Delhi Technological University

Department of Applied Chemistry

Program: M.Tech. (Polymer Technology)

Program Outcomes

1. **Scholarship of Knowledge:** Acquire in-depth knowledge of a specific discipline or professional area, including a more comprehensive and global perspective, with an ability to discriminate, evaluate, analyze, and synthesize existing and new knowledge and integrate the same to enhance understanding.
2. **Critical Thinking:** Critically analyze complex engineering problems and apply independent judgment when synthesizing information to make intellectual and creative advances in conducting research in a broader theoretical, practical, and policy context.
3. **Problem-Solving:** Think laterally and initially, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems, and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal, and environmental factors in the core areas of expertise.
4. **Research Skill:** Extract information pertinent to unfamiliar problems through literature surveys and experiments; apply appropriate research methodologies, techniques, and tools; design and conduct experiments; analyze and interpret data; demonstrate higher-order skill and view things in a broader perspective; contribute individually or in group(s) to the development of scientific, technological knowledge in one or more domains of engineering.
5. **Usage of modern tools:** Create, select, learn, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work:** Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, and make decisions based on open-mindedness, objectivity, and rational analysis to achieve common goals and further their own and others' learning.
7. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply them to work as a team member and leader. Manage projects efficiently in respective disciplines and multidisciplinary environments after considering economic and financial factors.
8. **Communication:** Communicate confidently and effectively with the engineering community and society regarding complex engineering activities, such as comprehending and writing effective reports and design documentation by adhering to appropriate standards, making effective presentations, and giving and receiving clear instructions.

9. **Lifelong Learning:** Recognize the need for and have the preparation and ability to engage in lifelong learning independently, with enthusiasm and commitment to continuously improving knowledge and competence.
10. **Ethical Practices and Social Responsibility:** Acquire professional and intellectual integrity, a professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices, and an understanding of the responsibility to contribute to the community for the sustainable development of society.
11. **Independent and Reflective Learning:** Observe and critically examine the outcomes of one's actions, make corrective measures, and learn from mistakes without depending on external feedback.

Programme Specific Outcomes

PSO.1) Highly valued technocrats competent to take up challenging positions in industry, academia, and government sectors

PSO.2) Ability to execute new ideas with established principles of polymer technology in the field of Research & Development in India and abroad

PSO.3) Ability to adapt continuously changing techniques and play a pivotal role in the process of sustainable development of society

M.Tech Full Time Scheme

SEMESTER I			
Type	**Cr**	**L-T-P**	**Total Credits**
PTE-101 Polymer Chemistry	4	3-0-2	24
PTE-103 Polymer Structure & Properties	4	3-0-2	
PTE-105 Polymer Processing	4	3-0-2	
PTE-107 Polymer Testing & Characterization	4	3-0-2	
Department Elective 1	4	3-1-0	
Self-Study	2	-	
Skill Enhancement Course 1	2	1-0-2	
Audit Course	0	0-0-2	

SEMESTER II			
Type	**Cr**	**L-T-P**	**Total Credits**
PTE-102 Plastic Technology	4	3-0-2	24
PTE-104 Rubber Technology	4	3-0-2	
Department Elective 2	4	3-0-2	
Department Elective 3	4	3-1-0	
Research Methodology and IPR	4	3-1-0/3-0-2/2-0-4/0-0-8	
Skill Enhancement Course 2 /Industrial Training	2	1-0-2/0-0-4	

SEMESTER III			
Type	**Cr**	**L-T-P**	**Total Credits**
PTE-201 Fiber Technology	4	3-0-2	16
Open Elective 1	4	3-1-0	
Minor Project, Research Thesis, Patent	8	-	

SEMESTER IV			
Type	**Cr**	**L-T-P**	**Total Credits**
Major Project, Research Thesis, Patent	16	-	16

M. Tech Part Time Scheme

SEMESTER I			
Type	**Cr**	**L-T-P**	**Total Credits**
PTE-101 Polymer Chemistry	4	3-0-2	12
PTE-103 Polymer Structure & Properties	4	3-0-2	
PTE-105 Polymer Processing	4	3-0-2	

SEMESTER II			
Type	**Cr**	**L-T-P**	**Total Credits**
PTE-102 Plastic Technology	4	3-0-2	12

PTE-104 Rubber Technology	4	3-0-2	
Department Elective 2	4	3-0-2	

SEMESTER III			
Type	**Cr**	**L-T-P**	**Total Credits**
PTE-107 Polymer Testing & Characterization	4	3-0-2	12
Department Elective 1	4	3-1-0	
Self-Study	2	-	
Skill Enhancement Course 1	2	1-0-2	
Audit Course	0	0-0-2	

SEMESTER IV			
Type	**Cr**	**L-T-P**	**Total Credits**
Department Elective 3	4	3-1-0	12
Research Methodology and IPR	4	3-1-0/3-0-2/2-0-4/0-0-8	
Skill Enhancement Course 2 /Industrial Training	4	1-0-2/0-0-4	

SEMESTER V			
Type	**Cr**	**L-T-P**	**Total Credits**
PTE-201 Fiber Technology	4	3-0-2	16
Open Elective 1	4	3-1-0	
Minor Project, Research Thesis, Patent	8	-	

SEMESTER VI			
Type	**Cr**	**L-T-P**	**Total Credits**
Major Project, Research Thesis, Patent	16	-	16

List of Elective Courses

Department Elective I		
Type	**Cr**	**L-T-P**
PTE 109 Rheology	4	3-1-0
PTE 111 Polymer Degradation	4	3-1-0
PTE 113 Green Polymers	4	3-1-0
PTE 115 Inorganic Polymers	4	3-1-0

Department Elective II		
Type	**Cr**	**L-T-P**
PTE 106 Additives and Compounding	4	3-0-2
PTE 108 Speciality Polymers	4	3-0-2
PTE 110 Resin Technology	4	3-0-2
PTE 112 Biomedical Applications of Polymers	4	3-0-2

Department Elective III		
Type	**Cr**	**L-T-P**
PTE 114 Paint and Coating Technology	4	3-1-0
PTE 116 Adhesives	4	3-1-0
PTE 118 Tyre Technology	4	3-1-0
PTE 120 Membrane Technology	4	3-1-0

Skill Enhancement Course I		
Type	**Cr**	**L-T-P**
PTE 117. Extrusion and Injection molding	2	1-0-2
Skill Enhancement Course II		
Type	**Cr**	**L-T-P**
PTE 122 Polymer Product Design	2	1-0-2

