outcomes: The students will be able to**

<table>
<thead>
<tr>
<th>CO-1</th>
<th>Understand the concepts of thermoset injection moulding.</th>
<th>K2</th>
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<tbody>
<tr>
<td>CO-2</td>
<td>Acquire knowledge of processes for manufacturing of different Plastic foams.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3</td>
<td>Understand the concepts of gas &amp; water Injection moulding.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4</td>
<td>Acquire knowledge about various forms of plastics laminates.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5</td>
<td>Explain the phenomenon of sandwich moulding.</td>
<td>K2</td>
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</tbody>
</table>

**UNIT I**

**Thermoset Injection Molding**
Principle, Materials, Process description, Machine Design, Set up procedure and process parameter, Troubleshooting, Applications

**Reaction Injection Moulding**

**Resin Transfer Moulding**
Principle, Materials, Process description, Process Characteristics, Troubleshooting

**UNIT II**

**Plastic Foam Molding, Structure Foam Moulding**

**Expandable Bead Foam**

**Extruded Thermoplastics Foams**

**UNIT III**

**Gas Assist Injection Moulding**

**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

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 :-
2. Plastics Material & Processing- By Strong, A, Brent

References :-
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

<table>
<thead>
<tr>
<th>CO-1</th>
<th>Understand various aspects of polymer additives</th>
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</thead>
<tbody>
<tr>
<td>CO-2</td>
<td>Understand the use of fillers, stabilizers and pigments</td>
</tr>
<tr>
<td>CO-3</td>
<td>Acquire knowledge of Plasticizers, antistatic agents and their merits &amp; demerits.</td>
</tr>
<tr>
<td>CO-4</td>
<td>Understand various compounding methods used in the manufacturing of compounded thermoplastics and thermosets.</td>
</tr>
<tr>
<td>CO-5</td>
<td>Acquire knowledge about various selection criteria for polymeric additives and their characterization</td>
</tr>
</tbody>
</table>

**Blooms Taxonomy**
- 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**

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 :-**

3. Al – Malaika; S. Golovoy; A and Wilkie(Eds), Chemistry and Technology of Polymer Additives, Black well Science Ltd, Oxford (1999)

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

Course Outcomes: The students will be able to

<table>
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<th>Course Outcomes</th>
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<tr>
<td>CO-1 Understand mould making process</td>
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<tr>
<td>CO-2 Understand the Electro discharge machining process</td>
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<tr>
<td>CO-3 Acquire knowledge in surface texturing of mould</td>
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<tr>
<td>CO-4 Understand polishing technology in mould making</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Understand the concept of computer aided manufacturing for polymers</td>
<td>K2</td>
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</table>

UNIT I
Mould Making

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
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 :-
11. “Plasctics 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

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<th>Course Outcomes: The students will be able to</th>
<th>Blooms Taxonomy</th>
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<tbody>
<tr>
<td>CO-1 Carry out thermal characterization of polymeric sample using DSC &amp; TGA</td>
<td>K4</td>
</tr>
<tr>
<td>CO-2 Analyze a sample using X Ray Diffractometry (XRD)</td>
<td>K4</td>
</tr>
<tr>
<td>CO-3 Analyze the data acquired through characterization of polymeric sample by various spectroscopic methods</td>
<td>K4</td>
</tr>
<tr>
<td>CO-4 Interpret the topography of a sample using SEM</td>
<td>K4</td>
</tr>
<tr>
<td>CO-5 Carry out the study of biodegradability of plastics</td>
<td>K4</td>
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</tbody>
</table>

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

<table>
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<tr>
<td>CO-1 Demonstrate various types of cutting tool</td>
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</tr>
<tr>
<td>CO-2 Demonstrate mould manufacturing on EDM</td>
<td>K3</td>
</tr>
<tr>
<td>CO-3 Attain skills for mould assembly</td>
<td>K3</td>
</tr>
<tr>
<td>CO-4 Acquire skills for manufacture of Guide pillars</td>
<td>K3</td>
</tr>
<tr>
<td>CO-5 Demonstrate the use Wire cut EDM</td>
<td>K3</td>
</tr>
</tbody>
</table>

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

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

| CO-1 | Have knowledge about various aspects of X-ray diffractometry | Blooms Taxonomy |
| 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.

