DEPARTMENT OF CHEMISTRY
ANNAUNIVERSITY, CHENNAI

VISION
The Department of Chemistry at Anna University shall strive towards attaining world class status and recognition by producing students with sound knowledge, professional skills, high levels of integrity and ethical values. The Department shall provide an outstanding ambience for teaching, research and consultancy. The Department shall perform frontier research and create knowledge base in theoretical and applied chemistry, polymeric and catalytic materials, fuel and energy related processes and materials, environmental chemistry and other trans disciplinary areas of technological importance.

MISSION
The Department of Chemistry, Anna University shall contribute to the educational, economic and social development by:

- producing Postgraduates and Doctorates who are equipped with thorough knowledge in Chemistry, analytical thinking, practical skills and ethics by enabling interaction with experts from around the world in the fields of Chemistry.
- inspiring the students to be creative thinkers, inspirational role models and citizens with environmental and social consciousness.
- ensuring a supportive ambience in the Department with dynamic leadership and growth opportunities to meet the needs of the students, faculty and staff.
- Promoting the development of technologically and socially relevant processes and products in the fields of catalysis, polymers, corrosion resistance coatings and energy conversion through academic and sponsored research, in collaboration with global research groups.
- facilitating collaborative partnership with industries and other institutions and catalyze innovation, transfer of technology and commercialization towards fulfilling societal developments.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Master of Polymer Science and Engineering curriculum is designed to prepare the graduates to

| I. | To provide an interdisciplinary specialization in master’s degree with an emphasis on polymeric materials and their processing. |
| II. | To undertake a career in industries that involve innovation, problem-solving and leadership in polymer science. |
| III. | To excel both in academia and R&D organizations involving polymeric materials. |
| IV. | To contribute to the society by becoming a model citizen with high standards of intellectual qualities having good academic skills and personal honesty. |
| V. | To enable the graduates to engage in life-long learning with social and ethical responsibility. |
I. PROGRAM OUTCOMES (POs)

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<tr>
<td>1</td>
<td>Ability to independently carry out research/investigation and development work to solve practical problems.</td>
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<td>Ability to write and present a substantial technical report/document.</td>
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<td>Able to demonstrate a degree of mastery over the area as per the specialization of the programme. The mastery shall be at a level higher than the requirements in the appropriate bachelor programme.</td>
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<td>4</td>
<td>Develop an in-depth expertise in the field of polymers that encourage them for higher studies and continuous professional development.</td>
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<td>5</td>
<td>Mark them for successful career in industries of international repute and help them to excel in this field.</td>
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<td>Create an operational expertise for successful entrepreneurship.</td>
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PEO/PO Mapping:

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PROGRAM ARTICULATION MATRiX

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### MAPPING OF ELECTIVES AND PROGRAMME OUTCOMES

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### THEORY

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### Professional Elective Courses

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### SUMMARY

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MA3161  STATISTICAL METHODS FOR ENGINEERS  L T P C
                                4 0 0 4

OBJECTIVES:

- To enable them to estimate the value of the parameters involved in the specific distribution from a possible continuum of alternatives.
- To give an idea of testing the statistical hypothesis claimed based on a set of data points using suitable test statistics which follows standard sampling distributions.
- To establish a relationship that make it possible to predict one or more variable in terms of others using correlation and regression analysis.
- To introduce the various experimental designs and their corresponding analysis of variance which play vital role in many real time scenarios.
- To impart knowledge of handling random vectors which represent random variables in multi-dimensional space.

UNIT I  ESTIMATION THEORY  12

UNIT II  TESTING OF HYPOTHESIS  12
Tests based on Normal, $t$, $\chi^2$ and $F$ distributions for testing of means, variance and proportions – Analysis of $r \times c$ tables – Goodness of fit.

UNIT III  CORRELATION AND REGRESSION  12
Multiple and Partial Correlation - Method of Least Squares- Plane of Regression - Properties of Residuals - Coefficient of Multiple Correlation - Coefficient of Partial Correlation - Multiple Correlation with total and partial correlations - Regression and Partial correlations in terms of lower order coefficients.

UNIT IV  DESIGN OF EXPERIMENTS  12
Analysis of variance – One-way and two-way classifications – Completely randomized design – Randomized block design – Latin square design.

UNIT V  MULTIVARIATE ANALYSIS  12

TOTAL: 60 PERIODS

OUTCOMES:
At the end of the course, students will be able to

CO1 Obtain the value of the point estimators using the method of moments and method of maximum Likelihood.

CO2 Use various test statistics in hypothesis testing for mean and variances of large and small samples.

CO3 Determine the regression line using the method of least square and also to calculate the partial and multiple correlation coefficient for the given set of data points.

CO4 Test the hypothesis for several means using one way, two way or three way classifications.

CO5 Get exposure to the principal component analysis of random vectors and matrices.

REFERENCES:


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RM3151 RESEARCH METHODOLOGY AND IPR

OBJECTIVES:
To impart knowledge on
- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION
Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION
Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING
Sampling, sampling error, measures of central tendency and variation.; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS
Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS
Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS
COURSE OUTCOMES
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiments; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,

PL3101 POLYMERCHEMISTRY L T P C
3 0 0 3

OBJECTIVE
- To make the student to acquire knowledge in fundamental basics of polymers and organic and inorganic polymers
- To educate the student to understand structural properties and reaction of polymers
- To provide exposure to the students about Molecular weight, solubility and fractionation of polymers
- To inculcate the student to have knowledge on Bio and inorganic polymers

UNIT I BASICS OF POLYMERS AND CHAIN GROWTH POLYMERIZATION
Basics–polymer classifications based on occurrence, types, process, and end uses. Kinetics and mechanism of free radical, cationic, anionic, living polymers and coordination polymerization—Ziegler Natta catalysts- monometallic mechanism—stereo regular polymerization—chain transfer reaction and constant.

UNIT II STEP GROWTH POLYMERIZATION AND COPOLYMERIZATION
Kinetics of condensation polymerization—copolymerization kinetics—copolymer equation composition of copolymers by NMR—monomer reactivity ratios and their significance—polymerization reactions- metathetical, electrochemical, Group transfer polymerization and ring opening.

UNIT III STRUCTURAL PROPERTIES AND REACTION OF POLYMER MOLECULES
Functionality—tacticity of polymer—chemical and geometrical structure—ladder,star and telechelic polymers—interpenetrating networks-Polymers-crystalline amorphous nature—crystallizability-effect on properties. Reactions of polymer molecules with specific groups OH,CHO,C=O,COOHand—NH2and polymer—crosslinking,cyclisation—polymer degradation-thermal, mechanical, photoandradiation.

UNIT IV THERMAL TRANSITION, MOLECULAR WEIGHT AND POLYMER DISSOLUTION
UNIT V BIOAND INORGANIC POLYMERS


TOTAL:45 PERIODS

COURSE OUTCOMES:
CO 1: Will be aware of preparation and properties of polymers at length.
CO 2: Will be able to methodically discuss step growth polymerization techniques
CO 3: Will be able to analyze structure-property relationship in polymers
CO 4: Will be able to describe thermal transitions and choose appropriate method to determine molecular weight in polymers
CO 5: Will be capable to compare and discuss about the properties of bio-polymers and inorganic polymers.

REFERENCE BOOKS:

COURSE ARTICULATION MATRIX

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PL3102 SCIENCE OF POLYMERIC MATERIALS L T P C

OBJECTIVE
- The objective of this course is introduction to polymer structure, chain structure and mechanical properties.
- To impart knowledge on thermal properties, electrical and rheological properties.

