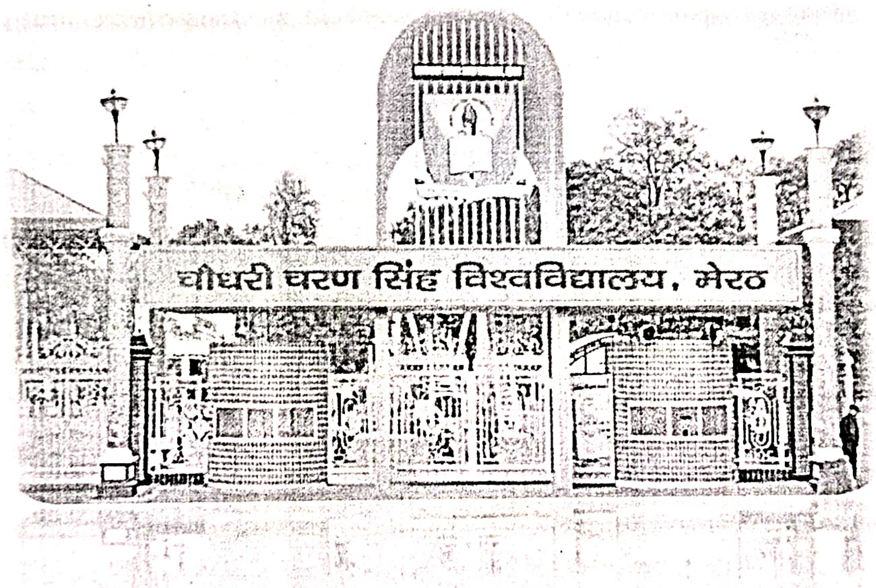
Course Structure, Credits and Syllabus

of

M.Sc. Chemistry
with specialization in
Polymer Science & Chemical Technology
(Effective from the Academic session 2025-2026)



Department of Chemistry
Chaudhary Charan Singh University, Meerut
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24/5/25

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M.Sc. Chemistry with Specialization in Polymer Science and Chemical Technology

Program Name: M.Sc. Chemistry with specialization in Polymer Science and Chemical Technology
Program Level/ Duration/ Semesters: PG/02 Years/04 Semesters
Maximum period to complete the degree: 04 Years
Minimum Eligibility Criteria: B.Sc. (H) Chemistry, Bachelor's Degree with PCM/CBZ/Polymer Science/B.E./B.Tech. (in any branch) as per the university rules
Research Project evaluation would be based on the following criterion:
Thesis: 50%
Presentation: 25%
Viva Voce: 25%

Programme Specific Outcomes

PSO1: Advanced Knowledge in Polymer Science
Develop a comprehensive understanding of the synthesis, characterization, structure-property relationships, and applications of polymers, including biopolymers, smart polymers, and nanocomposites.

PSO2: Expertise in Chemical Technology
Gain practical and theoretical knowledge of chemical process technologies, including polymer processing, catalysis, green chemistry approaches, and scale-up strategies relevant to industrial settings.

PSO3: Analytical and Instrumentation Skills
Acquire hands-on proficiency in modern analytical techniques such as spectroscopy (FTIR, NMR, UV-Vis), chromatography (GPC, HPLC), thermal (TGA, DSC), and rheological methods used in polymer and chemical analysis.

PSO4: Research and Innovation Competency
Develop the ability to design, execute, and interpret research projects in polymer chemistry and chemical technology, fostering innovation, critical thinking, and scientific communication.

PSO5: Industrial Readiness and Problem Solving
Demonstrate the capability to solve real-world problems in polymer industries and chemical manufacturing, including quality control, material selection, and sustainability considerations.

PSO6: Entrepreneurial and Lifelong Learning Skills
Cultivate an entrepreneurial mindset with the ability to pursue startup opportunities or higher studies, and remain updated with evolving technologies and regulatory standards in the chemical and polymer sectors.

M.Sc. Chemistry with spl. in Polymer Science and Chemical Technology

Approved Course Structure (24/05/2025)

Year	Course Title	Course Type	Internal Marks	External Marks	Total Marks	Credits	Total Hrs
	Semester-I						
1	Polymerization	Core Compulsory	30	70	100	4	60
	Properties of Polymers	Core Compulsory	30	70	100	4	60
	Organic Chemistry	Core Compulsory	30	70	100	4	60
	Rubber Technology or Paints, Coatings and Adhesives Technology	Elective I Elective II	30	70	100	4	60
	Polymer Practical-I	Core Compulsory and Skill Enhancement	30	70	100	8	240
		Total	**150**	**350**	**500**	**24**	**480**
	Semester-II						
	Synthesis and Applications of polymer	Core Compulsory	30	70	100	4	60
	Polymer Processing	Core Compulsory	30	70	100	4	60
	Physical chemistry	Core Compulsory	30	70	100	4	60
	Tyre Technology or Smart Polymeric Materials	Elective III Elective IV	30	70	100	4	60
	Polymer practical-II	Core Compulsory and Skill Enhancement	30	70	100	8	240
		Total	**150**	**350**	**500**	**24**	**480**
	Semester-III						
2	Polymer Blends and Composites	Core Compulsory	30	70	100	4	60
	Analytical Techniques	Core Compulsory	30	70	100	4	60
	Polymer Testing and Specification	Core Compulsory	30	70	100	4	60
	Fibre Technology or Polymers in Energy Applications	Elective V Elective VI	30	70	100	4	60
	Polymer practical-III	Core Compulsory and Skill Enhancement	30	70	100	8	240
		Total	**150**	**350**	**500**	**24**	**480**
	Semester-IV						
	Research Project	Core Compulsory and Skill Enhancement	-	500	500	24	720

M.Sc. Chemistry with Specialization in Polymer Science and Chemical Technology

Syllabus

Semester I			
	Title of Course: Polymerization (Core Compulsory)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100 (Int: 30; Ext:70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Understand the historical evolution, classification, and chemical nature of polymers.
CO2: Analyze mechanisms and kinetics of various polymerization processes.
CO3: Apply concepts of copolymerization and predict copolymer composition and behavior.
CO4: Evaluate polymer structure, morphology, and stereochemistry.
CO5: Demonstrate knowledge of industrial polymerization techniques and their applications

Unit	Topics	No. of Hours
I	**Introduction to Polymers and their Development** Historical development of polymer materials: Natural and synthetic polymers, Evolution of vinyl plastics, Raw materials for plastics, Market and future trends in the plastics industry, Chemical nature of plastics, Classification of polymers.	08
II	**Mechanism of Polymerization Processes and their Kinetics** Classification of polymerization processes: Addition (chain-growth) polymerization- Free radical, Ionic polymerization (cationic and anionic), Coordination polymerization (Ziegler-Natta, metallocene catalysis), Condensation (step-growth) polymerization General principles of stepwise polymerization, Condensation and rearrangement processes, Effect of stoichiometry and purity on degree of polymerization, Diffusion control of termination and propagation in step-growth systems, Ring-opening polymerization, Stereochemical considerations in radical polymerization, Polymer reactions and modifications.	18
III	**Copolymerization** Radical copolymerization: Instantaneous copolymer composition equation, Azeotropic System, alternating copolymers, Copolymerization at high conversion, Remote unit effects, polycomponent systems, kinetics of copolymerization.	10
IV	**Polymer Structure and Morphology** Polymer states of aggregation: amorphous, crystalline, semi-crystalline, Cross-linked structures and thermosets, Tacticity (isotactic, syndiotactic, atactic), Polymer blends and composites, Block and graft copolymers, Configuration and conformation, Molecular orientation: orientation functions and biaxial orientation, Crystalline vs. amorphous regions in polymers, polymer degradation.	12

V	**Polymerization Techniques** Commercial polymerization methods: Bulk polymerization, Solution polymerization, Suspension polymerization, Emulsion polymerization, Dispersion polymerization, Solid-state polymerization, Phase transitions during polymerization.	12

REFERENCE TEXT BOOKS:
1. Brydson, J.A., (1999) Plastics Materials, Butterworth-Heinemann.
2. Seymour, R.B., Carraher, C.E., (2003) Polymer Chemistry, Marcel Dekker.
3. Hiemenz, P.C., (2007) Polymer Chemistry.
4. Koltzenburg, S., (2017) Polymer Chemistry.
5. Lodge, T.P., (2020) Polymer Chemistry.
6. Canevarolo, Jr, SV. (2019) Polymer science: a textbook for engineers and technologists.
7. Shunmugam, R., (2017) Functional Polymers: Design, Synthesis, and Applications.
8. Bhatnagar, M. S. (2004) A Textbook of Polymer Chemistry.
9. Phillip, C., (2025) The Elements of Polymer Science and Engineering.
10. Ram, K. G., (2023) Specialty Polymers Fundamentals, Properties, Applications and Advances.

