



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Rubber Technology

Subject Code: ME02088061

Subject Name: Physics of Rubber Elasticity

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Basic knowledge of rubber technology, its characteristics and knowledge about rubber processing and rheology.
Rationale:	The study of the physical properties of rubber provides a foundational understanding of its unique elasticity, thermodynamic behavior, and molecular structure. This subject bridges theoretical principles with experimental analysis to explore how rubber's microstructure influences its macroscopic properties, enabling advancements in material design and applications. This subject equips students with the theoretical and practical knowledge necessary to analyze and manipulate rubber's unique properties. By integrating thermodynamic, statistical, and molecular perspectives, the study fosters innovation in rubber-based materials for advanced engineering and industrial applications.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
C01	Explain the chemical constitution of rubbers and its significance.
C02	Describe the principles of the kinetic theory of elasticity.
C03	Examine the statistical properties of long-chain molecules in rubber materials.
C04	Illustrate the elastic properties of swollen rubber and their contributing factors.
C05	Develop a relation between swelling and modulus and evaluate the impact of molecular entanglements.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
03	00	02	04	70	30	20	30	150



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	General Physical Properties of Rubber: Chemical constitution of rubbers, Early theories of Rubber Elasticity, The Kinetic theory of Elasticity, Cross-Linking and Vulcanisation: network theory, The glassrubber transition, Crystallization in raw rubber, Crystallization in the stretched state, Photoelastic Properties of Rubbers etc	7	15
2.	Internal Energy and Entropy Changes on Deformation: Stress-temperature relations, Thermodynamic analysis, Application to experimental data, Interpretation of thermoplastic data, Thermal effects of extension.	7	15
3.	The Elasticity of Long-Chain Molecules: Statistical Properties of Long-chain molecules, Statistical form of Long-chain molecule, The randomly jointed chain, Properties of Gaussian functions, The distribution of r-values, Equivalent random chain. The entropy of a single chain, the tension on a chain	7	15
4.	The Elasticity of a Molecular Network: The nature of the problem, Detailed development of the theory, Significance of theoretical conclusions, The principal stresses, Significance of single elastic constant, The elastic properties of a swollen rubber, Development of the theory by James and Guth, Network imperfections : 'loose end' corrections.	6	15
5.	Experimental Examination of The statistical Theory: Introduction, Particular stress-strain relations, Experimental examination of stressstrain relations, Derivations from theory: Mooney equation, Non-Gaussian Chain Statistics and Network Theory, Thermodynamic Analysis of Gaussian Network etc.	6	15
6.	Swelling Phenomena: Introduction, General Thermodynamic Principles, Significance of thermodynamic quantities, Statistical treatment of Swelling, The Swelling of Cross-linked polymers, Relation between swelling and modulus, The Cohesive-energy density, The dependence of swelling on strain, Swelling under torsional strain , etc.	6	15
7.	Cross linking and Modulus: Introduction, The experiments of Moore and Watson and of Mullins, Effect of entanglements etc.	6	10
	Total	45	100



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Suggested Specification Table with Marks (Theory):

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

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

References/Suggested Learning Resources:

(a) Books:

1. The Physics of Rubber Elasticity by L.R.G.Treloar.
2. Viscoelastic Properties of Polymers by John D.Ferry

(b) List of Open Source Software/learning website:

- <http://www.crcpress.com>
- www.citycollegiate.com
- www.rubberchemtechnol.org/doi/abs/10.5254/1.3546653

Suggested Course Practical List: If any

Practical based on above topics.

Suggested Project List:

1. Study of the Chemical Constitution of Rubbers and Its Effect on Elasticity
2. Thermodynamic Analysis of Stress-Temperature Relations in Rubber Deformation
3. Thermal Effects of Extension in Rubber: Experimental Approach
4. Gaussian Chain Statistics in Rubber: Theoretical and Experimental Analysis
5. Development of the James-Guth Theory for Rubber Networks: A Case Study
6. Effects of Crosslinking on Rubber Modulus and Mechanical Properties
7. Investigating the Effect of Entanglements on Rubber Modulus: Moore and Watson's Experiments
8. Statistical Treatment of Rubber Swelling: Experimental Validation
9. Crosslinking and Vulcanization: Impact on Rubber's Mechanical Properties

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