UNIT I INTRODUCTION
Polymer structure – chain structure – micro structure – crystal structure- crystallinity – determination of crystallinity, size and orientation of crystallites using x-rays-conformation and configuration.

UNIT II MECHANICAL PROPERTIES
Deformation of plastic materials- classification of plastic materials based on their stress –strain relationship–effect of temperature on deformation-time dependence and visco elasticity in solid plastics – Boltzmann’s superposition principle– dynamic mechanical properties–
yielding of plastics—mechanical failure in plastics.

UNIT III  THERMAL PROPERTIES
Enthalpy—melting and crystallization—importance of Tg—factors affecting Tg—determination of Tg—thermal conductivity—thermal expansion and contraction—factors affecting thermal expansion.

UNIT IV  ELECTRICAL 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—Effect of additives on electrical properties of polymers. Electrical properties at low stress and high stress—breakdown mechanisms—electrically conductive plastics—electrical applications of plastics.

ITA, the school of engineers in computer

UNIT V  RHEOLOGICAL PROPERTIES
Melt flow properties—fundamental concepts of rheology—geometry of flow—rheological and viscous behavior in simple shear—viscous properties of plastic melts in simple shear—measurement of shear properties; viscometry—types of capillary viscometer—factors affecting shear flow and elongational flow—MFI, melt elasticity

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO 1: Will be able to describe crystallinity and evaluate morphology of polymers
CO 2: Will be able to comprehend and choose plastic materials based on their mechanical properties for specific applications
CO 3: Will develop capacity to assess thermal properties of polymers.
CO 4: Will be capable to explain electrical properties and applications of plastics.
CO 5: Will be able to evaluate the rheological properties of plastics

REFERENCE BOOKS:
1. Birley, Haworth, Batchelor, Physics of Plastics—Processing

COURSE ARTICULATION MATRIX

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PL3103  POLYMER PROCESS ENGINEERING

OBJECTIVES
- To learn about the aspects of processing of polymers.
- To learn about the advancement in Injection and Blow moulding.
To understand the importance of injection moulding.
To provide exposure on special moulding techniques.
To learn about the die forming and mould making.

UNIT I PROCESSING OF POLYMERS 9
Introduction to polymer processing, quantitative aspects of polymer product processing additives and compounding – fillers, plasticizers, antioxidants, colorants, flame retardants, stabilizers compounding, mixing and compounding equipment.

UNIT II EXTRUSION AND BLOW MOULDDING 10
Analysis of flow in extruder - drag flow, pressure flow, leak flow - extruder/die characteristics - screw geometry - basic flow patterns in extrusion die - die exit instabilities - die swell - processing methods based on extruder (granule production, profile production, pipe and corrugated pipe, co extrusion, film blowing, multilayer extrusion) - blow moulding - extrusion and injection stretch blow moulding, advance blow moulding - deep draw double wall blow moulding, press blow moulding, 3 dimensional blow moulding - extrusion coating process (sheet coating and wire covering).

UNIT III INJECTION MOULDDING 9
Injection moulding machines and its components, its types- its process - moulds, multi cavity moulds, mould clamping devices, mould clamping force, disc moulding, injection blow moulding, reaction injection moulding - co injection moulding - two colour injection moulding - gas assisted injection moulding - multi layer injection moulding - liquid injection moulding - counter flow moulding.

UNIT IV SPECIAL MOULDING TECHNIQUES 10
Analysis of calendaring, methods of sheet forming - Thermoforming - vacuum forming, pressure forming and matched mould forming - Rotation moulding, processing and analysis of compression moulding, transfer moulding - sintering - solution casting - Sheet molding and dough molding compounds - Processing technology of elastomers - processing of natural and synthetic rubbers - vulcanization, mastication and cyclisation - plastic finishing techniques, powder coating, metallizing.

UNIT V TOOLING AND MOULDS 7
Tool making processes, die and die forming, compression moulds, transfer moulds, blow and extrusion dies, typical exercises in mould design and production, two plate mould, three plate mould, hot runner mould, insulated runner mould, runners, gates, mould making, mould cooling.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be able to acquire in depth knowledge on processing of polymers
CO2: Will be able to discuss about extrusion and blow moulding and choose a preferred plastic production process based on requirement.
CO3: Will be able to analyze the merits and demerits in various types of injection moulding
CO4: Will be aware of advancement in the special moulding techniques and develop skill to critically evaluate design of plastic product based on it.
CO5: Will gain knowledge in die forming and comprehend the mathematical calculations involved in the planning and design of moulds and dies

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OBJECTIVES
- To make the student conversant with polymer synthesis and kinetics of polymerization
- To impart knowledge on reactivity ratio and molecular weight of polymers
- To know about the importance of fractionation of polymers
- To understand about the emulsion polymerization technique.

UNIT I POLYMERIZATIONTECHNIQUES 20
Polymer synthesis - bulk, solution, emulsion, suspension and slurry polymerization - low and high temperature condensation polymerization, interfacial poly-condensation, thermal and redox initiated polymerizations - kinetics of polymerization - preparation of IPN polymer.

UNIT II PREPARATION OF COPOLYMER AND THERMOSET RESIN 20
Copolymerization of styrene and MMA - determination of reactivity ratio of MMA - styrene copolymer, preparation of an epoxy resin and unsaturated polyester resin, PF, UF, MF resin - determination of cure of resin - determination of acid value of resin.

UNIT III MOLECULAR WEIGHT DETERMINATION 10
Determination of Molecular weight - viscometry, end group analysis, GPC, light scattering, osmometry.

UNIT IV FRACTIONATION OF POLYMERS 5
Fractionation of polymers - Fractional precipitation method - poly-dispersity.

UNIT V EMULSION-PAINT 5
Emulsion polymerization - paint formulation, coating.

TOTAL: 60 PERIODS

COURSE OUTCOMES:
CO1: Will gain awareness in the synthesis of polymers and discuss about the kinetics of polymerization.
CO2: Will be able prepare copolymers and thermosets.
CO3: Will understand and calculate molecular weight of polymers by different methods.
CO4: Will be able to describe methods for fractionation of polymers
CO5: Will be able to prepare to paint by emulsion polymerization technique.

REFERENCE BOOKS:

COURSE ARTICULATION MATRIX

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OBJECTIVES:

- To enable the students to learn about testing of polymers using various standards.
- To gain practical knowledge about molding techniques.
- To know the sample preparation techniques.
- To know about parts and functions of various processing equipments.
- To learn about compounding and mixing operations.

UNIT I MECHANICAL TESTING 15
UTM- tensile, compression, flexural - Impact test- Izod/Charpy - Abrasion resistance and Rockwell hardness test, Durometer.

UNIT II THERMAL, ELECTRICAL AND OPTICAL TESTING 10
Heat deflection temperature, Vicat softening point, Adhesion testing, Dielectric test and arc resistance - Light transmittance and Opacity - gloss.

UNIT III PRODUCT TESTING 10
Bottle testing - drop impact, Pipe testing - hydrostatic pressure (Burst strength) -Woven sack and film testing - UTM, dart impact.

UNIT IV PROCESSING 15

UNIT V MIXING/ BLENDING 10
Two roll mill- Banbury mixer- ribbon blender.

COURSE OUTCOMES:
CO1: Will able to discuss the mechanical properties of plastics.
CO2: Will able to comprehend the thermal and electrical properties of plastics.
CO3: Will be able to analyze the test results obtained from polymer product testing..
CO4: Will be able to evaluate the suitable processing method for polymers as per product requirement.
CO5: Able to design and formulate based on compounding of polymers.

