GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Plastics Engineering

Subject Code: ME03084011

Subject Name: Advanced Polymer Physics

w.e.f.Academic Year:	2024-25
Semester:	3
Categoryof theCourse:	MOPEC

Pre requisite:	NIL
Rationale:	NIL

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes
01	• **Understand the fundamental principles of polymer physics** • Analyze polymer chain models and molecular interactions • Identify the role of molecular flexibility in polymer applications
02	• **Apply thermodynamic theories to polymer solutions and blends** • Explain phase behavior using the Flory-Huggins theory • Predict miscibility and solubility parameters for various polymer systems
03	• **Evaluate mechanical and rheological properties of polymers** • Understand viscoelastic behavior using models like Maxwell and Voigt • Analyze non-Newtonian fluid dynamics and rubber elasticity
04	• **Utilize computational techniques for polymer analysis** • Implement Monte Carlo and molecular dynamics simulations • Interpret simulation results for polymer behavior prediction
05	• **Conduct experiments to assess polymer properties** • Operate advanced laboratory equipment for rheological analysis • Analyze experimental data for polymer structure and dynamics

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
02	0	02	03	70	30	20	30	150

Course Content:

Unit No.	Content	No.of Hours	%of Weightage
1.	**Introduction to Polymers and Polymer Chains** • **Fundamentals of Polymers**: Macromolecules and Life, Molecular Flexibility, Classification of Polymers, Types of Polymerization. • **Polymer Chain Models**: Random walk models in polymer physics: 1-D random walk (drunkard walk), 2-D random walk on a lattice, freely jointed chain, modified freely jointed chain, freely rotating chain. • **Polymer Molar Mass & Distribution**: Average Molecular Weights and Polydispersity, Determination of Polymer Molar Mass by Osmometry, Light Scattering, Frictional Properties, Viscometry, Size Exclusion Chromatography. • **Branching & Network Formation**: Gelation process, Structural properties of polymer networks.	05	15
2.	**Thermodynamics of Polymer Solutions and Blends** • **Polymer Solution Thermodynamics**: Mixing and Phase Separation, Osmotic Pressure, Chemical Potential, Thermodynamic Origin of Diffusion. • **Lattice Models and Theories**: Flory-Huggins Theory of Polymer Solutions, Definition of Partition Function and Free Energy, Binodal and Spinodal Curve, Critical Point, Extension to Polymer Blends and Melt. • **Polymer Blends and Block Copolymers**: Phase Behavior, Miscibility, and Solubility Parameters. • **Excluded Volume Effects**: Flory Theory in Good Solvent, Bad Solvent, and Theta Solvent.	7	20
3.	**Mechanical and Rheological Properties of Polymers** • **Polymer Phases**: Crystalline and Amorphous Polymer Phases, Mechanical Properties. • **Viscoelastic Behavior**: Maxwell and Voigt Models, Non-Newtonian Behavior and Rheology, Rubber Elasticity.	7	20

	• **Polymer Chain Elasticity**: Elastic Energy of Polymer Chain, Bead-Spring Model, Ideal Polymer Chain, Finite Extension Models, Radius of Gyration, Pair Correlation Function. • **Scattering Experiments**: Experimental Analysis of Polymer Chain Dynamics.		
4.	**Polymer Dynamics and Brownian Motion** • **Unentangled Polymer Dynamics**: Rouse and Zimm Models. • **Entangled Polymer Dynamics**: Reptation Theory. • **Brownian Motion and Correlation Functions**: Time Translational Invariance, Time Reversal Symmetry, Brownian Motion of a Free Particle, Einstein Relation, Brownian Motion in a Potential Field. • **Introduction to Computational Techniques**: Monte Carlo Simulations of a Polymer Chain, Importance Sampling, Metropolis Criteria, Monte Carlo Simulations in Good Solvent and Bad Solvent Regime.	8	25
5.	**Experimental Rheology and Computational Modeling** • **Continuum Mechanics**: Equations of Motion, Stress Tensor, Deformation Tensor, Deformation Gradient Tensor, Constitutive Relations of Solids, Liquids, and Rubber, Microscopic Definition of Stress Tensor. • **Experimental Rheology**: Rheometers, Linear Viscoelasticity, Superposition Principle, Relaxation Modulus, Storage Modulus, Loss Modulus. • **Molecular Dynamics and Brownian Dynamics**: Application in Polymer Physics. • **Practical Aspects of Computational Modeling**: Simulation-Based Analysis of Polymer Properties.	8	20
	Total	**35**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	15	20	10	5	5

Where R:Remember; U:Understanding; A:Application, N:Analyze and E:Evaluate C:Create (asper Revised Bloom's Taxonomy)

References/Suggested Learning Resources: Books:

1. Rubinstein, M., & Colby, R. H. (2003). *Polymer Physics.* Oxford University Press.
2. Doi, M., & Edwards, S. F. (1988). *The Theory of Polymer Dynamics.* Oxford University Press.
3. Flory, P. J. (1953). *Principles of Polymer Chemistry.* Cornell University Press.
4. Strobl, G. (2007). *The Physics of Polymers.* Springer.
5. Young, R. J., & Lovell, P. A. (2011). *Introduction to Polymers.* CRC Press.
6. Sperling, L. H. (2005). *Introduction to Physical Polymer Science.* Wiley-Interscience.
7. Odian, G. (2004). *Principles of Polymerization.* Wiley.

(b) Open source software and website:

https://nptel.ac.in/

Suggested Course Practical List:As per the above syllabus topics

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