Open Elective I		
Type	**Cr**	**L-T-P**
PTE203 Polymer Recycling	4	3-1-0
PTE204 Application of nanomaterials in Polymers	4	3-1-0
PTE205 Biosensors	4	3-1-0
PTE207 Polymer Blends and Composites	4	3-1-0

Detailed Syllabus

Polymer Chemistry	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Understand mechanisms and kinetics of step-growth and chain polymerization • Explain the general reaction course for ring-opening, cycloaddition, and coordination polymerization • Compare and value the homogenous, heterogenous, and interfacial polymerization techniques. • Evaluate copolymer composition and predict copolymerization behavior considering different parameters of copolymerization. • Develop sustainable polymers using new monomers

Syllabus Content:	**Hours**
Unit 1: Introduction- Nomenclature, classification, general characteristics of polymers, ring-opening polymerization, coordination polymerization, and cyclopolymerization.	8
Unit 2: Step-Growth Polymerization- General characteristics & chemistry of condensation polymerization, Ring vs Chain formation, Requirement of high conversion & high molecular weight polymer, step copolymerization, polymerization kinetics: the concept of equal reactivity of functional group, non-linearity in step growth polymerization, step growth polymerization other than poly-esterification,	9

catalyzed vs uncatalyzed, kinetics analysis of polymerization of A-A with B-B' and non-stoichiometric polymerization	
Unit 3: Chain growth polymerization- General characteristics & chemistry of chain growth polymerization, Ionic vs radical polymerization, nature of radical chain polymerization, the effect of substituents, constitutional isomerism: experimental evidence and synthesis; Initiator and initiation systems, initiator efficiency, types of radical initiation; kinetic expression for the rate of initiation and polymerization	9
Unit 4: Copolymerization- General considerations, types of copolymers, significance of copolymerization, kinetic equation, copolymerization behavior for alternate, random, block, graft copolymer	8
Unit 5: Polymerization techniques- solution, emulsion, bulk, suspension	8

References:
➢ Textbook of Polymer Science, F.W. Billmeyer, John Wiley, 2008
➢ Polymer Science, V.R. Gowarikar, New Age International, 2016
➢ Polymer Chemistry, M.P. Stevens, Oxford University Press,1999
➢ Principle of Polymerization, G. Odian, Wiley, 2004

Polymer Structure and Properties	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Predict polymer properties such as mechanical, rheological, thermal based on their structure. • Acquire in-depth knowledge of the molecular weight of the polymer and its relation with mechanical properties • Analyze the structure of polymers using modern analytical techniques and able to explain the data.

Syllabus Content:	**Hours**
Unit 1: Polymer molecular weight and its importance, molecular weight and its distribution method of determining different molecular weights, number average,	8

weight average, viscosity average, z-average molecular weights, and polydispersity index and its significance.	
Unit 2: Polymer Structure analysis, configuration, the conformation of polymers, structure, and properties of amorphous, semi-crystalline, and cross-linked polymers, crystal morphologies: unit cell structure, extended chain crystals, chain folding, lamellae, and spherules	8
Unit 3: Thermal properties of polymers, glass transition temperature (Tg), melting temperature (Tm), softening temperature (Ts), degradation temperature, flow temperature, tack temperature, flex at lower temperature, factors affecting the Tg and Tm of polymers, thermal analysis of polymer by dilatometer, TGA, DSC, DTA and HDT, determination of crystallinity and crystallization Kinetics	9
Unit 4: Non-Newtonian fluids, viscoelastic properties of the polymer, basics of rheological characteristics, experimental determination, mechanical models (Maxwell model, Kelvin-Voigt model), determination of rheological properties through viscometers and DMTA.	9
Unit 5: Mechanical properties of polymer strength (creep, fatigue, stress relaxation tensile, flexural, and compressive), hardness, resilience, impact properties, factors affecting these properties, methods of determination of these properties. Optical properties of polymers (haze, glaze, refractive index).	9

References:
➢ Polymer Science & Technology, P. Ghosh, Tata McGraw Hill, 2001
➢ Thermal Analysis of Polymeric Materials, Wunderlich, Springer, 2005
➢ Handbook of Plastic Testing & Failure Analysis, V. Shah, Wiley Inter-science, 2006
➢ Testing & Evaluation of Plastics, Mathur & Bhardwaj, Allied Publishers Pvt Ltd, 2003

Polymer Processing	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Prepare polymeric recipes to meet required product properties.

- Identify the polymer compounding operations depending on the material and final product requirements.
- To describe the working principle of the Polymer Processing Machines.
- Identify and solve the problems related products developed through Polymer Processing Machines
- Create and apply appropriate polymer processing techniques to give engineering solutions for new polymers.

Syllabus Content:	**Hours**
Unit 1: The importance of polymer compounding, the additives used in compounding, their functions in compounded products, and mixing techniques.	8
Unit 2: Working principle of single screw extruder, twin screw extruder, vent extruder, process of manufacturing films, tubes, rods, laminates, coatings	8
Unit 3: Working Principle of Compression molding machine, types, molding cycle, process variables, troubleshooting, applications of compression molding machine	8
Unit 4: Working Principle of Injection molding machine, gas-assisted injection molding, structural foam molding, reaction injection molding process, their industrial applications; troubleshooting	8
Unit 5: Working Principle of Blow molding process, their industrial applications; troubleshooting.	8
Unit 6: Miscellaneous processing methods: casting, rotational molding, decoration of polymers, working principles of calendaring and thermoforming process	8

References:

- Handbook of Plastic Processes, Harper, Wiley Inter science, 2006
- Principles of Polymer Processing, Tadmor & Gogos, Wiley Inter science, 2013
- Plastics Engineering, R.J. Crawford, Butterworths, 2013
- Handbook of Plastic Technology, Allen & Baker, CBS Publications, 2004
- Plastic Materials, J.A. Brydson, Butterworth-Heinemann, 1999

Polymer Testing & Characterization	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Identify different polymers based on their different chemical and physical properties. • Characterize Polymers' structural and morphological properties by using different characterization techniques. • Identify the suitable testing method for analyzing the specific properties of polymers. • Operate the testing and characterization equipment properly.