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OBJECTIVES:
- To understand about the various spectroscopic characterization of polymers
- To understand the thermal and electrical properties of polymers
- To learn mechanical properties and hardness of plastics
- To understand the flammability, ignition and optical properties.
- To learn about the testing of plastics.

UNIT I  SPECTROSCOPIC CHARACTERIZATION
Vibrational spectroscopy (FTIR, ATRIR and Raman spectroscopy), UV-visible and photoluminescence, XPS, NMR, mass spectroscopy, Thermal analysis (TGA, DTA, DSC, DMA, TMA) - Electron Microscopes (SEM, TEM, AFM) - Chromatography (GC, GPC) - X-ray Diffraction - Structure Identification (IR, NMR) - Melt index and viscosity.

UNIT II  THERMAL AND ELECTRICAL PROPERTIES
Thermal conductivity - Thermal Expansion - Linear coefficient - HDT - VICAT softening - Brittleness - Temperature - dielectric strength, dielectric constant, dissipation factor - arc resistance.

UNIT III  MECHANICAL PROPERTIES AND HARDNESS
Tensile tests - strength, modulus and Elongation - Flexural and compression properties - Impact properties - Types - Izod - charpy, chip and drop impact tests - Abrasion Resistance (Transparent / Flat specimen) -Hardness tests (Rockwell, Durometer, Barcol).

UNIT IV  FLAMMABILITY, IGNITION & OPTICAL PROPERTIES AND ANALYTICAL TESTS
Flammability test (Non rigid, solid plastics) Ignition Temperature-Oxygen Index Test - Refractive Index, luminous transmittance, haze, Specular gloss, clarity, Photoelasticity, Birefringence, density, water absorption, moisture analysis - sieve analysis, crush and burst strength.

UNIT V  TESTING OF FOAM PLASTICS, NON DESTRUCTIVE TESTING AND TESTING ORGANIZATIONS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be able to discuss the various spectroscopic characterization techniques of polymers.
CO2: Will be able to assess thermal and electrical properties of polymers
CO3: Will be able to analyze the test results of mechanical properties of polymers.
CO4: Will be able to understand ignition, optical and analytical tests of polymer and interpret the test results.
CO5: Will be able to evaluate NDT testing of plastics and explain the relevance of standards and specifications.

REFERENCE BOOKS:
PL3202  

UNIT OPERATIONS 

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OBJECTIVES:
- To learn about the concepts of unit operations and their importance in polymer industries
- To understand the concepts of heat transfer by conduction and convection process.
- To learn about the analogy between heat, mass and momentum transport processes

UNIT I  
MOMENTUM TRANSPORT PROCESS  
Momentum transport – fluid behavior – overall mass, energy and momentum balances – differential mass, energy and momentum balance-polymeric liquids.

UNIT II  
SOLUTION TO EQUATIONS OF MOTION  
Solution to equations of motion - boundary layer flow – turbulent flow– dimensional analysis applied to momentum transport – design equation for incompressible fluid flow through packed column–fluidization.

UNIT III  
HEAT TRANSFER BY CONDUCTION PROCESS  

UNIT IV  
CONVECTIVE HEAT TRANSFER PROCESS  
Convective heat transfer – heat transfer in laminar and turbulent flow- boiling and condensation – design equations for convective heat transfer – heat exchangers.

UNIT V  
MASS TRANSFER  
Mass transfer – molecular diffusion – binary systems – convective mass transfer coefficients – mass transfer in laminar and turbulent flow –design equations for convective mass transfer – analysis between momentum, heat and mass transfer.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be able to select suitable criteria for solving material and energy balance problems
CO2: Will be able to analyze and assess solutions to equation of motion.
CO3: Will be able to methodically discuss and apply appropriate methods for problems in conductive heat transfer.
CO4: Will be familiar with convective heat transfer process and in the design of heat exchangers.
CO5: Will be able to discuss the importance of mass transfer and compare the analogy between heat, mass and momentum transport processes.

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PL3203 PROCESS CONTROL IN POLYMER INDUSTRY

OBJECTIVES:
- To make the student familiar with the process variables and their measurement.
- To impart knowledge on controllers used in polymer industries.
- To impart knowledge on Computer control and applications.
- To acquaint student with the concepts of instrumentation involved in injection and blow moulding.

UNIT I PROCESS VARIABLES
Process variables such as temperature, pressure, flow etc. and their measurements. Examples in polymer processing in moulding and extrusion.

UNIT II MEASUREMENT AND CONTROL
Measurement and control – Simple systems-first and higher order systems- Design specifications on system time response – feedback control diagram – proportional, integral, derivative and PID controls.

UNIT III MATHEMATICAL ANALYSIS
Mathematical analysis of processes and feedback control systems – poles, zeros and system stability- Stability Analysis- Routh’s Test-Root locus-frequency response using Bode plot.

UNIT IV COMPUTER CONTROL
Computer control and application – mathematical concepts of discrete variables analysis and multivariable processes and other control methods as feed forward control, ratio control and internal model control etc.

UNIT V INSTRUMENTATION
Instrumentation in blow moulding, extrusion and injection moulding and control systems.

COURSE OUTCOMES:
CO1: Will be able to describe the various process variables and their measurements.
CO2: Will identify physical examples for first and second order systems and choose appropriate systems for practical applications.

TOTAL: 45 PERIODS
CO3: Will gain knowledge on the concepts of control system stability and assess different methods to arrive at it.

CO4: Will be able to apply computer control methods to solve problems in stability analysis.

CO5: Will be able to illustrate the instrumentation concepts in blow, injection and extrusion moulding.

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PL3204 POLYMER PRODUCT AND MOULD DESIGN

OBJECTIVES:
- To learn about the basic concepts of polymer product design.
- To know about the design concepts of mold and die
- To acquire knowledge about the design of extrusion and injection mould dies
- To understand the design concepts in compression and transfer moulding.

UNIT I BASIC CONCEPTS OF PRODUCT DESIGN
Mould material selection - polymeric material and its processing effects on performance of parts and its limitation on product design - polymeric product design concept - design of radii, fillets, ribs and bosses, design of parting line, wall thickness, Moulded holes - drilled and tapped holes, taper or draft - design of hinges and snap for boxes - feed system - sprue, runner & gate - ejector system - mould vent - venting method - external & internal undercuts - Moulded threads - thread types - threaded holes - assembly - fits & tolerances.

UNIT II POLYMERIC PRODUCT DESIGN
Structural design of beams, columns, plates, bars, pipes and shells - design procedure for polymeric parts - design of plastic structural parts for static and dynamic load - gears and bearings design - design of plastic parts for electrical and optical applications - basic design configuration for elastomeric seals and rings - Concepts of composite product design.

UNIT III INJECTION MOLD DESIGN
Introduction - process variables - moulding cycle - General mould construction - core, cavity, guide pillar, feed system & ejection system and techniques - Two plate mould - Stripper plate mould - three plate mould-single impression and multi-impression - split moulds - finger
cam and dog-leg cam actuation mould-inserts - Selection of metal for inserts - side cores and side cavities - split cores - relieving moulding stress around inserts - flow characteristics - injection pressure - injection speed - hold on time - gate freezing - clamping force calculation - temperature control system - cooling system.

UNIT IV   EXTRUSION DIE DESIGN   9
Principle of Extrusion - Important aspects of die design - basic geometry of die - die land design - die swell - construction of extrusion die - blown film, pipe, profile - sheet, flat film, tube, wire/cable coating dies, co-extrusion die - spiral mandrel die, fish tail die, adjustable core die - extrusion die for rubber parts - heating system - temperature control - effect of temperature and pressure on die design.