ADDITIONAL RESOURCE TEXT BOOKS:
1. Billmeyer, F.A., (2011) Text book of Polymer Science, John-Wiley & Sons.
2. Flory, P.J., (2007) Principles of Polymer Chemistry, Asian Books Private Limited.

Semester I			
	Title of Course: Properties of Polymers (Core Compulsory)	**4 hours /week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Understand the theoretical basis, instrumentation, and experimental procedures involved in various molecular weight determination techniques, and apply them to real-world polymer systems.
CO2: Analyze how molecular features like chain stiffness, polarity, and branching affect the thermal transitions and mechanical performance of polymers.
CO3: Assess how molecular architecture affects chemical reactivity, durability, permeability, and environmental resistance.
CO4: Relate electronic and optical properties to structural features and understand applications in electronics and photonics.
CO5: Understand the role of additives like plasticizers, UV stabilizers, flame retardants, and cross-linking agents in enhancing polymer performance.

Unit	Topics	No. of Hours
I	**Molecular weight determination:** Introduction, average molecular weights, Colligative methods-theoretical background, apparatus for determination of molecular weight by Colligative methods, End group analysis- determination of the carboxyl and the amino groups of a polyamide, light scattering methods-theoretical background, light	14

	scattering instruments, Differential refractometry, experimental aspects of light scattering and application to polymersolutions, viscometric methods, limiting viscometry number, analysis of viscosity data.	
II	**Relation of structure to thermal and mechanical properties:** Introduction, factor affecting the glass transition temperature, factors affecting the ability to crystallize, factor affecting the crystalline melting point, some individual properties.	12
III	**Relation of structure to chemical properties:** Introduction, chemical bonds, polymer solubility, chemical reactivity, ageing and Weathering, Diffusion & permeability, toxicity, fire & plastics.	11
IV	**Relation of structures to electrical & optical properties:** Introduction, Dielectric constant- Power factor & structure, electronic application of polymers, electrically conductive polymers, LEDs, Optical properties.	11
V	**Additives for Plastics:** Introduction, fillers, plasticizers and softeners, lubricants and flow promoters, anti-ageing-antioxidants, ultra violet and related materials additives, flame retarders, blowing agents, photodegradation, cross-linking agents, sealants.	12

REFERENCE TEXT BOOKS:

1. Lutz, J.T., (2001), Polymer Modifiers and Additives, Marcel Dekker.
2. Zweifel, H., Amos, S.E., (2009) Plastics Additives Handbook, Hanser.
3. Gachter, R., Muller, H., (1987) Plastics Additive Handbook, Hanser Publishers.
4. Wypych, G., (2023) Functional fillers: chemical composition, morphology, performance, applications.
5. Gupta P., (2022) Polymer Additives and Compounding Part 1: Fundamentals of Polymer Additives
6. George, W., (2023) Handbook of Polymer Processing Additives
7. Muhammad, I. M., (2021) Molecular Characterization of Polymers: A Fundamental Guide
8. Ferdinand, R., (2015) Principles of Polymer Systems

ADDITIONAL RESOURCE TEXT BOOKS:

1. Brydson, J., (1999) Plastic Materials, Butterworth-Heinemann.
2. Mascia, L., (1974) The Role of Additives in Plastics, Edward Arnold Publishers Ltd., U.K.
3. Murphy, J., (2001) Additives for Plastics Handbook, Second Edition, Elsevier Advanced Technology, Oxford.
4. Gerard, J. F., (2001) Fillers and Filled Polymers, Wiley-VCH verlag GmbH.

Semester I			
	Title of Course: Organic Chemistry (Core Compulsory)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Describe electronic displacements (inductive, resonance), hydrogen bonding, molecular geometry, and hybridization principles influencing organic reactivity and stability.
CO2: Identify and differentiate structural, geometric, and optical isomers, understand chirality,

and perform conformational analysis of alkanes and cyclohexanes.
CO3: Compare SN1, SN2, E1, E2, and E1cb mechanisms, analyze stereochemical outcomes, and predict the major product based on reaction conditions.
CO4: Apply Hückel's rule to assess aromatic character and explain the mechanism and regioselectivity of key EAS reactions such as halogenation, nitration, and Friedel-Crafts alkylation.
CO5: Outline methods of extraction, hydrogenation, and inter-esterification of oils and fats, and explain the manufacturing and uses of soaps, detergents, glycerin, and natural compounds like essential oils and alkaloids.

Unit	Topics	No. of Lectures
I	**Basics of Organic Chemistry:** Electronic theory of valancy, electronic, displacements in a molecule, inductive effect, electronic effect, resonance, hydrogen bond, van der waals interaction, electrostatic force, hydrophobic interaction, atomic and molecular orbital, shapes of molecules, hybridization and tetracovalancy of carbon.	14
II	**Stereochemistry:** Structural isomerism, stereomerism, geometrical isomerism (E and Z nomenclature), optical isomerism, optical activity, meso compound, specific rotation, chirality, chiral center, enantiomers, diasterioisomer, D, L, R, S, threo, erythro rotations, conformation and configuration, dihedral angle, conformational analysis of ethane, n-butane, cyclohexane, mono and di substituted cyclohexane, boat and chair forms, eclipsed, gauche and staggered conformations, axial and equatorial, bonds, anomers and mutarotation.	15
III	**Types of Organic Reaction:** Substitution, SN1, SN2, and SNi, neighboring group participation, addition, elimination, E1, E2 and E1cb, with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.	10
IV	**Aromatic Hydrocarbon** Huckle's rule, aromatic character of arenes, cyclic carbocations/carbanions with suitable examples. **Electrophilic aromatic substitution:** Halogenations, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.	11
V	**Oil and fats:** Vegetables oil by solvent extraction process, processing of animal fats, oil by hydrogenation and inter esterification. **Soaps and detergents**: Detergents, fatty acids, fatty alcohol, soaps, manufacturing of glycerin, essential oils, alkaloids, cellulose, starch, perfumes and cosmetics.	10

REFERENCE TEXT BOOKS :

1. Clayden, J., Greeves, N., (2014) Organic Chemistry
2. Norman, R.O.C., (2020) Organic Chemistry.
3. Carey and Sundberg, (2008) Part B – Adv. Organic Chemistry (Ed. III).
4. House, H. O., (2018) Synthetic Organic Chemistry.
5. Nashipuri, D., (2020)Stereochemistry of Organic Compounds
6. Peter, Vol., (2009) Organic-Chemistry-Structure-and-Function.
7. Sujata, V. B., (2023) Chemistry of Natural Products: A Unified Approach.