Syllabus Content:	**Hours**
Unit 1: Introduction to national and international standards, BIS, ISO, ASTM for testing of polymers, identification of common polymers by simple tests	8
Unit 2: UV-visible, IR and Raman spectroscopy: Principle and Applications in polymer characterization,	8
Unit 3: NMR spectroscopy in liquid and solid phase (1H and 13C): Principle and Applications in polymer characterization.	9
Unit 4: Mass spectrometry, separation techniques (GC, LC), Principle and Applications in polymer characterization.	9
Unit 5: X-ray diffraction method, scanning electron microscopy, transmission electron microscopy, and atomic force microscopy, Principle and Applications in polymer characterization.	9

References:
➢ Polymer Characterization, P. Nicholas Cheremisinoff, Elsevier, eBook ISBN: 9780815518693; Hardcover ISBN: 9780815514039, 1996
➢ NMR Spectroscopy of Polymers, Kitayama, Tatsuki, Hatada, Koichi, Springer, 2004
➢ Analytical Methods for Polymer Characterization, R. Yang, CRC Press, 2018

Plastic Technology

Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Explain the manufacturing of different commodities and Engineering plastics. • Categorize the polymers based on their properties. • Identify the applications of polymers based on their properties • Design new polymer material by applying knowledge of recent advances in polymer material.

Syllabus Content:	**Hours**
Unit 1: Manufacturing, properties, and applications of general purpose thermoplastics - Polyethylene, Polypropylene, Polyisobutylene, Polystyrene, Modified Polystyrene,	9
Unit 2 Manufacturing, properties, and applications, Polyvinyl chloride, Polyvinyl acetate, Polyethylene glycol, Polyacrylic acid, Polyacrylates, Poly(methyl methacrylate), Polyacrylamide, Polyacrylonitrile	9
Unit 3. Manufacturing, properties, and applications of Polyesters: Poly(ethylene terephthalate), Polybutylene terephthalate; Polycarbonates; Polyamides; Polyimides; Polyacetals; PU	9
Unit 4. Manufacturing, properties, and applications of Silicones, Polyphenylene sulfide (PPS), Polysulfones, Polyarylether-ketone (PEEK, PEKK), Polyetherimide (PEI), PTFE	9
Unit 5: Recent advancements in Plastic Technology	6

References:
➢ Brydson's Plastics Materials, Eighth Edition, Butterworth-Heinemann, Elsevier, 2016
➢ Polymer Synthesis: Theory and Practice, Braun et al , Springer International, 2013
➢ Synthesis of Polymers, Schluter et al, Wiley VCH, 2012
➢ Principles of Polymerization, 4th Ed., G. Odion, Wiley Inter science, 2004
➢ Synthetic Polymers, Feldman & Barbalate, Chapman & Hall, 1995

Rubber Technology	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Differentiate natural rubber and synthetic rubber - their preparation, properties, and applications. • Explain the basics of rubber compounding, vulcanization, and rubber product manufacturing. • Co-relate the concepts of flexible polymer chains and their influence on the properties of rubber. • Describe the chemistry, manufacturing technology, compounding, vulcanization, properties, and applications of different elastomers. • Identify suitable rubber materials for various engineering applications.

Syllabus Content:	**Hours**
Unit 1: Introduction to rubber, theory of rubber elasticity, thermodynamics of rubber elasticity, morphology of rubber, structure-property relationship in rubbers, non-elastomeric properties, chemical reactivity solution properties, theory of reinforcement and crosslinking- mechanism and practice of sulfur vulcanization and non-sulfur vulcanization (peroxide, metal oxides and other special curing systems) silicone rubber, thermoplastic elastomers, specialty elastomers	9
Unit 2: Natural Rubber: Various sources of natural rubber, history and development of *Hevea brasiliensis* as the commercial source of natural rubber, chemical formula, molecular weight distribution, the concept of Sol, Gel, microgel, and microgel. natural rubber from latex, field latex composition, methods of concentration and stabilization of latex, the effect of electrolyte and protein, processing of latex into sheet and pale crepe rubber	9
Unit 3: Chemistry and technology of synthetic rubbers –Nitrile Rubber, SBR, polybutadiene, polychloroprene, ethylene propylene, polysulfide, butyl, silicon , fluorosilicon, polyurethane, fluoro-elastomer, ECO, TPO, TPE, TPV, CPE, CSM, Acrylate rubbers.	8
Unit 4: Rubber additives and compounding: Pre-vulcanized latex, vulcanizing agents, activators, accelerators, fillers, softeners, antioxidants,antiozonants, peptizers, retarders, resin, flame retardants, colors and pigments, tackifying agents, blowing agents, bonding agents, compound development, and compounding of rubbers.	8

Unit 5: Manufacture of latex products by impregnation and spreading process, casting impregnation, a dipping process, latex coatings, latex cement and adhesives, latex thread, and coir, latex foam, manufacture of rubber products, manufacture of rubber products as tubes, hoses, and footwear	8

References:
➢ Rubber Technology, M. Morton, Springer Publications, 2013
➢ Rubber Technology and Manufacture of Rubber Products, S.N. Chakravarty, Polym Consultant, 2013
➢ Physical Testing of Rubbers, R.B. Brown, Springer, 1996
➢ Rubber Technology and Manufacture, Blow C.M., Numbers Butterworth London, 1982
➢ The Science & Technology of Rubber, Erman& Ronald, Academic Press, 2013
➢ Rubber Technologist's Handbook, Volume 1, K. Sadhan, De, R.J. White, Smithers Rapra Publishing, 2001
➢ Handbook of Rubber Technology: Natural, Synthetic Rubber and Technology of Vulcanisation Vol. I (HB), Martin & Smith, CBS Publishers, 2004
➢ Rubber Compounding: Chemistry and Applications, Rodgers, CRC Press, 2015

Fiber Technology	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Identify the structure and properties correlation of the natural and manufactured fibers to predict the properties of new fibers • Identify and solve the problems related to the manufacturing process of synthetic fibers • Identify and solve the problems related to post-spinning operations of synthetic fibers • Design the new fibers and their processing methods for application in different disciplines