UNIT V   OTHER MOULD DESIGNS   8
Compression mould, principles, types - designing of open flash, positive and semi-positive, and displacement moulds, types of loading chambers, bulk factor, flash thickness, projected area, compression pressure, clamping force. transfer mould design, principles, types - pot and plunger - projected area, transfer pressure, clamping force, pressure pad design, flash thickness, bulk factor - design of sprue runner and gate, blow moulds - types - parison and pinch off design - rotational mould design.

COURSE OUTCOMES:
CO1: Will be able to describe the basic concepts of product design.
CO2: Will be able to apply the knowledge of design aspects based on the type of polymer and its applications.
CO3: Will be able to analyze the design aspects of various plastic parts by injection moulding.
CO4: Will be able to assess the die design of plastic parts prepared by extrusion moulding.
CO5: Will be able to design mold/die for different molding process.

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PL3211 POLYMER ANALYSIS AND CHARACTERISATION LAB

OBJECTIVES:
- To identify the plastics and rubber materials.
- To learn about the structural and electrochemical analysis of polymers.
- To enable the students to interpret the data obtained from DSC and TGA

UNIT I IDENTIFICATION 20
Identification of plastics - PP, PE, polyamide, polyester, PVC, NBR, PS, ABS, PC, IIR, SBR, Thiokol, CR, Butyl rubber, etc.

UNIT II ANALYSIS METHODS 20
MFI, Brookefield viscometer - oxygen index - filler content determination (muffle furnace) - determination of carbon black content - density measurement, electrochemical analysis - cyclic voltammetry, chronopotentiometry, chronoamperometry.

UNIT III INTERPRETATION 20
Surface morphology study – SEM, Interpretation of DSC, TGA, IR and NMR.

COURSE OUTCOMES:
CO1: Will be able to identify the polymeric materials.
CO2: Will be able to determine the filler and carbon black content.
CO3: Will be able to assess the electro-chemical properties of polymer.

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PL3212 MOULD DESIGN AND ANALYSIS LAB

OBJECTIVES:
- To learn about the basics in designing of mould and die.
- To understand the basics in injection mould design
- To know about mould flow simulation and FEA
- To understand about rapid prototyping and PLC
UNIT I  BASIC MODELING AND DRAFTING  12
2D drawing and drafting (2 drawings) using software - 3D modeling and drafting using software (3 models) - Assembling and drafting (2 assemblies) - Surface modeling (2 exercises) - 2D and 3D modeling of plastic components.

UNIT II  INJECTION MOULD DESIGN  12
Mold design concept- Fixed clamping plate, cavity plate, back plate, ejector retainer plate, ejector back plate, movable clamping plate, runner, gate, side cores and its assembly - Design calculation for number of cavities, plasticizing rate, clamping force - 2D, 3D designing and modeling of single cavity mould, Multi cavity mould, split mould.

UNIT III  MOULD/DIE DESIGN  12
2D, 3D designing and modeling of compression, transfer moulds - calculation of clamping force, flash thickness allowance - 2D, 3D designing and modeling of blow moulds - calculation of pinch off, head die design, parison dimension - 2D, 3D designing and modeling of extrusion die.

UNIT IV  FLOW ANALYSIS  12
Design and process parameter optimization - Mold flow simulation - finite element analysis, meshing - Mold flow analysis - Fill analysis, pack analysis, cool analysis, warp analysis, shrinkage analysis, gate location analysis, wall thickness analysis, runner balance analysis, stress analysis.

UNIT V  PRODUCT LIFE CYCLE AND PROTOTYPING  12
Programs on PLC for plastic products (3-5 programs) – solid free form manufacturing and Reverse Engineering.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1: Will be able to design and develop any type of mold and die for plastic products.
CO2: Will be able to analyze the flow behavior using mould flow analysis
CO3: Will be able to discuss the design of complicated parts in injection moulding.
CO4: Will be able to assemble and draft components in 2D and 3D models.
CO5: Will be able to evaluate the concepts of PLC and rapid prototyping.

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OBJECTIVES:
- To know about various additives like Antioxidants, Metal deactivators Lubricants, Fillers, fibres, flame retardants, colourants, anti-oxidants, Antistatic agents etc.
- To understand the functions of each of these additives, technical requirements,
- To learn about the additive types, mechanism and their effective evaluation.

UNIT I ADDITIVES

UNIT II COLORANTS AND COLORING TECHNOLOGY

UNIT III FILLERS AND REINFORCEMENT
Theories and action of fillers and reinforcement- properties of filled and reinforced plastics – Economical importance – Description of filler and reinforcements – Calcium Carbonate, Dolomite, Silicates, Talc, Kaolin, Mica, Feldspar, Wollastonite, metal and metal oxides Carbon, carbon black, graphite, basalt fiber, carbon fiber, sisal fiber, boron fiber, electrically conducting fillers.

UNIT IV COMPOUNDING TECHNIQUES
Selection criteria of polymers and compounding ingredients - General objectives - possibilities and limitations of mixing and compounding-Principle of mixing and compounding - Methods of incorporation of additives into polymer materials.

UNIT V COMPOUNDING EQUIPMENTS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will learn about various additives and choose them as per requirement in polymeric industries
CO2: Will grasp idea about colourant and colouring technology and its use in polymer industries
CO3: Will identify the required fillers and reinforcements for specific applications
CO4: Will be able to methodically discuss the compounding techniques
CO5: Will be able to identify the suitable compounding equipments as per requirement.

REFERENCE BOOKS:

**COURSE ARTICULATION MATRIX**

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**PL3002 ADDITIVEMANUFACTURING**

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**OBJECTIVES:**
- To educate students with fundamental and advanced knowledge in the field of additivemanufacturing technology for plastics products.
- To learn about the additive manufacturing process and applications.
- To understand the design concepts in additive manufacturing.
- To familiarize various software tools, processes and techniques to create physical objects that satisfy product development / prototyping requirements, using AM.

**UNIT I INTRODUCTION**
9

**UNIT II ADDITIVEMANUFACTURING(AM)TECHNOLOGIES**
12
Powder based, droplet based, extrusion based - Object Stereolithography - Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins - Solid Ground Curing (SGC)- Fused deposition Modeling (FDM) - Laminated Object Manufacturing (LOM) - Selective Laser Sintering (SLS) - Laser Engineered Net Shaping (LENS) - Shape Deposition Manufacturing (SDM) - Ballistic Particle Manufacturing (BPM).

**UNIT III MATERIALSFORAM**
6
Multi-functional and graded materials in AM - Role of solidification rate - Evolution of non-equilibrium structure - structure property relationship.

**UNIT IV DESIGN FOR ADDITIVEMANUFACTURING(DFAM)**
9

**UNIT V APPLICATIONS ANDPOSTPROCESSING**
9
Direct processes; Rapid prototyping, Rapid tooling, Rapid manufacturing – Indirect processes: Indirect prototyping, indirect tooling, indirect manufacturing - Application examples for
Aerospace, defense, automobile, Bio-medical and general engineering industries. Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Ability to choose a suitable Additive Manufacturing (AM) method.
CO2: Ability to face the research challenges associated with AM and its data processing tools.
CO3: Ability to understand the concepts of AM, AM technologies.
CO4: Will acquire knowledge on selection of materials for AM
CO5: Will able to learn about AM process plan including building strategies and postprocessing.

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PL3003 ADHESIVE AND COATING TECHNOLOGY

OBJECTIVES:
• To bring a sound knowledge of theoretical and technological aspects of mechanism and characterization of adhesives.
• To understand the various types of Adhesives employed in Industries.
• To acquire knowledge of Applications of adhesives in various fields.