Text Books :-
1. Nicholas P. Cheremisinoff, Polymer characterization – Laboratory Techniques and Analysis, Elsevier Books.

References :-
1. ASTM – Volume: 8.01, 8.02 & 8.03, 2000
Subject Code: KPE 062  
Speciality: Polymers  
L T P: 3 0 0  
Credits: 3

Course Outcomes: The students will be able to

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<th>Co-1</th>
<th>Understand about the properties of fire resistant and high temperature polymers</th>
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<tbody>
<tr>
<td>Co-2</td>
<td>Acquire knowledge about polymers with electrical properties</td>
<td>K2</td>
</tr>
<tr>
<td>Co-3</td>
<td>Acquire knowledge of ionic polymers and their applications</td>
<td>K2</td>
</tr>
<tr>
<td>Co-4</td>
<td>Understanding of polymer concrete and its applications</td>
<td>K2</td>
</tr>
<tr>
<td>Co-5</td>
<td>Understand various application of speciality polymers in telecommunication and transmission</td>
<td>K2</td>
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</tbody>
</table>

UNIT I

UNIT II
Polymers with electrical and electronic properties - Conducting polymers, conducting mechanisms, polyacetylene, poly paraphenylenel, poly pyrrole, 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, ionomers 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 :-

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

Course Outcomes: The students will be able to

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<tr>
<td>CO-1 Understand various adhesives and their specific applications</td>
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<tr>
<td>CO-2 Understand various concepts of speciality and their applications</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Acquire knowledge of surface coatings and their uses</td>
<td>K2</td>
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<tr>
<td>CO-4 Acquire knowledge about various types of paints</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Acquire knowledge of various aspects of paint properties and their evaluation</td>
<td>K2</td>
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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

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

Course Outcomes: The students will be able to

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<th>Understand about various aspects of fibres</th>
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<td>CO-2</td>
<td>Understand various methods of fibre production</td>
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<tr>
<td>CO-3</td>
<td>Understand different processes of formation of fibres</td>
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<tr>
<td>CO-4</td>
<td>Acquire knowledge of various aspects of modified synthetic fibres</td>
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<tr>
<td>CO-5</td>
<td>Acquire knowledge for testing and quality control of fibres</td>
<td>K2</td>
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</table>

UNIT I
Criteria for fibre forming Polymers

UNIT II
Fibre Production Methods

UNIT III
Fibre Drawing Processes

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:-

References :-
B. Tech Plastic Engineering

Evaluation Scheme

Effective in Session 2021-22 (Yet to finalized)

**MESTER- VII**

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

**SEMESTER- VIII**

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<tr>
<td>CO-1 Understand the concepts of polymer composites and their applications</td>
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<tr>
<td>CO-2 Understand of theories of composite formation and mechanism of load transfer</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Acquire knowledge of various techniques for compounding of thermoplastics.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Understand the process of manufacture of fibre reinforced plastics</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Acquire knowledge of testing &amp; characterisation of composites</td>
<td>K2</td>
</tr>
</tbody>
</table>

UNIT I
Introduction to composite materials

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:-

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

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<tr>
<td>CO-1 Acquire knowledge of nature and application of biomedical plastics</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2 Understand various aspects of natural biomedical polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Acquire knowledge about various applications of polymers in biomedical devices</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Understand the various aspect of application of polymers in soft lenses</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Understand the various aspect of biopolymers in dental field</td>
<td>K2</td>
</tr>
</tbody>
</table>

UNIT I
Introduction to biomedical applications of polymers;
contemporary biomedical materials, Their advantages over other materials in use.