Syllabus Content:	**Hours**

Unit 1: Introduction to fibers and basic terminology, characteristics of fiber-forming polymers, classification of fibers, and properties and structure of natural fibers.	9
Unit 2: Principles of fiber spinning, melt spinning, solution spinning, gel spinning, electro-spinning, the effect of process parameters of each spinning technique on structure and properties of fibers	9
Unit 3: Post-spinning operations, principles, and effects on fiber properties, drawing, heat setting, spin finish and texturing	8
Unit 4: Manufacturing, properties, and uses of viscose rayon, acetate rayon, polyester, polyamide, polyacrylonitrile, polypropylene, aramid, polyurethane, high-density polyethylene fibers.	8
Unit 5: Manufacturing process of bicomponent fibers, hollow fibers, and micro-denier fibers. Applications of fibers in technical textiles such as medical, geotextiles, and filtration	8

References:

- A Textbook of Fibre Science and Technology, S.P. Mishra, New Age Publication, 2014
- Manufactured Fibre Technology, Gupta and Kothari, Springer, 1997
- Handbook of Fiber Science and Technology, Vol. III, Lewin and Prestone, Dekker
- Progress in Textile Science & Technology, Vol I & II, Kothari, Chapman & Hall, 1985

Rheology	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome

After completing this course, students will be able to

- Explain the different aspects of polymer rheology and flow viscoelasticity, stress relaxation, creep, stress-strain correlations, etc.
- Describe the rheological properties of polymers using mathematical models.
- Describe the principles of Rheometers and measure the different Rheological properties
- Apply the rheological concepts in the polymer processing.

Syllabus Content:	**Hours**
Unit 1: Rheological properties of polymeric liquids basic concepts of fluid flow, Newtonian fluids, Non-Newtonian behavior of polymeric fluids and their reasons, Simple shear flow, Models describing the simple shear flows in non-Newtonian fluids, Generalized Newtonian models, Power law, Eyring model, Ellis model, Reiner Philipp off model, and Bingham Fluid model.	9
Unit 2: Viscoelastic models, Mechanical Elements, Maxwell Model, Voigt Element, Maxwell-Wiechert Model, Voigt-Kelvin Model, Molecular theories, application of flexible chain models to solutions, The Zimm modification, extension to bulk polymer.	9
Unit 3: Shear rheometer: sliding plates, falling ball rheometer, concentric cylinder rheometer, cone and plate rheometer, parallel disks, capillary rheometer, slit rheometer, oscillating disc rheometer, moving die rheometer and squeezing flow behavior. Mathematical modeling of rheometers,	8
Unit 4: Viscoelastic behavior of polymeric fluids, elastic moduli, Boltzmann Superposition principle, the relationship between the creep, compliance, and the stress relaxation modulus.	8
Unit 5: Time-Temperature Correspondence, Four regions of viscoelastic behavior, time-temperature superposition, the WLF equations transitions and relaxation in amorphous polymers, statistics of a polymer chain, rubber elasticity.	8

References:
➢ Introduction to Polymer Viscoelasticity, J.J. Aklonis, W.J. MacKnight, John Wiley and Sons, 1973
➢ Dynamics of Polymeric Liquids; Volume 1, R. B. Bird, O. Hassager, John Wiley and Sons, 1987
➢ Rheology: Concepts, Methods, and Applications, A.Y. Malkin, A.I. Isayev, Chem Tec Publishing, 2006
➢ Transport phenomenon, Bird, Stewart and N. Lightfoot, John Wiley and Sons New York, 2002

Polymer Degradation	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Recognize the importance of polymer degradation and able to select the method for its degradation. • Describe the mechanical and thermal methods of polymer degradation. • Explain the photodegradation of polymeric materials. • To know the importance of biodegradation of polymers and design the setup for large-scale polymer degradation. • Explain the chemical degradation of polymeric materials.

Syllabus Content:	**Hours**
Unit 1: Introduction to polymer degradation: definition and classification, its importance and limitations for industry and society, factors affecting polymer degradation.	9
Unit 2: Thermal and photo-degradation: Mechanism, random scission, and sequential elimination, structure stability relationship, photochemical reactions, types of radiations and their effects, quantum yield, the role of stabilizers	9
Unit 3: Mechanical degradation: Mastication, mechanochemical degradation, ultrasonication, degradation due to shear (turbulent flow, shaking)	8
Unit 4: Chemical degradation: Solvolysis, oxidative degradation, ionic degradation, weathering, stress-induced chemical alteration of polymers	8
Unit 5: Biological degradation: Modes of biodegradation, enzymatic degradation of biopolymers & synthetic polymers	8

References:
➢ Fundamentals of Polymer Degradation and Stabilization, N.S. Allen, M. Edge, Elsevier, 1992
➢ Handbook of Polymer Degradation, Second Edition, Hamid, Taylor & Francis, 2000
➢ Degradable Polymers, Recycling, and Plastics Waste Management, Albertsson, CRC Press, 1995
➢ Polymer Degradation and Stabilisation, Grassie& Scott, Cambridge University Press, 1988

Green Polymer	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Recognize the importance of Green chemistry and its application in synthesizing polymers. • Explain the fundamentals of biopolymers, their processing, and their properties. • Explain the properties of Polysaccharides, proteins, polyisoprene, polynucleotides, lignin • Design new polymers with green chemistry principles

Syllabus Content:	**Hours**
Unit 1: Introduction to green chemistry, basic principles of green chemistry, green polymers, need for green polymers, limitations, obstacles in the pursuit of the goals of green polymer.	11
Unit 2: Biopolymers and bioplastics, types of biopolymers and bioplastics, Naturally occurring polymers: Polysaccharides, protein, polyisoprene, polynucleotides, lignin.	11
Unit 3: Biopolymer derived plastics: Starch-based plastics, cellulose-based plastics, and aliphatic polyesters (PLA, PHB), polyamides, bio-based composites from soybean oil and chicken feathers, bio-derived polyethylene and genetically modified bioplastics	10
Unit 4: Designing of polymers using green principles; future trends in green polymer, biomimetic, multifunctional reagents; applications of green polymers in sustainable development	10

References:
➢ Green Chemistry: Environmentally Benign Reactions, V.K. Ahluwalia, CRC Press, 2008
➢ New Trends in Green Chemistry, V.K. Ahluwalia, M. Kidwai, , Kluwer Academic, 2004
➢ Green Chemistry and Engineering, M. Doble, A.K. Kruthiventi, Elsevier, 2007
➢ Green Polymer Chemistry: Biobased Materials and Biocatalysis, H.N. Cheng, R.A. Gross, P.B. Smith, American Chemical Society, 2016
➢ Organic Coatings: Science and Technology, 3rd Ed, Wicks et al, Wiley, 2007

Inorganic Polymers	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Explain the technical aspects of inorganic polymers, their specific properties, classification and applications. • Describe the synthesis of various types of inorganic polymers, their mechanism and reaction kinetics. • Correlate the chemical structure of inorganic polymers to their specific properties. • Apply structure-property correlations to develop and synthesize the new inorganic polymers of desired properties. • Identify new applications for inorganic polymers. • Characterize the inorganic polymers by various testing methods.