UNIT I ADHESION MECHANISM
Definition and mechanisms of adhesion - mechanical interlocking – inter-diffusion theories – adsorption and surface reaction. Surface topography, surface features and forces, wetting and

UNIT II  CHARACTERIZATION OF ADHESIVES  9
Principle of fracture mechanics, peel, lap sheen and butt tensile tests. Pull out of an extendable fibre, various testing and evaluation of adhesives, energy dissipation – plasticity – strength of elastomers.

UNIT III  COATING TECHNOLOGY  9

UNIT IV  ADHESIVE TYPES  9

UNIT V  APPLICATIONS OF ADHESIVES  9
Adhesives for building construction, medical use, automobile industry bonded and coated abrasives – fabrics, cyanoacrylate based adhesives, bonding technology for textile, metal, plastics, wood, paper and glass.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be able to attain the basic knowledge of adhesives.
CO2: Will be able to comprehend the utility of adhesives in industry.
CO3: Will develop capacity to apply coatings in various fields
CO4: Will know the various testing methods for adhesives and coatings.
CO5: Will acquire knowledge on various material used for adhesives.

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COURSE ARTICULATION MATRIX
OBJECTIVES:
- To acquire knowledge on biodegradable polymers and the degradation mechanisms.
- To gain knowledge on principles of biodegradation in liquid and soil.
- To study about the structures and applications of biopolymers.
- To understand the biopolymer processing techniques and its application in packaging.
- To appreciate the structure and functions of natural biopolymers and their applications.

UNIT I  BIODEGRADABLE POLYMERS
Introduction, Advantages, Classification; Degradation of polymers – Mechanism - Thermal degradation, Mechanical Degradation, Degradation by Ultrasonic Waves, Photo degradation, Degradation by High Energy Radiation, Oxidative Degradation and Hydrolytic Degradation; Biological Degradation - Enzymic Hydrolysis, Enzymic Oxidation; Analysis of Biodegradation - Enzyme assays, Plate test, Respiratory test, Natural environment, Field trial, Gas evolution test, Factors Affecting Biodegradability.

UNIT II  BIODEGRADATION OF POLYMER IN LIQUID AND SOIL
Biodegradation in Liquid Environments - Degradation in real & laboratory Tests - Simulating real aquatic environments, Defining and optimizing liquid media; Standard tests using liquid media, Biodegradation behavior of polymers in the soil - The soil environment - Surface factors, underground factors, Degradability of polymers in soil, Effects of biodegradable polymers on Soil Living Organisms.

UNIT III  GREEN CHEMISTRY FOR POLYMERS

UNIT IV  BIOPOLYMERS
Types of Biodegradable Polymers - Bio based polymers, starch based polymers, cellulose based polymers, chitin and chitosan, bacterial polyesters, synthetic biodegradable polymers, polymers from bio based monomers - Proteins, hemicellulose and cellulose based biopolymers - Plant and animal based proteins – Solution casting of proteins – Processing of proteins as plastics – preparation and properties of hemicellulose – Cellulose based composites - Surface and chemical modifications of cellulose fibers.

UNIT V  STRUCTURE OF BIOPOLYMERS
Natural Polymers: chemical & physical structure, properties, source, important chemical modifications, applications of polymers such as cellulose, lignin, starch, rosin, shellac, latexes, vegetable oils and gums, proteins.– the macromolecular structure and biological functions of polymers - primary, secondary, tertiary and quaternary structure of polymers – structure maintenance and transmission of the biological information- viruses and phages – living macromolecules.

COURSE OUTCOMES:
CO1: Will understand the nature of biodegradable polymers and the degradation mechanisms.
CO2: Will gain knowledge on principles of biodegradation in liquid and soil.
CO3: Will evaluate the structures and applications of biopolymers.
CO4: Will analyse biopolymer processing techniques and its application in packaging.
CO5: Will gain skill in the structure and functions of natural biopolymers and their applications.
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PL3005 CAD/CAM APPLICATION INMOULD/TOOLDESIGN

COURSE OBJECTIVES:
- To provide knowledge on computer aided design and computer aided manufacturing.
- To learn about CAD/CAM in designing of plastics moulds.
- To understand about CAD/CAM applications in tool designing.
- To introduce the evolution, types and principles of CNC machining tools.
- To gain knowledge on manual part program and generation of CNC part program.

UNIT I INTRODUCTION
Basic concepts of CAD - graphic primitives, curve representation, windowing, clipping - shape and size description- parametric programming – interactive programming (LISP)- 2D drafting - 3D modeling - surface and solid modeling - assembly modeling.

UNIT II GRAPHICSANDDATABASE

UNIT III CNC
UNIT IV  AM, CIM& FEA

UNIT V  MOLDFLOW ANALYSIS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will acquire knowledge on computer aided design and manufacturing for mould designing.
CO2: Will able to learn about basic graphic primitives, 2D drafting and 3D modeling.
CO3: Will have the ability to know about the database management.
CO4: Will learn about CNC, FEM, etc.,
CO5: Will able to analyse mould flow characteristics.

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PL3006  COMPOSITE TECHNOLOGY

OBJECTIVES:
- To acquire knowledge of the importance and various types of reinforced plastics and its advantages and needs.
- To become aware of the various types of fibers, resins and other additives materials available for making composites.
- To develop expertise in the various types of moulds, premix moulding compounds and processes used in the processing of composites.
- To be conversant with the basic destructive and non-destructive testing of reinforced plastics.
• To be familiar with the concept of nano reinforcements, their types, processing of nano reinforced plastics and their applications

UNIT I  INTRODUCTION TO COMPOSITES
Characteristics, advantages, and need for reinforced plastics – Classification – particulate, fibrous, laminated, PMC, MMC, CMC, advanced, hybrid, braided and carbon matrix composites. Predicting properties of Fiber-Reinforced composites.

UNIT II  MATRIX MATERIALS

UNIT III  PROCESSING OF COMPOSITES

UNIT IV  TESTING OF COMPOSITES
Fiber volume fraction, tensile, shear, compressive, flexural, thermo elastic and off-axis responses of lamina and laminates - notched strength – fracture toughness – nondestructive testing.

UNIT V  POLYMER NANOCOMPOSITES
Introduction: Nanoscale Fillers – Clay, POSS, Carbon based nanomaterials, nanoparticle fillers; Processing into nanocomposites; Modification of interfaces; Properties. Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be able to classify composites and discuss its advantages
CO2: Will be able to evaluate various types of fibers and polymers to prepare composites.
CO3: Will gain adequate knowledge on all types of processes to prepare composites and will be able to choose suitable process as per product requirement.
CO4: Will develop expertise to do the required quality control tests and evaluate suitability of the composite products for various applications.
CO5: Will become aware of the new developments related to synthesis, characterization and applications in the various types of nanomaterials as reinforcements for composites and able to predict the properties of such composites.

REFERENCE BOOKS:
PL3007 CONDUCTING POLYMERS

OBJECTIVES:
- To impart knowledge of doping and conductivity in polymers
- To learn about synthesis, processing and applications of conducting polymers.
- To understand electrochemical, spectral and morphological characterization of conducting polymers

UNIT I ELECTROCHEMISTRY OF CONDUCTING POLYMERS
Theory of conduction-band theory; requirements for polymer to work as conductor; types of conducting polymers-intrinsic and extrinsic; source of electronic conduction in polymers - solitons, polarons and bipolarons; doping; factors affecting conductivity; measurement of conductivity-Vander Pauw technique.