8. David, R. K., (2022) Organic Chemistry.

Semester I			
	Title of Course: Rubber Technology (Elective I)	4 hours/week	4 Credits (60 hours)
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:

CO1: Understand the historical development and significance of latex and rubber in the manufacturing of rubber goods.

CO2: Identify and classify various rubber additives and compounding ingredients and their functions.

CO3: Explain the structure, properties, processing, and compounding of natural and synthetic rubbers.

CO4: Demonstrate knowledge of rubber latex technology and latex-based product development.

CO5: Evaluate the importance and process of rubber recycling and reclamation technologies.

Unit	Topics	No. of Lectures
I	A historical introduction on the application of latex and rubber for the manufacturing of rubber goods, an introduction to compounding, classification of materials. **Rubber additives and compounding:** Vulcanizing agents, activators, accelerators, fillers, plasticizers, softeners, antioxidants, peptisers, retarders, stiffeners, flame retarders, colors and pigments, tackifying agents, blowing agents etc, compound development and compounding of rubbers.	13
II	**Natural rubber**: Introduction, types of natural rubber, natural rubber latex, concentration and stabilization of latex, latex processing and applications, latex compounding from latex. **Diene Homopolymer rubbers:** Synthesis of monomers- isomerism in diene rubber- characterization of microstructure, polymerization of dienes structure and properties of diene rubber.	12
III	**Styrene butadiene rubber (SBR):** Introduction, manufacturing of butyl rubber, properties of butyl rubber, butyl rubber compounding, halogenated butyl rubber and application. **Nitrile and polyacrylic rubber**: Introduction, manufacturing of nitrile rubber, properties of nitrile rubber, application of nitrile rubber, mixing and processing of nitrile, polyacrylic rubber, manufacturing of polyacrylic rubber, compounding and processing of polyacrylic rubber.	12

IV	**Neoprene and Hypalon rubber:** Introduction, commercial neoprene-compounding, processing and application of neoprene latex, Hypalon-manufacturing process, processing of Hypalon rubber, properties and application of Hypalon rubber. **Silicon rubber:** Introduction, types of silicon rubber, vulcanization, compounding of silicone rubber, liquid silicone rubber compounding, relation properties of silicon rubber, application of silicon rubber.	12
V	**Reclaimed rubber:** Introduction, types of reclaimed, evolution of reclaiming process, dynamic revulcanization, advantages of using reclaimed rubber, reclamation of waste, rubber from latex waste.	11

REFERENCE TEXT BOOKS:

1. Martin, J.M., Smith, W.K., (2007) Handbook of Rubber Technology, CBS Publisher.
2. Mark, J. E., Erman, B., Eirich, F.R., (2005) The Science and Technology of Rubber, 43 Elsevier Academic Press.
3. Blow, S., (2000), Hand Book of Rubber Technology, Hanser Gardner.
4. Tripathi, P.K., (2023) The Complete Book on Rubber Processing and Compounding Technology (3rd Revised Edition)
5. Alam, M. N., (2024) Advances in Functional Rubber and Elastomer Composites
6. Wan, C., (2025) Innovations of Rubber Chemistry and Technology for Sustainability
7. Andreas, L., (2012) Mixing of Rubber Compounds
8. Sarkawi, S. S., (2023) Epoxidised Natural Rubber: Properties & Applications

Semester I			
	Title of Course: Paints, Coatings, and Adhesives Technology (Elective II)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Explain the roles, types, and applications of paints, coatings, and adhesives.
CO2: Identify and select raw materials based on formulation requirements.
CO3: Apply surface preparation and modification techniques for improved adhesion.
CO4: Understand formulation principles and describe production processes.
CO5: Compare application methods and justify suitable techniques for various substrates.

Unit	Topics	No. of Lectures
I	**Fundamentals of paints, coatings, and adhesives:** Introduction to paints and coatings: definitions, roles, and industrial applications, Basic composition of paints: pigments, binders, solvents, and additives, Classification and types of paints, Properties and functional requirements of high-performance paints, Overview of adhesives: structural, elastomeric, and pseudoplastic types, Importance of coatings in various industries, Challenges, advancements, and future trends in the paints, coatings, and adhesives sector.	14
II	**Essential raw materials for formulation:** Pigments: natural vs synthetic, functional pigments, Binders and resins: natural and synthetic;	11

	thermoplastic and thermosetting (e.g., polyester, epoxy, alkyd, phenolic, vinyl), Solvents and thinners: classifications, roles, and selection criteria, Driers and drying oils: types, mechanisms, and performance impact.	
III	**Surface preparation and modification techniques:** Surface cleaning and pretreatment for plastics, metals, wood, and cement-based substrates, Surface activation methods: thermal treatment, corona discharge, flame treatment, Mechanical surface modification and its role in adhesion, Adhesive preparation and application techniques, Fundamentals of surface adsorption, interfacial reactions, and wetting behavior, Surface topography and its impact on bonding.	13
IV	**Formulation and production processes:** Guidelines for selecting raw materials and assessing water solubility, Formulation principles for paints, coatings, and adhesives, Manufacturing processes for paints and coatings, Adhesive production: structural and elastomeric systems, Overview of manufacturing equipment: high-speed mixers, vertical/horizontal/ continuous mills, sand mills, and ball mills.	12
V	**Application methods and coating technologies:** Coating application techniques: brushing, rolling (single and double-sided), Spray techniques: manual spray, airless spray, and air-assisted spray systems, Dip coating: procedures, advantages, and limitations, Flow coating: mechanism and industrial relevance.	10

REFERENCE TEXT BOOKS:

1. Schackmann, M., (2023) Coatings Formulation: 4th Revised Edition
2. Hofer, R., (2022) Renewable Resources for Surface Coatings, Inks, and Adhesives
3. Pietschmann, J., (2023) Industrial Powder Coating: Basics, Methods, Practical Application
4. Hofer, R., (2019) Green Chemistry for Surface Coatings, Inks, and Adhesives: Sustainable Technologies
5. Lohse, H., (2021) Formulating Adhesives and Sealants

Semester I			
	Title of Course: Polymer practical-I (Core Compulsory and Skill Enhancement)	**18 hours/week**	**8 Credits (240 hrs)**

Max Marks: 100; Practical: 100 (Int: 30; Ext: 70)

Course Outcomes: Upon completion of lab program, students will be able to:
CO1: Gain practical knowledge of bulk, solution, suspension, and emulsion polymerization using polystyrene as a model.
CO2: Conduct benzoylation, acetylation, bromination, and nitration to understand functional group transformations.
CO3: Learn to analyze natural rubber and latex for properties like tensile strength, curing time, and dry rubber content.
CO4: Apply TLC, viscometers, hardness and peel tests to evaluate polymers, paints, and adhesives.
CO5: Use eco-friendly methods in synthesis to reduce environmental impact

	Experiments	

Polymer Practical	1. To prepare polystyrene by bulk polymerization techniques 2. To prepare polystyrene by solution polymerization technique 3. To prepare polystyrene by emulsion polymerization techniques. 4. To prepare polystyrene by suspension polymerization techniques. 5. To prepare viscocity average molecular weight of polymer with the help of Ostwald viscometer. 6. Benzolyation of one of the following amines (aniline, o-, m-, p-toluidines and o, m-, p-anisidine) or one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction. 7. Acetylation of any one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-, p-anisidine) and phenols (β-naphthol, salicylic acid) using green approach. 8. Bromination of acetanilide/aniline/phenol. 9. Nitration of nitrobenzene/chlorobenzene/phenols. 10. Functional group tests for alcohols, phenols, carboxylic acids, phenols, carbonyl compounds, esters. 11. To determine dry rubber contents of latex. 12. To determine the coagulation strength of latex. 13. Mastication of Natural Rubber (NR) on two roll mill. 14. Mixing of rubber compounds 15. To determine tensile strength, modulus, elongation at break of Rubber sheet. 16. To determine curing time and physical properties of rubber compounds. 17. To test mechanical and physical properties of vulcanized rubber. 18. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC). 19. To prepare paints (water and solvent based). 20. To determine adhesive strength by peel test method. 21. To prepare adhesive of different formulations. 22. To measure the wettability of adhesives. 23. To measure the resin/paint viscosity by Brookfield viscometer. 24. To test film hardness of a coated adhesive film. 25. To measure the scratch resistance of painted films. 26. To calculate weight percent of paint in a painted film. 27. To analyze humidity of painted films. 28. Analysis of paints film by pencil hardness test	