Syllabus Content:	**Hours**
Unit 1 Introduction, types of inorganic polymers and their special characteristics.	6
Unit 2: Characterization of inorganic polymers, Molecular weights, molecular weight distributions, chain statistics, solubility considerations, crystallinity, transitions, spectroscopy, and mechanical properties.	12
Unit 3: Polyphosphazenes: Synthesis, ring opening polymerization, mechanism, structure-property relationships; advanced elastomeric, fiber, and film-forming polyphosphazenes, polyphosphazenes as biomedical materials, organometallic polyphosphazenes, liquid crystalline and high refractive index polymers, polycarbophosphazenes, and polythiophosphazenes.	12
Unit 4: Polysilanes and related polymers: Introduction, synthesis, and chemical modification of polysilanes, physical properties of polysilanes, electronic properties, and conformations, photo-degradation of polysilanes, the structure of polysilanes, the technology of polysilanes.	12

References:

➢ Inorganic Polymers, Second Edition, Mark, Allcock and West, Oxford, 2005
➢ Inorganic Polymers, Jaeger & Gleria , Nova Science Publisher, 2007
➢ Inorganic and Organometallic Polymers, Chandrasekhar, Springer, 2005
➢ Inorganic Polymers, Saxena, Discovery Publishing House, 2007

Additives and Compounding	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Apply knowledge of polymer additives in formulating the desired polymer product • Identify and analyze the problems related to polymer compounding and mixing. • Solve complex problems related to polymer extrusion and related products using modern tools • Develop the environmentally safe and sustainable new polymer compounded products

Syllabus Content:	**Hours**
Unit 1: Additives for processing: Heat stabilizer, plasticizer, lubricants, extender, processing aids, flow promoter, antistatic agents, nucleating agents, clarifiers.	9
Unit 2: Additive for specific properties: Fillers and reinforcement, antiaging agents, colorants, flame retardants, blowing agents, antimicrobial agents.	9
Unit 3: Compound development for end use, recipe formation, prediction of properties of product using compounded recipes, Introduction of mixing, blending, kneading, mixing mechanisms for solid, liquid and gases.	8
Unit 4: Working principles of two roll mills, internal batch mixers, sigma mixers, high speed mixer, Impellers, process variables and product qualities of above machines, Trouble shooting of above machines.	8
Unit 5: Extrusion: Qualitative and quantitative aspects of mechanism of screw extrusion and effects of screw speed and temperature on output and quality of extrudate, Twin screw extruder, type of twin screw extruder, Qualitative and quantitative aspects of mechanism of screw extrusion and effects of screw on output quality of compounds granulating equipment.	8

References:
➢ Plastics Engineering, R.J. Crawford, Butterworths, 2013
➢ Handbook of Plastic Technology, Allen & Baker, CBS Publications, 2004
➢ Plastic Materials, J.A. Brydson, Butterworth-Heinemann, 1999

Speciality Polymers	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Understand the significance of specialty and high-performance polymers and their various applications in specific industries. • Analyse the specific properties of High-Performance Polymers with respect to their structure. • Understand the mechanism of electrical conduction in electroactive polymers and will be able to select polymeric materials for electrical and electronic applications. • Apply the knowledge for the development of High-Performance Polymers and their impact on environment, engineering community, and society at large

Syllabus Content:	**Hours**
Unit 1: Electrically Conductive Polymers, Photoconductive Polymers, Polymers in the Conversion and Storage of Energy, Polymeric Liquid Crystals, Organic Light-Emitting Diodes (OEDs).	9
Unit 2: Polymeric stabilizers, flame retardant polymers, corrosion inhibitor polymers, polymeric flocculating agents, antistatic polymers.	9
Unit 3: Polymeric cement additives, polymers in oil production, polymeric dye carriers and surfactants, ionomers, and IPN polymers, Polymers in lithographic processes, and polymeric nuclear track detectors	9
Unit 4: Polymer microgels, stimuli-responsive polymers.	8
Unit 5: Recent progress in specialty polymers.	8

References:

➢ Specialty Polymers, R.W. Dyson, Blackie Academic & Professional, London, 1998
➢ Functional Polymers, B. Martin, Plenum Press, New York, 1989
➢ Conducting Polymers, Wan, Springer
➢ Handbook of Conducting Polymers, Skotheim & Reynolds, CRC Press, 2007
➢ Conductive Electroactive Polymers, Wallace, CRC Press.

Resin Technology	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome
After completing this course, students will be able to • Identify the structure and properties correlation of the natural and synthetic resin • Identify and solve the problems related to the manufacturing process of synthetic resin • Design the new resin and their processing methods for application in different disciplines

Syllabus Content:	**Hours**
Unit 1: Resins and resinous state, classification, natural and synthetic resins, composition, purification and uses, modification of natural resins	9
Unit 2: Phenolic resins: Basic components, theory of resinification, reaction mechanism, the effect of the ratio of reacting components and pH on the reaction mechanism, Novolacs, and Resol, curing and molding, applications of phenolic resins.	9
Unit 3: Amino Resins: Synthesis and properties of UF and MF resins, theory of resinification, reaction mechanism, E\effect of pH on the reaction mechanisms, curing and molding, applications of amino resins.	8
Unit 4: Epoxy resins: Manufacturing and applications.	8
Unit 5: Alkyd Resins: Functionality concepts, use of polyfunctional acids and alcohols, phthalic acid resins, Manufacturing, modifications and properties of modified alkyd resins, Applications of alkyd resins.	8

References:

- Polymer and Resins; Their Chemistry and Chemical Engineering, B. Golding, D. Van Nostrand Company Inc., 2012
- Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003
- Synthetic Resins Technology Handbook, NIIR Board of Consultants & Engineers, 2005
- The Complete Book on Adhesives, Glues & Resins Technology, NPCS Board of Consultants & Engineers, 2007

Biomedical Applications of Polymers	
Teaching Scheme	L-T-P: 3-0-2

Course Outcome

After completing this course, students will be able to

- Analyze the properties of biopolymer
- Describe the function of biomaterials
- Tune the biopolymer properties for desirable applications
- Identify application-oriented biopolymer products as well as biomaterials