UNIT II SYNTHESIS, PROCESSING AND APPLICATIONS OF CONDUCTING POLYMERS
Synthesis of conducting polymers - chemical and electrochemical methods; synthesis, processing and applications of polyacetylene, polyaniline, polypyrrole, polythiophene and poly-para phenylene based conducting polymers.

UNIT III ELECTROCHEMICAL CHARACTERIZATION OF CONDUCTING POLYMERS
Electro-analytical techniques - cyclic voltammetry, chronoamperometry and chrono-coulometry

UNIT IV SPECTRAL AND MORPHOLOGICAL CHARACTERIZATION OF CONDUCTING POLYMERS
FTIR, UV-vis, Raman, XRD, SEM, TEM, DETA, TGA, DTA, DSC and DMA.

UNIT V DEVICE FABRICATION
Rechargeable batteries, solar cells, light emitting devices; microelectronics-PCB fabrication; antistatic coating, EMI shielding, functionalized bio-conductive polymers- sensors and actuators; super capacitor; super conductor (Inorganic, organic hybrid structure), composites of conducting polymers

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be able to understand the classification, principle and mechanism of conducting polymers along with the concept of doping.
CO2: Will be able to synthesize a conducting polymer and discuss its applications
CO3: Will be able to assess the electro-chemical properties of conducting polymer.
CO4: Will be able to analyze and describe the spectral properties of conducting polymers
CO5: Will be able to apply the knowledge of conducting polymers and construct devices for energy storage
REFERENCE BOOKS:

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PL3008 HIGHPERFORMANCEPOLYMERS L T P C 3 0 0 3

OBJECTIVES:
• To learn about high performance polymers and its applications.
• To impart knowledge on the use of polymers in energy storage devices.
• To gain knowledge of polymers in lithography and water treatment.
• To impart knowledge on the use of polymers in bio-medical field.

UNIT I POLYMERS FOR ELECTRICAL AND ELECTRONICS APPLICATIONS 9
Engineering plastics - polymers in electrical and electronics industry - electro conducting polymers polymer batteries - electrets - polymers with piezoelectric, pyroelectric and ferroelectric properties photo conducting polymers.

UNIT II POLYMERS FOR HIGH TEMPERATURE APPLICATIONS 9
Polymers for high temperature resistance - fluoro polymers, aromatic polymers, heterocyclic polymers; polymers as building materials; aramids and carbon fibres.

UNIT III POLYMERS FOR ENERGY CONVERSION AND STORAGE 9
Basic of electrochemical energy devices; organic/plastic/flexible solar cells, polymer composites for solar cells, device fabrication and characterization; mechanism and materials for different types of batteries, super capacitor; fuel cells- polymer membranes for fuel cells.

UNIT IV POLYMERS IN LITHOGRAPHY AND WATER TREATMENT 9

UNIT V POLYMERS FOR BIOMEDICAL APPLICATIONS 9
Polymer for biomedical applications - polymers in dentistry – tissue adhesives - dialysis membrane - blood oxygenators - bone cement - prostheses - biodegradable sutures - control drug delivery systems.

TOTAL: 45 PERIODS
COURSE OUTCOMES:
CO1: Will be able to discuss about the various types of engineering plastics.
CO2: Will be able to analyze and choose polymers for high temperature applications.
CO3: Will be able to evaluate the use of polymers in energy storage devices.
CO4: Will be capable to assess polymers for lithography and water treatment applications.
CO5: Will be able to analyze and choose polymers for bio-medical applications.

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PL3009 PLASTICS MOULD MANUFACTURING TECHNOLOGY L T P C 3 0 0 3

OBJECTIVES:
- To develop knowledge about the mould manufacturing process.
- To impart knowledge on mould materials, metal cutting tools, CNC.
- To learn the basics of mold assembly, product dimension and precision.

UNIT I MATERIALS

UNIT II TOOLING

UNIT III CNC & RAPID TOOLING
Introduction of NC and CNC -programming - G and M codes - CNC machines - CNC EDM (wire EDM), CNC Milling, CNC Lathe- CNC machining and turning center - rapid vs
conventional tooling - mould element development using rapid tooling- application of rapid tooling.

UNIT IV MOULD FINISHING AND ASSEMBLY

UNIT V INSPECTION
Dimension and tolerance - accuracy and precision - working principle and application of measuring instruments used in tool room – coordinate measuring machine (CMM) - micrometer, surface plates, angle plates, squares, vernier height gauges, depth gauges, slip gauges, dial gauges, surface roughness measurement - hardness testing comparators - optical profiles projectors, tool makers microscope - optical flats.

COURSE OUTCOMES:
CO1: Will able to understand the mould manufacturing techniques.
CO2: Will have the ability to select the material for mould depending upon application and processing.
CO3: Will know about the metal cutting tools, CNC based tool room machineries and its application in mould manufacture.
CO4: Will gain knowledge on different inspection techniques
CO5: Will acquire the concepts of mould maintenance

REFERENCE BOOKS:

COURSE ARTICULATION MATRIX

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COURSE OUTCOMES:
- To impart knowledge on polymeric blends and alloys.
- To learn about compatibilizer and high performance blends
- To understand about the characterization of polymer blends.

PL3010 POLYMER BLENDS L T P C 3 0 0 3

OBJECTIVES:
- To impart knowledge on polymeric blends and alloys.
- To learn about compatibilizer and high performance blends
- To understand about the characterization of polymer blends.
UNIT I  POLYMER BLENDS

UNIT II  COMPATIBILIZATION OF POLYMERS
Reactive Compatabilization - methods and mechanism of compatibilization- block and graft copolymers as compatibilizers – block co Compatabilization by reactive blending - Crystallization of polymer blend - Interpretation of polymer/polymer interactions.

UNIT III  PREPARATION TECHNIQUES AND RHEOLOGY OF POLYMER BLENDS

UNIT IV  LCP POLYMER BLENDS
High performance polymer blends- LCP blends – LCP/Polyester blends, LCP/Polyolefin blends, LCP/Polyethersulfone blend, LCP/thermoplastic polyimide blend, LCP/LCP blends.

UNIT V  CHARACTERIZATION OF POLYMER BLENDS

TOTAL: 45 PERIODS

OUTCOMES:
CO1: Will able to prepare blends of various polymers for different applications.
CO2: Will acquire knowledge on miscibility behaviour based on thermodynamics.
CO3: Will able to gain knowledge concepts of techniques involved in polymer blend preparation.
CO4: Gain knowledge about solubility parameter and compatibility of blends.
CO5: will be familiar with the phase separation and rheology of polymer blends and alloys.

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OBJECTIVES:
- To learn about the basis of nano-composites and its applications.
- To understand the structure and properties of nanostructured polymer composites.
- To attain knowledge on components and preparation of bio based nanocomposites.
- To understand about the rheological and thermal properties of nano-composites.
- To appreciate the applications of nanocomposites in automotive and health care.

UNIT I  NANOCOMPOSITES-AN INTRODUCTION
Introduction - Organic and Inorganic materials - Polymer Nanocomposite Materials; Preparation of nanostructured materials - top-down processes, bottom-up processes, template assisted structuring of nanomaterials, ordering of nanostructures; Nanoscale fillers – Clay, POSS, CNT, nanoparticle fillers. Nano ceramic for Ultra high temperature MEMS; Optimizing nano filler performance in polymers; Preparation techniques; Modification of interfaces; Macromolecules at interface and structured organic films; Processing into nanocomposites.

UNIT II  NANOSTRUCTURED POLYMERCOMPOSITES
Nanocomposites: particulate, clay, and carbon nanotube, graphene nanocomposites. synthesis, characterization, properties, and applications. Flow behavior of carbon nanofiber-based polymeric nanocomposites; Rheology in polymer/clay nanocomposites: mesoscale structure development and soft glassy dynamics; Polymer-graphite nanocomposites; Polymer nanocomposite-flammability and flame retardancy.