Semester II			
	Title of Course: Synthesis and Application of Polymers (Core Compulsory)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Explain the historical development, raw materials, and industrial relevance of polymers
CO2: Describe the synthesis, structure, and applications of key polyolefins and olefinic copolymers.
CO3: Discuss the preparation, properties, and uses of acrylics, polyurethanes, and polyesters.
CO4: Differentiate between various types of polyamides, heat-resistant, and inorganic polymers.
CO5: Identify the roles and applications of functional polymers in advanced technologies.

Unit	Topics	No. of Lectures
I	**Introduction:** General introduction to industrial polymer, historical overview, raw material for the polymer industry, application of polymer as plastics, rubber fibers etc. Brief introduction to the preparation, structure, properties and applications of the followings. Polyolefin's: Introduction, polyethylene, polyvinyl chloride, polyvinylidene, chloride, polytetrafluoroethylene, polypropylene, polyisobutylene, polystyrene, polyvinyl diene, polybutadiene, polyisoprene and polychloroprene.	15
II	**Olefin Copolymers:** Introduction, styrene acrylonitrile copolymers, acrylonitrile butadiene styrene terpolymers, ethylene – methyl metha acrylic acid copolymers, styrene butadiene rubber, nitrile rubber, ethylene propylene elastomers, butyl rubber, thermoplastic olefin, elastomers, fluoro-elastomers.	11
III	**Acrylic polymers:** introduction, polyvinyl acetate, polyvinyl alcohol, polyvinyl formate, polyvinyl pyrrolidene, polyvinyl carbazole. **Polyurethanes:** Introduction rigid polyurethane foam, polyurethane coatings, flexible polyurethanes foam, polyurethane elastomers.	11
IV	**Polyesters:** Introduction, polyethylene terephthalate, polybutylene terephthalate, polydihydroxymethyl cyclohexyl terephthalate, cellulose esters, unsaturated polymers, Saromatic polyesters, polycarbonate. **Polyamides:** introduction, aliphatic polyamides, aromatic polyamides, polyamide imides and polyimides. **Heat resistant polymers:** Introduction, sulphide polysulfene.	12
V	**Silicones and other inorganic polymers:** Silicones, polyphosphazene, polythiazyl. **Functional polymers:** Introduction, photoconductive polymers, electroconductive polymers, light sensitive ion exchange resins, polymeric reagents.	11

REFERENCE TEXT BOOKS:
1. Brydson, J. A., (1999) Plastic Materials, Butterworth-Heinemann.
2. Dyson, R. W., (1990) Engg. Plastics, Blackie, Chapman and Hall.
3. Mohammad, F., (2007) Specialty Polymers: Materials and Applications, I.K. International Publishing House Pvt. Ltd.
4. Khalid, H., (2020) A Hand Book of Polymer Science
5. Dieter, A., (2012) Synthesis of Polymers: New Structures and Method
6. Krzysztof, M., (2022) Macromolecular Engineering: From Precise Synthesis to Macroscopic Materials and Applications, 5 Volume Set, 2nd Edition
7. Gowariker, V. R., (2022) Polymer Science
8. Manna, A. K., (2024) fundamentals of polymer science and technology (part 1)

ADDITIONAL RESOURCE TEXT BOOKS:
1. Seymour, R.B., Kirshenbaum, G.S., (1986) High Performance Polymers: their origin and development, Springer.
2. Sebastião, V. C., (2020) Polymer Science: A Textbook for Engineers and Technologists
3. Chaturvedi, V., (2025) Textbook of Polymer Science and Technology
4. Seymour, R.B., Kirshenbaum G.S., (1986) High Performance Polymers: their origin and development, Springer.
5. Sebastião, V. C., (2020) Polymer Science: A Textbook for Engineers and Technologists
6. Chaturvedi, V., (2025) Textbook of Polymer Science and Technology

Semester II			
	Title of Course: Polymer Processing (Core Compulsory)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Explain the principles and mechanisms of polymer mixing and select appropriate mixers for various applications.
CO2: Illustrate the working principles and applications of various extrusion techniques.
CO3: Describe calendaring operations and analyze factors affecting roll performance and product uniformity.
CO4: Differentiate between compression, transfer, and injection molding techniques and evaluate their suitability for thermoplastic and thermoset materials.
CO5: Understand blow molding and plastic finishing techniques for industrial applications.

Unit	Topics	No. of Lectures
I	**Principle of mixing and mixers:** Introduction, mechanism of mixing, practical mixing variables. **Types of mixers:** Roll mill, Kneader, sigma mixers, high speed mixers, internal batch mixer, ball mill, blender and extruder.	11

II	**Extrusion:** General features of single screw extruders, constructional features of dies, equipment for extrusion of monofilaments, tubes, rods, pipes, blown film, flat film, sheet, wire and cable covering, extrusion coating. **Calendaring:** Introduction, calendar configuration and operations, calendar roll temperature control, roll deflection and methods of correction.	13
III	**Compression and Transfer Moulding processes:** Machine description study- Compression moulding machine – types – principles of operations-sources of heat and pressure moulding cycle – meaning of terms bulk factor- and flow properties as applied to moulding materials- the interplay of heat, pressure, friction, catalysts, etc., for thermosetting materials	13
IV	**Injection moulding process:** Machine description study – Types and limitations – Working principles- Constructional features- Specifications maintenance- types starting and shut down procedures – press capacity. Hydraulics – basic principles hydraulic systems as used in injection moulding machine hydraulic oil requirements – safety rules, General constriction, types of injection moulds.	11
V	**Blow moulding process:** Introduction, types of blow moulding – injection blow moulding, extrusion blow moulding, rotational moulding and thermoforming. **Decoration of plastics:** Electroplating, Machining of plastics, Paintings, vacuum metallization & finishing.	12

REFERENCE TEXT BOOKS:

1. Rosen, S.L., (2012) Fundamental Principles of Polymeric Materials, Wiley-Interscience.
2. Ghosh, P., (2010) Polymer Science and Technology of Plastic and Rubber, Tata McGraw Hill.
3. Strong, A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
4. Rosato, D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.
5. Klemens, K., (2021) Mixing in Polymer Processing
6. Savvas, G., (2020) Advances in Polymer Processing: From Macro- to Nano- Scales
7. Sebastian, L., (2023) Mixing & Compounding

ADDITIONAL RESOURCES:

1. Morton-Jones, D.H., (2007) Polymer Processing, Chapman & Hall.
2. Crawford, R.J., (1998) Plastic Engg, Butterworth-Heinemann.
3. Rauwendaal, C., (2024) Extrusion & Die Design.
4. Rosato, D.V., (2020) Injection Molding Handbook.

Semester II			
	Title of the Course: Physical Chemistry (Core Compulsory)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Apply Raoult's and Henry's laws to analyze colligative properties and relate them to thermodynamic principles.
CO2: Analyze the variation of electrical conductivity in electrolytic solutions and apply Kohlrausch's law and Debye-Hückel-Onsager theory.
CO3: Interpret photochemical processes based on radiation characteristics and quantum yield principles.
CO4: Use phase rule and phase diagrams to analyze single, binary, and ternary phase equilibria.
CO5: Differentiate between types of adsorption and interpret adsorption isotherms for surface phenomena.