Syllabus Content:	**Hours**
Unit 1: Natural polymers, synthetic polymers, biopolymers, biocompatibility of synthetic polymers.	8
Unit 2: General Principles and properties of biomaterials, biofluids, cells, tissue, and organs, and Properties of implant polymers.	8
Unit 3: Biomedical applications of water-soluble polymers, Hard tissue prosthesis, bone prosthesis, bone cement, soft tissue prosthesis, hydrogels, contact and intraocular lenses, wound dressing and sutures, organ repair, tissue engineering	9
Unit 4: Polymer in drug delivery, gene therapy, synthetic gene delivery to a cell, applications of polymers in specific biomedical uses, devices like syringes, catheters, hemodialysis, hemofiltration, artificial muscles, soft actuators, the interface of polymers and biometrics, contraceptives based on polymers, Nano biomedical and molecular sensors.	9

Unit 5: Biosensors, such as glucose, cholesterol, urea, and DNA biosensors, transducers, bioprocess monitoring and control, and nanodevices, for the early detection of different diseases.	9

References:
➢ Biomedical Applications, Abd-EL-Aziz, Wiley-Blackwell, 2004
➢ Biomedical Polymers, Jenkins, CRC Press, 2007
➢ Biopolymers for Medical & Pharmaceutical Applications, Vol.I & II, S. Buchel, CBS, 2005

Paint and Coating Technology	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Understand the technical aspect of paint technology, properties of paints, varnishes and pigments, their classifications and applications • Synthesize different types of inorganic and organic pigments, dyes and paints based on desired properties. • Perform the various testing of dyes, pigments and paints to characterize them based on desired properties • Apply the fundamentals of coating processes • Apply the knowledge to select the coatings for requisite application.

Syllabus Content:	**Hours**
Unit 1: A general introduction to paints and coatings, components of paint, pigments for paint, pigment classification, manufacture of pigments; additives for paint, anti-corrosive pigment enhancers, antifoams, and settling agents, anti-skinning agents, solvents, thinners, and diluents, solvent effects on viscosity	8
Unit 2: Paint manufacturing process, equipment used for pigment paste manufacturing, high-speed mixers (HSD, HLM), different types of grinders used in paint industries	8

Unit 3: Liquid organic coatings, film formation, curing, dry film properties, coating selection, vinyl epoxies, urethanes, alkyds, oil-based paints, water-based paints, furans, phenolics, fluorocarbons, silicones, PVC coatings, application of coatings	8
Unit 4: Coating process: Immersion plating, impregnated coating, metalized coating, vapor deposition, chemical conversion coating, organic coating, Film formation, Polymer film forming mechanism	8
Unit 5: Testing methods: Viscosity, finished film testing, test standards, mechanical testing, humidity Testing, salt spray testing, QUV testing, temperature–humidity testing, color matching, and color control.	8
Unit 6: Health hazards and environmental aspects, safety measures in manufacturing and applications of paints & coatings	4

References:

- Paint Technology handbook, R. Talbert, CRC Press, 2008
- Introduction to Paint Chemistry and Principles of Paint Technology, 4th Ed, J. Bentley, G.P.A. Turner, CRC Press, 1997
- Paints Pigments Varnishes and Enamels Technology Handbook with Process and Formulations, NIIR Board, 2016
- Coatings Technology Handbook, 3rd Ed, Tracton, CRC Press, 2005
- Organic Coatings: Science and Technology, 3rd Ed, Wicks et al, Wiley, 2007

Polymer Adhesives	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome

After completing this course, students will be able to

- Understand the fundamentals of adhesion, the prerequisites for good bond formation, and the selection of adhesives for the required application.
- Analyze the process of manufacturing various adhesives and their properties.
- Apply their knowledge of the various adhesives for the required application.
- Design new adhesive based on the applications

Syllabus Content:	**Hours**
Unit 1: Fundamental aspects of adhesion technology: An introduction to adhesives, theories and types of adhesions, the process of bonding, the mechanism of adhesion, mechanical interlocking, inter-diffusion, adsorption, surface reaction, and electrostatic attraction.	9
Unit 2: Classification of adhesives: Solvent responsive adhesives, heat sealing, pressure sensitive, chemically reactive Structural adhesives: Epoxies, PF, UF and MF; non-structural adhesives: natural rubber (NR), polyester-based (unsaturated polyester), silicone, acrylics (reactive, aerobic, anaerobic and cyano acrylics), polyurethane, polyvinyl acetate and ethylene vinyl acetate copolymer	9
Unit 3: Preparation of adhesives: Animal glue, protein adhesives, starch adhesives, synthetic resin adhesives, rubber-based adhesives, cellulose & silicate adhesives	8
Unit 4: Industrial application of adhesives: Adhesives in electronics, wood and automotive industry, Dentistry and drug delivery, safety measures in manufacturing and applications of adhesives	8
Unit 5: Recent advancements in polymeric adhesives, including the application of nano-fillers in polymeric adhesives.	8

References:
➢ Additives for Coatings, Bieleman, Wiley, 2000
➢ Handbook of Adhesives Technology, Pizzi & Mittal, Marcel- Dekker, 2003

Tyre Technology	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Understand the basic concepts of tyre technology, different components of tyre, their functions, and desirable properties. • Identify and develop the different compounding and composite materials for different components of tyre based on specific properties.

• Describe the manufacturing process of the tyres and optimize the main operational parameters. • Perform the destructive and non-destructive testing of tyres.