UNIT III  BIONANOCOMPOSITES
Methods of preparation of bio nano composites – components - Animal based fiber reinforced composites; Biopolymeric nanofibers for tissue engineering; Potential use of poly hydroxyl alkanotes for tissue engineering; A reductionist approach for the molecular and supramolecular structures of elastin; Elastic based polymer nanocomposites; PLA based bio and nanocomposites; Toxicology of bio - nano composites – Applications of bio nanocomposites.

UNIT IV  SHEAR RHEOLOGY OF NANOFIBERBASEDCOMPOSITES
Introduction; Rheology background; Preparation of suspensions and composites; Rheological characterization- Start-up of steady shear, steady state shear measurements, small amplitude oscillatory shear measurements, measurements of temperature effects; Modeling of CNF suspensions; Modeling of CNF/PS melt composites- Modeling and simulation methods.

UNIT V  APPLICATIONSOFNANOCOMPOSITES
Barrier and membrane applications; Composite products based out of flammability resistance; Polymer blend compatibilization; Biomedical applications, Fuel cell applications, Electrical/electronic applications; Optoelectronics, Sensors; Automotive applications; Tyres; Wound care; Sport goods; Personal protective equipments.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be able to demonstrate the preparation of nanomaterials.
CO2: Will be able to analyse the science of nanomaterials
CO3: Will be able to evaluate the properties of polymeric bio nanocomposites.
CO4: Will be able to correlate the shear rheology of nanofiber based composites.
CO5: Will be able to gain knowledge in applications of polymer nanocomposites.

REFERENCE BOOKS:
3. Advani, S. G., “Processing and properties of nanocomposites”, World

COURSE ARTICULATION MATRIX

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PL3012 POLYMER REACTION ENGINEERING L T P C
3 0 0 3

OBJECTIVES:
- To acquire knowledge in reaction kinetics and evaluation of reaction rate.
- To familiarize in reactor design and to know about the effect of mixing on kinetics and MWD.
- To familiarize the students with mechanism of various polymerizations.
- To understand about the various polymerization techniques
- To know about the safety aspects and green approach in polymerization reactions.

UNIT I KINETICSOFPOLYMERISATION
Introduction to reaction kinetics - rate equation Polymerization kinetics for step growth and chain growth Bonding forces in polymers - Control on polymersynthesis - Interpretation of Batch Reactor data for irreversible reactions taking place in constant volume and variable pressure batch reactors - differential, integral, initial rate, half life, Graphical methods of Analysis and method of excess.

UNIT II INTRODUCTIONTOREACTOR DESIGN
Control of molecular weight and molecular distribution - the effect of mixing on kinetics and MWD - Different types of blenders - Micro structural features of polymers and their effect on properties - Chain branching, cross linking Units and dimensions, material balance, energy balance. Polymerization reactor design: batch reactors, plug flow reactors, continuous stirred tank reactors - Prediction of molecular weight distribution in different reactors, heat transfer problem in polymer manufacture.

UNIT III POLYMERIZATIONMECHANISMS

UNIT IV TEQUINQUESOFPOLYMERIZATION
Polymerization techniques - Homogeneous polymerization, Quiescent and stirred bulk

UNIT V REACTION PROCESSES AND SAFETY

TOTAL: 45 PERIODS

COURS OUTCOMES:
CO1: Will understand in reaction kinetics and evaluation of reaction rate.
CO2: Will be able to design stirrers and to know about the effect of mixing on kinetics and MWD.
CO3: Will be able to Understand mechanism of polymerization.
CO4: Will be able to evaluate various techniques of polymerization processes
CO5: Will be able to create safer reactor design and greener approach in polymerisation.

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PL3013 PLASTIC WASTE MANAGEMENT L T P C

OBJECTIVES:
- To make the student familiar with the plastic waste types and policies on plastic waste management.
- To acquaint the student with primary and secondary recycling techniques and their limitations.
- To introduce to students with tertiary and quaternary recycling, recycling of plastics.
- To make the students to understand the challenges faced in plastic recycling.
- To make them construct new efficient recycling techniques for recent category of waste.
UNIT I  PLASTIC WASTES  

UNIT II  PRIMARY AND SECONDARY RECYCLING  

UNIT III  TERTIARY AND QUATERNARY RECYCLING  

UNIT IV  CHALLENGES IN PLASTICS RECYCLING  

UNIT V  CIRCULAR ECONOMY AND BUSINESS OPPORTUNITIES  

COURSE OUTCOMES:
CO1: Will be aware of plastic waste types and policies on plastic waste management. CO2: Will able to decide on primary and secondary recycling techniques and their limitations.
CO3: Will develop techniques for recycling plastics into economically useful products.
CO4: Will analyze the challenges in plastic recycling.

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PL3014 POLYMERS FOR BIOMEDICAL ENGINEERING APPLICATIONS L T P C 3 0 0 3

OBJECTIVES:
- To acquire a knowledge of various types of biopolymers and their advantages and needs.
- To understand the various types of bio-materials and their applications for bio-medical engineering.
- To understand the knowledge of various bio-materials used in processing of components and the basic destructive and non-destructive testing of such biomaterials.
- To organize fabrication of bio-composites in biomedical applications.
- To create biocompatible biomedical devices using suitable biopolymers.
- To evaluate the modification techniques conventionally used for biomedical devices.

UNIT I BIOMATERIALS IN MEDICINE
Introduction to classes of materials used in medicine, world-wide market for biomaterials, clinical implications of biomaterials development. Types of materials - inert, toxic, bioactive, natural materials - collagen, biopolymers etc. Introduction to biocompatibility, requirements and standards, cell-material interaction, testing of biomaterials, in vitro assessment, invivo assessment of tissue compatibility, testing of blood-materials interaction, animal models.

UNIT II BIOPOLYMERS
Polymers as biomaterials, silicones, polyurethanes, polyvinyl chloride, Ultrahigh molecular weight polyethylene, polyacrylates, polyether ether ketone, water soluble polymers, hydrogels, bio-adhesives, diffusion principles, polymers for controlled drug delivery applications, polysaccharides, poly(orthoesters), polyanhydrides, aminoacid derived polymers, polyphosphazenes, bacterial polyesters.

UNIT III COMPOSITES IN BIOMEDICAL APPLICATIONS

UNIT IV MEDICAL DEVICES
Medical devices, medical device development, material choice, device design, extracorporeal devices, oxygenators, intravenous catheters, stents, polymeric implants, heart valves, total artificial heart, cardiac pace makers, vascular grafts, artificial kidney, dialysis membranes, hard tissue implants, orthopedic implants, fracture plates, intramedullary devices, spinal fixation, joint replacements, bone cement, soft tissue replacements, wound dressing, artificial skin, sutures, contact lenses, tissue adhesives, maxillofacial implants, ear and eye implants, controlled drug delivery systems, biosensors, gloves, condoms, urinary catheters, intrauterine systems, cosmetic implants. Regulation and standards for quality, FDA, EU-medical directives, GMP,
UNIT V MODIFICATION TECHNIQUES

Surface modification techniques, plasma modifications, coating methods. Sterilization methods, dry heat, steam, ethylene oxide, gamma ray, effect of sterilization on polymers, importance of packaging, shelf-life.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be aware of preparation and properties of bio-polymers.
CO2: Will attain knowledge on different medical devices and its functions.
CO3: Will be able to use bio-polymeric materials for making components.
CO4: Will be able to appreciate the basic destructive and non-destructive testing of bio- polymeric materials.
CO5: Will gain knowledge in various applications of biopolymers