Unit	Topics	No. of Lectures
I	**Solutions and Colligative Properties:** Dilute solutions; lowering of vapour pressure, Raoult's and Henry's laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four Colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) depression of freezing point, (iv) osmotic pressure] and amount of solute.	13
II	**Conductance:** Quantitative aspects of faraday's laws of electrolysis Arrhenius theory of electrolytic dissociation, Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions, Debye-Huckle-Onsager equation, Wein effect, Debye-Falkenhagen effect, Walden's rules.	13
III	**Photochemistry:** Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficient, Laws of photochemistry, quantum yield.	8
IV	**Phase Equilibria:** Concept of phases, components and degrees of freedom, derivation of Gibbs Phase rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems (H_2O and S), with applications, phase diagrams for systems of solid- liquid equilibria involving eutectic, congruent and incongruent melting points, Three component systems; triangular plots, water-chloroform-acetic acid system.	15
V	**Surface Chemistry:** Physical adsorption, chemisorption, adsorption isotherms (Langmuir and Freundlich), nature adsorbed state, Qualitative discussion of BET.	11

REFERENCE TEXT BOOKS –

1. Atkin, P. W., (2022) Physical Chemistry 11th edition.
2. Barrow, G. M., Graw Hil, M. C., (1988) Physical Chemistry.
3. Donald, A., Quarrie, M.C., John, D. S., (2021) Physical Chemistry: A Molecular Approach.
4. Kapoor, K. L., (2020) A Textbook of Physical Chemistry –3rd Edition.
5. Atkin, P., (2020) Physical Chemistry: How Chemistry Works.
6. Wesley, R. B., (2021) Electrochemistry- Oxford Chemistry Primers.

Semester II			
	Title of Course: Tyre Technology (Elective III)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext:70)			

Course Outcomes: Upon completion of this course, students will be able to:

CO1: Understand the current status, classification, and future prospects of the tyre industry in India.

CO2: Analyze the design criteria and sizing parameters of tyres for different vehicles and applications.

CO3: Formulate and evaluate rubber compounds for different tyre components using various elastomers and additives.

CO4: Explain the step-by-step manufacturing processes of tyre components and the construction of different tyre types.

CO5: Demonstrate knowledge of tyre curing technologies and equipment used in shaping and vulcanizing tyres.

Unit	Topics	No. of Lectures
I	**Introduction:** Current status of the tyre industry in India and its future prospects, characterization, performance and the basis of materials required for the construction of solid tyres for light and heavy vehicles, pneumatic tyres for bicycles and light motor vehicles, tyres for heavy motor vehicles, off the road tyre, and air craft tyre, component parts and relative merits for different tyres of automotive tyres such as cross-ply, Bias-belted, concentrates, minter and tubeless tyres.	12
II	**Design and Sizing:** Factors to be considered in the designer of tyres-safety requirements and tread life requirements, vehicle weight distribution and load carrying capacity, desired inflation, pressure of operation, axle height and clearance for the basis, suspension and breaking system.	11
III	**Tyre Sizing:** General system for indicating tyre dimensions — typical compound formulations with different elastomers and reclaimed rubbers for the production of the component parts of the different tyres. Compounding techniques and procedures for the production of different components/compounds required for various components of tyres.	12
IV	**Manufacturing of tyre components and tyre construction:** Manufacture of cycle tyres and tubes, automotive tubes, tyre treads, beads, carcass, side walls adhesive solutions and misc. components.	12
V	**Tyre building and curing:** An introduction to tyre building and building drum, building of standard diagonal ply tyres, belted bias tyres and redial ply tyres. Tyre moulds, shaping machines, curing bags, bladders and diaphragms. Preparation of raw tyres for vulcanization, tyre curing, curing plastics- autoclave and pans, ordinary pressures, bagomatic and autoform	13

	cure temperature and times after treatment.	

REFERENCE TEXT BOOKS:

1. Clark, S.K., (1971) Mechanics of Pneumatic Tires, National Bureau of Standards, Monograph, US Govt. printing office.
2. French, T., (1989) Tyre Technology, Adam Hilger, New York.
3. Nikuni, J., (2023) Tire Manufacturing Process
4. Rodgers, B., (2023) Tire Engineering: An Introduction

ADDITIONAL RESOURCE TEXT BOOKS:

1. Ford, T.L., Charles, F.S., (1988) Heavy Duty Truck TIRE Engineering SAE's 34th L. Ray Buckingdale Lecture, SP729.
2. Gent, A.N., Walter, J.D., (2006) The Pneumatic TIRE, U.S. Department of Transportation, National Highway Traffic Safety Administration.
3. Mar, J.E., Erman, B., Eirich, F.R., (2005) The Science and Technology of Rubber, Elsevier.
4. Koutny, F. Z., (2007) Geometry and Mechanics of Pnumatic TIRE, CZE.

Semester II

	Title of Course: **Smart Polymeric Materials** (Elective IV)	4 hours/week	4 Credits (60 hours)

Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)

Course Outcomes: Upon completion of this course, students will be able to:

CO1: Understand the types, mechanisms, and applications of smart materials and piezoelectric polymers.

CO2: Explain stimuli-responsive behaviors and fundamental properties of various smart polymers.

CO3: Describe synthesis methods and applications of smart polymers in drug delivery and diagnostics.

CO4: Analyze the design and function of smart hydrogels and soft actuators in biomedical fields.

CO5: Evaluate advanced smart polymer systems such as shape-memory, self-healing polymers, and nanocomposites for specialized applications.

Unit	Topics	No. of Lectures
I	**Introduction to Smart Materials and Structures:** Definition and overview of smart materials and smart structures, Classification and components of smart structures, Common smart materials and their stimulus-response mechanisms, Applications of smart materials in aerospace, biomedical, civil, and electronics. Piezoelectric materials: Piezoelectric effect, direct and converse effects, Piezoelectric parameters and characterization, Types: piezoceramics and piezopolymers, Applications as sensors, actuators, energy harvesters, and bimorphs.	13

II	**Smart Polymers – Fundamentals and Types:** Introduction to smart polymers and stimuli-responsiveness, Thermo-responsive polymers: LCST/UCST behavior and applications, Electroactive polymers (EAPs): types, mechanisms, and applications, pH-responsive and photo-responsive polymers: principles and uses, Protein-based and bio-derived smart polymers, Concept of self-assembly in polymer systems, Basic principles of molecular imprinting using smart polymers.	13
III	**Synthesis and Applications of Smart Polymers:** Methods of synthesizing smart polymers (radical polymerization, RAFT, ATRP, etc.), Microgels: synthesis, responsive behavior, and applications, Molecular imprinting approaches and applications in sensing and separation, Smart drug delivery systems: targeted delivery, stimuli-controlled release, Role of smart polymers in tissue engineering and diagnostics.	12
IV	**Smart Hydrogels and Soft Actuators:** Definition and classification of hydrogels, Synthesis and crosslinking methods of smart hydrogels, Fast-response and multi-responsive hydrogels, Smart hydrogels as actuators and artificial muscles, Controlled drug release and biomedical applications, Hydrogels in microfluidic systems.	10
V	**Advanced Smart Polymeric Systems and Applications:** Shape-memory polymers: mechanism, synthesis, and applications, Self-healing polymers: concepts, chemistry, and performance evaluation, Smart nanocomposites: polymer-based nanomaterials with responsive functions, Smart coatings for corrosion protection and surface functionality, Space and aerospace applications, Introduction to molecular machines and nano-actuators.	12

REFERENCE TEXT BOOKS:

1. Galaev, I., (2007) Smart Polymers: Applications in Biotechnology and Biomedicine (2nd Edition).
2. Ji, W., (2023) Smart Polymer Hydrogels: Synthesis, Properties and Applications –Volume I.
3. Tiwari, N., (2023) Shape Memory Polymer Composites: Characterization and Modeling.
4. Thomas, S., (2019) Shape Memory Polymers, Blends and Composites:Advances and Applications.