Syllabus Content:	**Hours**
Unit 1: Tyre industry overview, development of tyre, raw materials for tyre aspects of tyre design, analysis of motive forces, types of bonding, set of service conditions, tyre size requirements, safety requirements manufacturing, classification of tyres, sizing & designation, tyre components,	9
Unit 2: Tread design, the role of footprint area and factors affecting tread life, various types of tread pattern, carcass design, the role of various fibers used in a carcass, estimation of the number of plies, bead design, various configurations of wires in bead assembly	9
Unit 3: Compound design, the role of various mixing ingredients, various recipes, compound mixing, mixing equipment: extrusion and its components, tyre, and wire cord manufacture, component preparation, green tyre building, pre- and post-curing operations, treatments	9
Unit 4: Tyre testing and evaluation, carcass strength, resistance to bead unseating, machine simulation tests, Indoor laboratory testing, field test on road, proving grounds, latest testing techniques.	9
Unit 5: Problems associated with tyres and their remedies	6

References:
➢ Introduction to Tyre Technology, S.N. Chakravarty, Polym Consultant, 2014
➢ Rubber Technologists Handbook vol 1, De, Rapra Publishing, 2001
➢ Science and Technology of Rubber, Mark, Elsevier, 2005
➢ The Pneumatic Tire, (Part I and Part II), A.N. Gent, J.D. Walter, National Highway Traffic Safety Administration, USA, 2005

Membrane Technology	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Explain the basic concept of membrane technology and describe various membrane-based processes based on their characteristics and applications. • Synthesize the polymeric and inorganic membrane by phase inversion and gel formation methods respectively. • Classify the different membrane-based techniques based on the types of membrane used, driving force, fluxes, and final applications. • Develop mathematical equations to model membrane based processes by using various laws of mass transfer, thermodynamics and fluid mechanics. • Design simple membrane modules for achieving the desired separation in a given application. • Troubleshoot the problems related to membrane technology, such as concentration polarization, membrane fouling, gel-layer creation, etc.

Syllabus Content:	**Hours**
Unit 1: Introduction of membrane based separation methods, classification, materials used for membrane manufacturing, their benefits and limitations, membrane preparation methods, phase inversion, symmetric and asymmetric membranes, composite membranes, inorganic membranes, sol-gel method.	9
Unit 2: Mass transport mechanism of membrane-based separation processes, Fick's law, non-equilibrium thermodynamics-based models, multicomponent mass transfer, concept of concentration polarization, and membrane fouling.	9
Unit 3: Concentration and pressure-driven membrane-based processes: reverse osmosis, liquid membranes, ultrafiltration, nanofiltration, gas separation, transport mechanism, material used, membrane properties, applications, advantages, and limitations.	8
Unit 4: Other separation processes: electro-dialysis, pervaporation, membrane distillation, membrane contractors, membrane reactors, forward osmosis, and pressure retarded osmosis.	8
Unit 5: Designing of industrial scale membrane based separation units, membrane modules, spiral wound modules, hollow-fiber and tubular modules, their benefits, limitations, modeling of membrane based modules.	8

References:
➢ Membrane handbook, W. S. Winston Ho, K.K. Sirkar, Van Nostrand Reinhold, New York, 1992
➢ Membrane Technology and Application, R.W. Baker, John Wiley & Sons Ltd., 2004
➢ Basic Principle of Membrane Technology, J. Mulder, M. Mulder, Springer, 2013
➢ Journal of Membrane Science (Journal) Publisher: Elsevier BV

Extrusion and Injection Molding	
Teaching Scheme	L-T-P: 1-0-2

Course Outcome
After completing this course, students will be able to • Understand the various parts of the extrusion and Injection molding Machines • Identify and solve the complex engineering problems related to extrusion and Injection molding Machines • Apply the knowledge of process parameters of Extrusion and Injection Molding to carry out new process design research for different polymers

Syllabus Content:	**Hours**
Unit 1: Types of extruders: Single Screw, multi-screw, disk, ram, vented, hardware of extruder: extruder drive, thrust bearing, barrel, feed throat, extruder screw, die assembly, heating and cooling systems.	3
Unit 2: Important polymer properties required for extrusion: Bulk properties, melt flow properties, thermal properties, functional process analysis: basic screw geometry, solid conveying, plasticating, melt conveying, die forming, devolatilization, mixing	3
Unit 3: Extruder Screw Design for various applications, Die design: basic consideration, film and sheet design, wire and cable dies, blown film dies, profile extrusion dies, coextrusion dies.	2

Unit 4: Injection molding machine-machine description study, types and limitations, constructional features, specifications, maintenance, types of clamping, temperature control, types of cylinder nozzles, ejection systems, starting and shutdown procedures	3
Unit 5: Mold design fundamentals, type of molds - two plate, three plate, feeding system – sprue, runner, gate design, ejection system - pin, sleeve, stripper plate, air ejection design. Moldings with undercuts – internal, external, threads, split cavity, split core designs.	3

References:
➢ Handbook of Plastic Processes, Harper, Wiley Interscience, 2006
➢ Principles of Polymer Processing, Tadmor & Gogos, Wiley Interscience, 2013
➢ Plastics Engineering, R.J. Crawford, Butterworths, 2013

Polymer Product Design	
Teaching Scheme	L-T-P: 1-0-2

Course Outcome
After completing this course, students will be able to • Identify various approaches and technique for designing and developing polymeric products • Predict life of the product by correlating properties of polymer with the design the of the product. • Categorize and apply product engineering guidelines in designing polymer products for moulding and extrusion process. • Solve complex problems related to product design.

Syllabus Content:	**Hours**
Unit 1: Basic design theory for product development, properties of plastic influencing design, simple structural load analysis and design aspects, wall thickness, tolerance,	5
Unit 2: Design limitations of plastic parts based on various processing techniques.	5

Unit 3: Basic consideration of designing polymer products with rigid, flexible, static and dynamic loaded parts, Product design based on reinforced plastics.	4

References:
➢ Plastics Design Handbook, Rosato, Springer, 2001
➢ Industrial Design of Plastic Products, Gordon, Wiley, 2002
➢ Plastic Product Design, R.D. Beck, Van Nostrand Reinhold, 1980
➢ Product Design & Manufacturing, Chitale& Gupta, Prentice Hall, 2007
➢ Mastering AutoCAD by George Omura, Sybex, 2018

Polymer Recycling	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Differentiate thermoplastics & thermosets, different plastics based on ease of recycling process. • Recognize the organizations working in waste plastic recycling and evaluate their working efficiency. • Understand the residential recycling and role of material recovery facilities • To know the methods for recycling of selected plastics like PET, PE, PS, PVC, etc.