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PL3015 POLYMERS FOR PACKAGING APPLICATIONS

OBJECTIVES:
- To impart knowledge on polymers as packaging material
- To gain knowledge about flexible packaging materials
- To make the students aware of rigid packaging materials and their molding techniques
- To learn about various food packaging materials and their problems
- To provide exposure to testing of packaging materials

UNIT I POLYMERS FOR PACKAGING

Polyethylene (LDPE, HDPE, LLDPE), Polypropylene, Polyvinylchloride, Polyvinylidene
chloride polycarbonate, polystyrene, polyvinyl alcohol, nylon, polyester, polycarbonate, fluoropolymers, ABS, and polyacrylonitrile

UNIT II FLEXIBLE PACKAGING MATERIALS

UNIT III RIGID PACKAGING MATERIALS
Material selection for rigid packaging, additives and compounding, Injection molding - closures, rotational molding, compression molding, blow molding-extrusion, injection, stretch, and aseptic blow molding – Plastic bottles, tubes, plastic pallets, drums, barrels, Jerry cans and shipping containers, Types of thermoforming – Drape, Vacuum and pressure forming

UNIT IV POLYMERS FOR FOOD PACKAGING
Properties of polymers for packaging, interaction between products and packaging. Biobased and biodegradable material for packaging- ecofriendly natural fibers for packaging-bio nanocomposites and their potential application in packaging industries

UNIT V TESTING OF PACKAGING MATERIALS
Packaging testing – Mechanical properties – tensile tear and impact properties, burst strength, stiffness, crease and flex resistance. Optical properties – clarity, haze and gloss. Barrier properties – oxygen transmission, water vapor transmission rate migration. Chemical resistance tests

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be aware of various polymers used for packaging applications
CO2: Will be conversant with flexible polymeric packaging materials and their types
CO3: Will be enriched with the knowledge about rigid packaging materials
CO4: Will be conversant with food packaging materials and their issues
CO5: Will be familiar with testing of polymeric packaging materials.

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OBJECTIVES:

- To acquire knowledge in the Fundamentals of Rubber and Specialty Rubbers.
- To know about the Vulcanization Processing and Compounding of Rubber and Manufacture of Tyres.
- To impart knowledge on quality control and testing methods of rubbers used.

UNIT I  FUNDAMENTALS OF RUBBER

UNIT II  SPECIALTY RUBBERS

UNIT III  PROCESSING AND COMPOUNDING OF RUBBER

UNIT IV  RUBBERS IN SEALING APPLICATIONS AND TYRES
Types of Seals - Gaskets - Flexible couplings Design considerations – Conveyor Belts V-belts. Troughing moulded, braided and hand–built hoses. Tyres – functions, requirements – basic design reinforcing systems. Block copolymers for dynamic applications including Tyres, Naval and space applications of rubber, Green tyre technology, Intelligent tyres - new generation tyres. Sustainable recycling technologies - Tyre recycling - Applications of recycled rubber.

UNIT V  QUALITY CONTROL, TESTING OF RUBBERS

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Will be able to recognize and list out the preparation and properties of rubbers.
CO2: Will be conversant and discuss the properties of Specialty rubbers.
CO3: Will develop capacity to appreciate and demonstrate compounding of rubbers.
CO4: Will have enriched knowledge about analyzing and rating the applications of rubbers.
CO5: Will have an update of current trends in testing of rubber processing technology.

REFERENCE BOOKS:

PL3017 SPECIALTY POLYMERS

OBJECTIVES
- To make the student acquire knowledge on liquid crystalline polymers.
- To provide exposure on conducting and piezoelectric polymers.
- To impart a thorough understanding of heat resistant polymers.
- To provide knowledge on photosensitive polymers and coating additives.
- To facilitate the students to understand the use of polymers for specialty applications.

UNIT I LIQUID CRYSTALLINE POLYMERS (LCPS)
Concept of liquid crystalline (LC) phase, definition and synthesis, liquid crystalline polymers - types and their classification - theories of liquid crystallinity, characteristics of LC state and LCPs, liquid crystalline elastomers, structure property relationship, rheology of liquid crystalline polymers, biphasic behaviour, blends of LCPs, self-reinforced composites, applications of LCPs.

UNIT II CONDUCTING POLYMERS
Theory of conduction, semi-conductors and conducting polymers, Background of conducting polymers, conductivity range of commercial polymers, band theory, requirements for polymer to work as conductor, types of conducting polymers - intrinsic and extrinsic, doping of polymeric systems, self-doped polymers, Mechanism of conducting polymers- Polyaniline, Polyacetylene, Polypyrole, polythiophene, polyphenylene sulphide, organometallic polymers – Photo conducting polymers- Polymers with Piezzo, ferro and pyro electric properties.

UNIT III HEAT RESISTANT POLYMERS
Requirements for heat resistance, determination of heat resistance, synthesis, structure-property relationships, methods to improve thermal stability and fire resistance, applications of heat resistant polymers like polyamides, polyimides and its derivatives, polynolinones, polyquinoloxines, Polymers for high temperature resistant applications, - PBT, PBO, PBI, PPS, PPO, PEEK, Fluro polymers, aromatic polymers and heterocyclic polymers.

UNIT IV PHOTOSENSITIVE POLYMERS AND POLYMERS AS COATING ADDITIVES
Photosensitive polymers - synthesis, curing reactions, applications in various fields. Photo resists for semiconductor fabrication, photoresists applications for printing, Membranes, their types, methods of casting and their applications. Polymer as coating additives - types, synthesis, requirements for polymer to work as coating additives and applications.
UNIT V POLYMERS IN MISCELLANEOUS SPECIALTY APPLICATIONS

Polymers in agricultural applications: green houses, mulches, control release of agricultural chemicals, seed coatings, etc., polymers in construction and building applications, polymer concrete—applications, Shape memory polymer, polymeric materials used in telecommunication, optical fibre telecommunication cables and power transmission applications, polymer composites in aerospace and other light weight applications, polymers for biomedical application, polymers in cosmetics.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Comprehend the importance of rheology of liquid crystalline polymers.
CO2: Understand the importance of Polymeric doping systems.
CO3: Have knowledge on the use of polymers for high temperature applications.
CO4: Identify the application of photoresists and polymeric coatings.
CO5: Understand the use of polymers for agricultural, aerospace and telecommunications.

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PL3018 SYNTHETIC RESINS

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OBJECTIVES:
- To acquire knowledge on the classification of natural, synthetic polymers and its commercial applications.
- To understand the basic concepts of water soluble polymers and its applications in various fields.
- To understand the concepts of thermoplastics and thermosetting resins, their importance of rubbers, fibers and plastics and their engineering applications.

UNIT I CLASSIFICATION OF POLYMERS

Introduction – Classification of natural, modified and synthetic polymers – effect of structure on properties of polymers — Salient features of plastics-water soluble polymers—

UNIT II WATERSOLUBLE POLYMERS

UNIT III THERMOPLASTIC RESINS

UNIT IV THERMOSETTING RESINS

UNIT V RUBBERS AND FIBERS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1: Will be aware of classification of polymers.
CO2: Will develop capacity to appreciate the applications of natural and synthetic polymers.
CO3: Will able to gain knowledge on properties of thermoplastic and thermosetting resin and its trade name.
CO4: Will able to know the preparation of various thermoplastic and thermosetting resins.
CO5: Able to gain knowledge in various rubber and its formulations.

REFERENCE BOOKS:

COURSE ARTICULATION MATRIX

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