Biomaterials

UNIT II
Biomedical Polymers
Natural biomedical polymers (natural rubber, representative biopolymers) Biodegradation and biodegradable polymers like polyactides, 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 Cosmuses, 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, Polycrylates, Polystyrenes and its copolymers, Polymers, Polymides (Nylons), Fluorocarbon polymers, Polyacetals, Polycarbonates, Polysulphones, Epoxy resins]

UNIT IV
Polymeric Lenses
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:
**Course Outcomes: The students will be able to**

<table>
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<th>CO</th>
<th>Description</th>
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<td>CO-1</td>
<td>Understanding of the basics of conducting polymers and their conduction mechanism</td>
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<tr>
<td>CO-2</td>
<td>understand various types of conducting polymers and their properties</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3</td>
<td>Aquire knowledge about various mechanisms and techniques used in synthesis of conducting polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4</td>
<td>Understand various characterisation techniques for conducting polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5</td>
<td>Acquire knowledge of various applications of conducting polymers</td>
<td>K2</td>
</tr>
</tbody>
</table>

**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-paraphenylene

**UNIT IV**

**Analytical Techniques for Characterization of Conducting polymers**

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 :-

Reference Books:
Subject Code: KPE 074  
Polymer Structure And Property Relationship  
LTP: 3 0 0  
Credits: 3

Course Outcomes: The students will be able to

<table>
<thead>
<tr>
<th>Course Outcomes</th>
<th>Blooms Taxonomy</th>
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</thead>
<tbody>
<tr>
<td>CO-1</td>
<td></td>
</tr>
<tr>
<td>Understand the basics of structure and properties of polymers.</td>
<td>K2</td>
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<tr>
<td>CO-2</td>
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</tr>
<tr>
<td>Acquire knowledge about effect of polymer structure on various properties of polymers.</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3</td>
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</tr>
<tr>
<td>Acquire knowledge of different thermal transitions in polymers</td>
<td>K2</td>
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<tr>
<td>CO-4</td>
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<tr>
<td>Understand various electrical and optical properties of polymers</td>
<td>K2</td>
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<tr>
<td>CO-5</td>
<td></td>
</tr>
<tr>
<td>Understand various chemical properties of polymers</td>
<td>K2</td>
</tr>
</tbody>
</table>

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 β-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 :-
Subject Code: KPE 075  Biodegradable Polymers  L T P : 3 0 0  Credits: 3

Course Outcomes: The students will be able to

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<tbody>
<tr>
<td>CO-1 Understand various methods of biodegradation of polymers</td>
<td>K2</td>
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<tr>
<td>CO-2 Understand various aspects of starch based products</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Acquire knowledge of bio-polyesters and their applications</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Acquire knowledge of the recycling of biodegradable polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Acquire knowledge about various test methods and standards for biodegradable polymers</td>
<td>K2</td>
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</tbody>
</table>

UNIT I
Chemistry and Biochemistry of Polymer Degradation

UNIT II
Particulate Starch Based Products

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

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

Course Outcomes: The students will be able to

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<tbody>
<tr>
<td>CO-1 Acquire knowledge about various aspects of Natural Rubbers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2 Apply the knowledge of compound design and vulcanisation</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Understand various aspects of synthetic elastomers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Understand various thermoplastic elastomers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Understand various applications of Rubbers</td>
<td>K2</td>
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</tbody>
</table>

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.

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<tr>
<td>CO-1 Understand basics of Polymeric nanoparticles</td>
<td>K2</td>
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<tr>
<td>CO-2 Understand various types of nanocomposites of polymers and inorganic particles</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Understand various aspects of carbon nanomaterials</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Acquire knowledge of various applications of nanomaterials</td>
<td>K2</td>
</tr>
<tr>
<td>CO-5 Acquire knowledge about various methods of characterisation of nanomaterials</td>
<td>K2</td>
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</tbody>
</table>

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 nanocomposites 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,

**Reference Books:-**

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

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<tbody>
<tr>
<td>CO-1 Understand various classifications of thermoplastic elastomers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-2 Understand different thermoplastic elastomers from conventional polymers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-3 Understand various aspects of Polyurethane elastomers</td>
<td>K2</td>
</tr>
<tr>
<td>CO-4 Acquire knowledge of various aspects of Polyamide and Polyether based Elastomers</td>
<td>K2</td>
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<tr>
<td>CO-5 Acquire knowledge of various Thermoplastic elastomer from Blends</td>
<td>K2</td>
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</tbody>
</table>

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

UNIT III
Polyurethane Elastomers

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

References: -