Syllabus Content:	**Hours**
Unit 1: Basics of polymer waste: Introduction to polymer waste, definitions of related terms – waste polymer, industrial polymer waste, postconsumer polymer waste, nuisance polymer, scrap polymer, management of polymer waste - 5 R's	8
Unit 2: Separation methods: Size reduction, separations using physical properties, recycling codes, wet separation process, electro-dynamic separation	8
Unit 3: Recycling process: Primary, secondary, tertiary, and quaternary recycling.	8
Unit 4: Recovery and value addition of waste of PVC, PET, PMMA, HDPE, LDPE, PS, rubber reclaiming.	9

Unit 5: Polymer waste management: Case studies; future trends of sustainable development	9

References:
➢ Polymer waste management: Case studies; future trends of sustainable development, 1998
➢ Polymer waste management: Case studies; future trends of sustainable development, 2016
➢ Handbook of Plastics Recycling, F.L. Mantia, Smithers Rapra Publishing, 2002

Application of Nanomaterials in Polymers	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Understand the different aspects of nanotechnology, Identify and classify the material properties at nano-scale, and its applications in different sectors. • Synthesize different nanomaterials by using various physical and chemical roots. • Characterize the nanomaterials using various testing methods based on their special properties. • Identify and apply nanomaterials in the fields of electronics and biotechnology. • Describe the advancements in the field of nanotechnology.

Syllabus Content:	**Hours**
Unit 1: Introduction to nanomaterials and nanocomposites, types of nanomaterials, and their morphology.	8
Unit 2: Preparation, structure, properties, and nano-reinforcing agents such as nano-clays, POSS, carbon nanostructures, and nanoparticles.	8
Unit 3: Effects of factors such as loading, dispersion, and distribution; influence of size, shape, and diameter of nanomaterials; functionalization of nanostructures.	9

Unit 4: Structural and morphological characterization of nanocomposites and nanomaterials.	9
Unit 5: Applications of Polymeric Nanocomposites: Polymeric nanoelectronics, molecular electronics components, concepts of nanopolymer-based switches and complex molecular devices, nanopolymers in medicines, nanomedicine, etc.	9

References:
➢ Polymer Nanocomposites, J H Koo, Mc Graw Hill, 2006
➢ Polymeric Nanocomposites- Theory and Practice, S.N. Bhattacharya, Hanser Gardner, 2008
➢ Mechanical properties of Polymers based on Nanostructures and Morphpology, G.H. Michler and F.J. Baltra, CRC Press, 2008
➢ Biomedical Nanostructures, Gonsalves, Halberstadt, Laurencin & Nair (Eds.), Wiley-Interscience, 2008

Biosensors	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome
After completing this course, students will be able to • Understand the concept of biosensors, their classification, measurement and instrumentation principles, and characteristics of biosensors. • Identify the application of biosensors in different fields. • Evaluate the testing of biosensors and their sensitivity. • Design and develop biosensors for new applications.

Syllabus Content:	**Hours**
Unit 1: Introduction to biosensors. Measurement and instrumentation principles. Fundamentals of transducers and sensors, their calibrations, selectivity, sensitivity, specificity, and transduction system analysis.	9
Unit 2: Transduction principles used in biosensors, i.e., electrochemical transducers (amperometric, potentiometric, conductometric), optical transducers (absorption, fluorescence, SPR), thermal transducers, piezoelectric transducers, and related technology.	9

Unit 3: Bio-recognition systems based on enzymes, oligonucleotides and nucleic acids, antigen-antibody, and molecularly imprinted polymer. Immobilization of biomolecules. Limitations & problems.	8
Unit 4: Methods for biosensors fabrication based on self-assembled monolayers, screen printing, photolithography, micro-contact printing, etc. Nanomaterial-based biosensors. Microfluidic devices for Lab-on-a-chip. Engineering concepts for mass production.	8
Unit 5: Application of biosensor technologies in clinical diagnostics, defense industries environmental monitoring, food, water quality control, forensic science. Selected examples and future developments.	8

References:

- Chemical Sensors and Biosensors: Fundamentals and Applications, B. Florinel-Gabriel, John Wiley & Sons, 2012
- Biosensors for Environmental Monitoring, U. Bilitewski, A.P.F. Turner, Academic Publishers, 2000
- Optical Biosensors: Present & Future, F.S. Ligler, C.A. Rowe, Elsevier, 2002
- Fundamentals of Microfabrication and Nanotechnology (Volume I, II and III), J. Madou-Marc, CRC press, 2012
- Biosensors: Fundamental and Applications (2nd Edition), C.M. Pandey, B.D. Malhotra, De Gruyter, 2019

Polymer Blends and Composites	
Teaching Scheme	L-T-P: 3-1-0

Course Outcome

After completing this course, students will be able to

- Understand the fundamentals of polymer blends, alloys, and composites. Understand the blending equipment along with the thermodynamic aspects, phase diagram and morphology of polymer blends.
- Analyze and co-relate the basic issues involved in polymer blends, and composites, and the compatibility of various systems of polymers.

- Select the appropriate combination of polymers and/or reinforcements to have the required synergistic properties in the polymer blends and composites.
- Design and develop novel polymer blends and composites to achieve synergistic properties.
- Analyze and characterize the various properties of polymer blends & composites and will be capable to apply the knowledge to develop cost-effective/ eco-friendly/ sustainable products.

Syllabus Content:	**Hours**
Unit 1: Polymer blends classification, principles of polymer compatibility, different theories of predicting compatibility, factors governing compatibility, compatibilizers, property achieved by blending, methods of blending, characterization of blends, properties of miscible and immiscible blends, their properties and identifications, commercial polymer blends and their properties, morphology of blends and its determination.	9
Unit 2: Introduction to rheology of polymer blends, its relevance in processing, rheology phase morphology relationships and their relevance, concept of rubber toughening, and its application commercial products.	9
Unit 3: Classification of composites, particulate and fibrous composites, Introduction to reinforcing materials, nano-fillers based composites, importance of composite materials in engineering applications	8
Unit 4: Fabrication of continuous and short fiber reinforced composites and particulate reinforced composites, different fabrication methods, their operating parameters, benefits and limitations, Industrial, commercial applications.	8
Unit 5: Characterization of composite materials, identification of key properties of a composite product, material, mechanical, thermal, morphological physical and chemical testing methods, non-destructive testing of polymer composites, recent advancement in polymer composites	8

References:

- Polymer Blends, Vol. I & II, D.R. Paul, Academic Press, 1978
- Composite Materials: Science & Engineering, Chawla, Springer India, 2012
- Handbook of Polymer Blends & Composites, vol 1, Kulshreshtha & Vasile, Rapra Tech Ltd, 2002

- Polymer composite, A.P. Gupta, M.C. Gupta, New Age publication, New Delhi, 2018
- Polymer blends and alloys, R.P. Singh, Asian Books Private Limited, 2002