Semester II			
	Title of Course: Polymer practical-II (Core Compulsory and Skill Enhancement)	**18 hours/week**	**8 Credits (240 hrs)**
Max Marks: 100; Practical: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of lab program, students will be able to:

CO1: Gain hands-on experience in preparing thermosetting resins, thermoplastics, rubbers, and specialty polymers like polyacrylonitrile and hydrogels.
CO2: Learn to analyze polymers for degradation temperature, glass transition temperature (Tg), melting point (Tm), flexural strength, elasticity, and swelling behavior.
CO3: Develop skills in volumetric analysis (oxalic acid, sodium carbonate), surface tension measurement, and conductometric titrations for chemical characterization.
CO4: Understand processes like solution polymerization, compression molding, and sheet formation to produce usable polymer and rubber products.
CO5: Gain practical exposure to corrosion-resistant coatings, corrosion inhibition testing, hydrogel water absorption, and conductivity analysis for materials engineering applications.

	Experiments	
Polymer Practical	1. To prepare urea-formaldehyde resin 2. To prepare aniline formaldehyde resin 3. To prepare bakelite plastic 4. To prepare resol resin 5. To prepare novolac resin 6. To prepare polyacrylonitrile polymer by solution polymerization technique. 7. To prepare PMMA sheet. 8. To prepare thiocol rubber 9. To determine K value of PVC region. 10. To prepare PVC sheet with the help of compression molding machine. 11. To prepare PVC compound. 12. To prepare natural rubber sheet. 13. To prepare nitrile rubber sheet. 14. To determine the degradation peak, Tg, Tm of unknown sample. 15. Estimation of oxalic acid using standardized NaOH solution 16. Estimation of sodium carbonate using standardized HCl. 17. Estimation of oxalic acid using standardized $KMnO_4$ solution 18. Determine the surface tension of a liquid by drop number method. 19. Study the effect of the addition of solutes on the surface tension of water at room temperature and explain the observations in terms of molecular interactions: (i) sugar (ii) ethanol (iii) sodium chloride. 20. Determination of cell constant 21. Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid. 22. Perform the conductometric titrations: Strong acid vs. strong base. 23. To determine the elastic properties of polymers. 24. To determine swelling % age of hydrogel. 25. To prepare corrosion resistance coatings. 26. To test the corrosion inhibition of materials. 27. To determine the flexural strength of epoxy/ polyester composite. 28. To synthesize and test water absorption behaviour of hydrogel	

	Semester III		
	Title of Course: Polymer Blends and Composite (Core Compulsory)	**4 hours/week**	**4 Credits (60 hours)**
	Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)		

Course Outcomes: Upon completion of this course, students will be able to:

CO1: Classify and evaluate the compatibility of polymers for blending applications.

CO2: Describe methods of blending and characterize the morphology, crystallinity, and rheological behavior of polymer blends.

CO3: Identify the types, fabrication methods, and performance characteristics of polymer composites.

CO4: Analyze methods to enhance miscibility of polymer blends and evaluate their structural and functional properties.

CO5: Apply knowledge of polymer blends and composites in industrial and structural applications.

Unit	Topics	No. of Lectures
I	**Classification, methods, properties and applications:** Polymer blends classification, principles of polymer compatibility, different theories of predicting compatibility, factors governing compatibility, compatibilisers, properties achieved by blending. Methods of blending, characterization of blends, commercial polyblends their properties and applications, crystallization in polyblends, morphology of blends and its determination. Introduction to rheology of polymer blends its relevance in processing, rheology phase, morphology relationships and their relevance.	13
II	**Classification, methods, properties and applications:** Classification of composite, particulate and fibrous composite, introduction to reinforcing material, particulate filled composites, mechanical and physical properties, environmental effects on composites, test methods for composites, applications of composites, ceramics, refractories.	12
III	**Enhancement of polymer miscibility:** Compatibilization, reactive compatibilization, non- reactive compatibilization, modification of structures, incorporation of block and graft copolymers, interpenetrating network formation, cross-linking, introduction of interacting groups.	12
IV	**Criteria for selection of polymers:** Physical and chemical properties, miscibility, polydispersity, molecular weight distribution, enthalpy of mixing, polarity, energy parameters, lower critical solution temperature (LCST), upper critical solution temperature (UCST), crystallization. **Utilization of miscible polymers:** Industrial examples, mechanical compatibilities versus miscibility in polymer blends.	12
V	**Structural applications of composites:** Aerospace applications, transportations, marine, infrastructures, constructions, sporting goods, composites, clean energy generation.	11

REFERENCE TEXT BOOKS:

1. Paul, D.R., Bucknall, C.B., (2000) Polymer Blends Vol. 1 & Vol. 2, Wiley- Interscience.
2. Robeson, L.M., (2007) Polymer Blends, Hanser Gardner.
3. Singh, R.P., Das, C.K., Mustafi, S.K., (2002) Polymer Blends and Alloys, Asian Books Private Limited.
4. Mehra, P., (2025) Polymer Blends and Additives.
5. Behera, B. K., (2025) Polymer Composites: Fundamentals and Applications.
6. Behera, B. K., (2024) Advancements in Multifunctional Composite Materials.
7. Thomas, S., (2023) Characterization of Polymer Blends: Miscibility, Morphology and Interfaces
8. Norkhairunnisa Mazlan, R. A., (2022) Advanced Composites in Aerospace Engineering Applications.

ADDITIONAL RESOURCE TEXT BOOKS:

1. Utracki, L.A., (2003) Polymer Blends Handbook Vol. 1 & Vol. 2, Kluwer Academic Pub.
2. Bhowmick, A.K., De, S.K., (1990) Thermoplastic Elastomers from Rubber-Plastic Blends, Ellis Horwood Publishers Ltd.

Semester III

	Title of Course: Analytical Techniques (Core Compulsory)	**4 hours/week**	**4 Credits (60 hours)**

Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)

Course Outcomes: Upon completion of this course, students will be able to:

CO1: Interpret UV-Visible spectra based on electronic transitions and apply empirical rules for structural analysis.

CO2: Analyze functional groups and molecular interactions using IR spectroscopy.

CO3: Elucidate organic molecular structure using ^{1}H and ^{13}C NMR spectroscopy.

CO4: Describe principles and applications of ESR spectroscopy in studying unpaired electrons and transition metal complexes.

CO5: Utilize thermal and microscopic techniques for polymer and material characterization.

Unit	Topics	No. of Lectures
I	**Ultraviolet Visible Spectroscopy:** Various electronic transitions (185-800 nm), Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes., Fieser-Woodward rules for conjugated dienes and carbonyl compounds ultraviolet spectra of aromatic and heterocyclic compounds, steric effectin biphenyls.	10
II	**Infrared Spectroscopy Instrumentation and sample handling:** Characteristic vibrational frequencies of alkanes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines, detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds), effect of hydrogen bonding and solvent effect on vibrational frequencies.	11

III	**Nuclear Magnetic Resonance Spectroscopy:** General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanisms, of measurement chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides and mercapto), intensity of NMR reagents, chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei (first order spectra) virtual coupling, stereochemistry hindered rotation, Karplus curve variation of coupling constant with dihedral angle. Simplification of complex spectra, nuclear magnetic double resonance, contact shift reagent, solvent effects, Fourier transform technique, nuclear overhauser effect (NOE).	14
IV	**Carbon-13 NMR Spectroscopy:** General considerations, chemical shift (aliphatic, olefinic, alkynes, aromatic, heteroaromatic and carbonyl carbon), coupling constant, introduction to 2 D NMR.	06
V	**Electron Spin Resonance Spectroscopy:** Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes (having one unpaired electron).	06
VI	**Thermal Analysis:** Introduction DSC, DTA, TGA and DMA; basic principle and instrumentation. Application in polymer systems.	07
VII	**Optical Microscopy:** Basic principle of SEM and TEM, SEM imaging, sample preparation, TEM direct examination and indirect examination.	06

REFERENCE TEXT BOOKS:

1. Skoog, D.A., (2023) Fundamentals of Analytical Chemistry (8th, edn.)
2. Silversteine and Basser, (2014) Spectrometric Identification of Organic Compounds.
3. Kalsi, P. S. (2020) Organic Spectroscopy (8thedi).
4. Bellamy, J., (2021) Infrared spectra of Complex molecules.
5. Fleming, I., (2019) Organic Spectroscopy (7th edi).
6. Pavia, L., (2005) Spectroscopy of Organic Compounds
7. Willard, H.H. (2014) Instrumental Methods of Analysis (CBS Publisher) 7th edn.
8. Hore P. J. (2020) Nuclear Magnetic Resonance (Oxford Chemistry Primers)
9. John Wiley & Sons, (2020) Carbon-13 NMR Chemical Shifts in Structural and Stereochemical Analysis

ADDITIONAL RESOURCE TEXT BOOKS:

1. Singh, R., (2024)Transmission Electron Microscopy Sample Preparation
2. Arunadevi, S. B., (2022)UV-Visible Spectroscopy
3. Thomas, M., (2024) Infrared (IR) Spectroscopy

Semester III			
	Title of Course: Polymer Testing & Specifications (Core Compulsory)	4 hours/week	4 Credits (60 hours)
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:

CO1: Describe the significance of standardized testing methods and prepare test specimens as per standard.

CO2: Evaluate processing behavior of polymers using rheological and plastometric methods.

CO3: Measure mechanical performance of polymers using static, dynamic, and impact testing techniques.

CO4: Analyze thermal, electrical, and environmental resistance of polymer materials.

CO5: Investigate optical, permeability, and chemical properties using advanced instrumentation.

Unit	Topics	No. of Lectures
I	**Fundamentals of Polymer testing:** Introduction, methods of testing polymers and polymer products, specification & standards professional and testing organizations. **Test Piece Preparation:** Cutting flexible material, buffing, machining rigid materials, dimensional measurements and gravimetric measurements. **Processing Properties:** Difference in approach to processability of plastics and rubber, capillary viscometers, rotational viscometers, miniature, Processing machine, torque rheometers, compression Plastimeters, plasticity retention, rotations and oscillating rotor Plastimeters, extrusion Plastimeters, tack testing, scorch and cure rate, tests on latex.	13
II	**Mechanical Properties:** Hardness Durometer, dead load instruments and other indention tests, static stress and strain measurements, tensile machines, grips and jigs, extensiometry environmental cabinets, dynamic stress and strain properties, forced vibrations machines, free vibration machines, rebound resilence, impact strength falling weight, Charpy and Izod, tensile impact. Frictio abrasion, creep, stress relaxation of rubber, dynamic fatigue of cellular materials, dynamic fatigue of plastics, static fatigue of plastics.	13
III	**Electrical properties:** Resistance & resistivity, insulating materials, conductive materials, electric strength, resistance to surface discharges and tracking, surface charge and discharge measurements, permittivity and power factor. **Thermal properties:** Specific heat, thermal conductivity, thermal diffusivity, transfer coefficient, effect of temperature, thermal expansion, Glass transition temperature, softening and melting point, low temperature tests, modulus tests, heat ageing and conditioning, air ovens, liquid bath, oxygen bombs.	12

IV	**Environmental Resistance:** Humidity, effects of liquids, effect of ozone, light ageing and weathering, fire testing, smoke, oxygen index test. **Optical Properties:** Microscopy, stereo bimolecular microscopes, standard microscopes, Microtomes, electron microscope, Ultramicrotomy.	11
V	**Permeability:** Vapour permeability, gas permeability. **Chemical Properties:** Chemical resistance, Extrusion, swelling, adhesion, corrosion, staining, chromatography, Gas chromatographs, High performance liquid chromatography.	11

REFERENCE TEXT BOOKS:

1. Shah, V., (2007) Handbook of Plastic Testing & Technology, Wiley-Inter science.
2. Hylton, D., (2004) Understanding Plastic Testing, Hanser publication.
3. Grellmann, W., Seidler S., (2013) Polymer Testing, Hanser publication.
4. Grellmann, W., (2022) Polymer Testing (3rd Edition).
5. Rapra, S., (2009) Handbook of Polymer Testing: Physical Methods.
6. Schubnell, M., (2022) Validation in Thermal Analysis.
7. Wampfler, B., (2022) Measurement Uncertainty in Analysis of Plastics: Evaluation by Interlaboratory Test Results.

ADDITIONAL RESOURCE TEXT BOOKS:

1. Berins, M. L., (1991) SPI Plastic Engineering Hand book, Springer.
2. Ward, I.M., Sweeney, J., (2004) An Introduction to the Mechanical Properties of Solid Polymers, Wiley.
3. Crawford, R.J., (1998) Plastic Engg, Butterworth-Heinemann.
4. Ray, S. S., (2023) Process-Induced Phase Separation in Polymer Blends: Materials, Characterization, Properties, and Applications.

Semester III			
	Title of Course: Fiber Technology (Elective V)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:

CO1: Explain the characteristics and production processes of natural, regenerated, and synthetic fibers.

CO2: Analyze fiber spinning techniques and their effects on fiber orientation, structure, and properties.

CO3: Compare the chemical synthesis, reactions, and industrial production of major textile fibers.

CO4: Examine post-spinning operations and physical treatments applied to improve fiber and yarn properties.

CO5: Apply knowledge of dyeing and finishing techniques to natural and synthetic fibers.

Unit	Topics	No. of Lectures
I	Introduction to natural and synthetic polymers. Essential characteristics of fiber forming polymers.	10

	Melt spinning process: Melt-extrusion, spinning conditions such as spinneret size, rate of extrusion, spinning stretch and its effect on filament structure and properties with special reference to polyamide and polyester fibers.	
II	**Polyamide fibers:** Introduction to important polyamides, polyamidation reaction, Synthesis of nylon-6 and 66, production of newer nylons. **Polyester fibers:** A detailed study of polyester, Esterification and poly condensation reactions, industrial process for fiber production of PET and Copolyesters	12
III	**Viscous Rayon:** A detailed study of the manufacture of regenerated cellulose fibers, Specification for raw materials. The formation and chemical constitution of alkali cellulose, ageing of alkali cellulose, cellulose xanthate and the xanthation reaction, the ripening process and its effect on molecular structure. Coagulation and the effect of variations in the composition of the coagulation bath on fiber properties, self-crimping of fibers. High tenacity and polynosic fibers. **Cellulose Acetate fiber:** Introduction to raw materials. Acetylation and hydrolysis of cellulose into primary and secondary acetate. Manufacturing of cellulose acetate. Commercial production methods. Preparation of dope, spinning and solvent recovery. Solution properties of triacetate and secondary acetate, Spinning stretch and its effect on orientation.	14
IV	**Fibers from addition polymers**: Polyethylene, polypropylene and fibers based on polyacrylonitrile, copolymers for fiber production, polyvinyl alcohol fibers, Elastomeric fibers of spandex type, chloro fiber, bicomponent fibers. **Fiber production and post-spinning operation;** Drawing effect on orientation and crystallization. Principles of setting of fibers and fabrics. Production of staple yarns on various systems. Problems of blending, static problems and remedies. Melt spinning and wet spinning of fibers, fiber drawing heat setting, texturing and mechanical properties of fibers.	13
V	**Dyeing and finishing:** chemistry and application of common dyes to natural and synthetic fibers. Bath, semi-continuous dyeing operations. Central principles of finishing and common types, applied to textiles-their theory and practice.	11

REFERENCE TEXT BOOKS:

1. Gupta, V.B., Kothari, V.K., (1997) Manufactured Fibre Technology, 1st Ed., Chapman and Hall.
2. NPTEL course material on manufactured fibre Technology.
3. Macintyre, J.E., (2005) Synthetic Fibres: Nylon, Polyester, Acrylic, Polyolefin, Elsevier Science.
4. Kothari, V.K., (2000), Textile Fibres: Developments and Innovations, IAFL Publications.
5. Cook, J.G., (2009), Hand Book of Textile Fibres, Woodhead Publishing.

ADDITIONAL RESOURCE TEXT BOOKS:

1. Collier, B.J., Martin, J.B., Tortora, P.G., (2009) Understanding Textiles, Prentice Hall.

2. Morton, W.E., Hearle, J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.
3. Vaidya, A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.

Semester III			
	Title of Course: Advanced Polymers in Energy Applications (Elective VI)	**4 hours/week**	**4 Credits (60 hours)**
Max Marks: 100; Theory: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of this course, students will be able to:
CO1: Understand polymer roles and synthesis in energy devices like fuel cells.
CO2: Analyze polymer electrolytes for lithium batteries and improve conductivity.
CO3: Explain fundamentals and materials of polymer solar cells and quantum dots.
CO4: Apply fabrication and design methods to optimize polymer solar cells.
CO5: Evaluate advanced and sustainable polymers for emerging energy applications.

Unit	Topics	No. of Lectures
I	**Introduction to polymeric materials for energy applications:** Overview of energy conversion and storage devices, Role of polymers in energy materials, Introduction to high-performance polymer hydrogels, Poly(vinyl alcohol) (PVA) hydrogels: properties and synthesis, Hydrogel electrolytes for fuel cells, Applications and performance metrics in fuel cells.	10
II	**Polymer electrolytes for lithium batteries:** Introduction to lithium battery systems, Polymer blend electrolytes: PVAc-based systems, Solid polymer electrolytes with: Inert oxide ceramics, Fast-ion conductive ceramics, Ionic liquids and Cellulose-based materials, Composite polymer electrolytes: Garnet-type, Perovskite-type and PPO-type, Sulfide-type, Challenges and design strategies for improved ionic conductivity and stability.	13
III	**Organic and polymeric solar cells – fundamentals:** Introduction to solar cell technologies, Classification of solar cells: inorganic vs. organic/polymeric, Operating principles and mechanisms, Key materials in polymer solar cells: donors, acceptors, and transport layers, Concept and role of quantum dots in solar energy conversion: Organic quantum dots, Polymer-based multiple quantum dots and Molecular multiple quantum dots.	14
IV	**Device fabrication and structure design for solar cells:** Architecture of solar cells, Design considerations for high efficiency, Preparation methods: Spin-coating of active layers, Influence of solvent and solvent engineering and Residual solvent effects on device performance, Hybrid solar cells: Polymer-inorganic hybrids, Conjugated polymer–inorganic semiconductor composites and Bulk heterojunction solar cells.	12
V	**Advanced polymer materials for energy technologies:** Emerging trends in polymer materials for energy devices, Smart hydrogels and self-healing polymers, Conducting polymers in supercapacitors and wearable energy devices, Sustainability aspects: biodegradable and recyclable polymeric materials, Future directions and case studies on commercial applications.	11

REFERENCE TEXT BOOKS:

1. Ram, P.S., (2025) Polymer Electrolytes: Evolution, Challenges, and Future Directions for Lithium-Ion Batteries
2. Subramani, N. K., (2022) Polymer-Based Advanced Functional Materials for Energy and Environmental Applications
3. Gupta, R. K. (2023) Recent Advancements in Polymeric Materials for Electrochemical Energy Storage Applications

Semester III			
	Title of Course: Polymer practical-III (Core Compulsory and Skill Enhancement)	**18 hours/week**	**8 Credits (240 hrs)**
Max Marks: 100; Practical: 100 (Int: 30; Ext: 70)			

Course Outcomes: Upon completion of lab program, students will be able to:

CO1: Students will determine properties like S-content, hydroxyl, acid, amine values, MFI, and viscosity, gaining skills essential for polymer quality control and formulation.

CO2: Students will prepare and test composites using various techniques, and assess mechanical performance under different filler loadings.

CO3: Students will use methods like Lee's Disk, Congo red, UV-Vis spectroscopy, and solar cell testing to study thermal conductivity, stability, energy storage, and optical behavior of materials.

CO4: Students will apply chromatography (TLC, paper) and compatibility tests to evaluate polymer blends and additives.

CO5: Students will fabricate and demonstrate solar cells, lithium battery testing, and prepare PVAc-based polymer electrolytes, enabling insight into green energy and storage technologies.

	Experiments	
Polymer Practical	1. To determine the S-content and volatile loss of polymer sample. 2. To determine M.F.I. of Polypropylene. 3. To determine the impact strength of laminates by falling weight test method 4. To determine hydroxyl value of polymer. 5. To determine acid value of polymer. 6. To determine amine value of polymer. 7. To determine aniline point of plasticizers. 8. To determine thermal conductivity by Lee's Disk Method. 9. To determine the compatibility of PVC sheet with the help of Loop-compatibility. 10. To determine migration loss of PVC sheet at different solvents as water, 10% NaOH solution, petrol, etc. 11. To determine M.F.I. of PVC. 12. To determine thermal stability of PVC sheet with the Congo red method. 13. Synthesis of copolymer of styrene & maleic anhydride, and styrene & MMA. 14. Compression moulding of fabric/rubber composite. 15. Preparation of rubber blends 16. To determine physical properties of fibres: tex, tenacity, denier,	

	moisture content, density etc. 17. Preparation of FRP laminates by hand lay-up technique. 18. Evaluate the effect of filler loading on mechanical properties of a composite. 19. Characterization (thermal and mechanical) of blends and composites. 20. To verify Lambert's Beer's Law with the help of U.V. visible spectrometer. 21. To determine the concentration of unknown sample with the help of UV-visible double beam spectrophotometer. 22. To determine kinematics viscosity of plasticizer with the help of Redwood viscometer. 23. To determine the dynamic viscosity of polymeric plasticizer at different temperature with the help of Brookfield viscometer. 24. To separate the chlorophyll pigments with the help of TLC. 25. To separate the chlorophyll pigments with the help of paper chromatography. 26. To prepare solar cell. 27. Demonstrate the working principle of solar cell. 28. To Prepare PVAc Based Polymer Blend Electrolytes.	

Semester IV			
	Title of Course: Research Project		**24 (Credits) 720 hrs**
Max Marks: 500			

Course Outcomes after completion of Research Project:

CO1: Students will identify a relevant problem, conduct a comprehensive literature review, define objectives, and design experiments or simulations to solve research questions in polymer science.
CO2: Demonstrate proficiency in advanced experimental techniques and characterization methods.
CO3: Analyze and interpret complex data to draw valid scientific conclusions.
CO4: Develop innovative solutions or materials for sustainable, industrial, or advanced applications.
CO5: Communicate research outcomes effectively through technical writing and presentations and inculcate varieties of learning styles and software tools (Powerpoint presentation, Chem Draw and Origin, etc.).