Enrollment No./Seat No.:

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering - SEMESTER - III EXAMINATION - SUMMER 2025

Subject Code: 3132606 **Date: 13-06-2025**

Subject Name: Numerical methods & Viscoelastic models of Elastomers

Time: 02:30 PM TO 05:00 PM **Total Marks: 70**

Instructions

1. Attempt all questions.

2. Make suitable assumptions wherever necessary.

3. Figures to the right indicate full marks.

			Marks
Q.1	**(a)**	A wire 4 m long and 4 mm in diameter, when stretched by weight of 10 kg has its length increased by 0.24 mm. Find the stress, strain and Young's modulus of the material of the wire. $g = 9.8\ m/s^2$	**03**
	(b)	A mass of 2 kg is hung from a steel wire of radius 0.6 mm and length 3m. Compute the extension produced. What should be the minimum radius of wire so that elastic limit is not exceeded? Elastic limit for steel is $2.4 \times 10^8\ N/m^2$, Y for steel = $Y = 20 \times 10^{10}\ N/m^2$	**04**
	(c)	Evaluate the relationship between Bulk modulus (K), Young's modulus (E), and Poisson's ratio (ν). Derive the interrelations and discuss their physical significance.	**07**
Q.2	**(a)**	State Hooke's Law and explain its significance in material deformation.	**03**
	(b)	Differentiate between elastic and plastic deformation with suitable examples.	**04**
	(c)	Derive the expression for the elastic free energy of an ideal rubber network based on entropy considerations.	**07**
		OR	
	(c)	Discuss the thermodynamic principles underlying the elasticity of rubber and how they differ from those of metals.	**07**
Q.3	**(a)**	Describe the molecular structure of an ideal rubber.	**03**
	(b)	Explain how molecular weight affects the viscosity of polymer solutions.	**04**
	(c)	Derive the relationship between intrinsic viscosity and molecular weight for a polymer solution, and discuss the assumptions involved.	**07**
		OR	
	(a)	What is the role of cross-linking in the elasticity of rubber?	**03**
	(b)	Compare and contrast the behaviors of monodisperse and polydisperse polymer systems in terms of viscosity.	**04**
	(c)	Analyze how polydispersity influences the rheological properties of polymer melts, incorporating theoretical models.	**07**
Q.4	**(a)**	Define Newton's law of viscosity and explain its relevance to Newtonian fluids.	**03**

	(b)	Compare and contrast the Maxwell and Voigt models in terms of their mechanical analogs and stress-strain behavior.	**04**
	(c)	Evaluate the limitations of the Maxwell and Voigt models and explain how the four-parameter model addresses these limitations.	**07**
		OR	
	(a)	Differentiate between Newtonian and non-Newtonian fluids with suitable examples.	**03**
	(b)	Analyze the application of the superposition principle in predicting the response of viscoelastic materials to complex loading histories.	**04**
	(c)	Derive the constitutive equations for the Maxwell and Voigt models and discuss their applicability in modeling real-world viscoelastic materials.	**07**
Q.5	**(a)**	What is the Deborah number, and how does it relate to material behavior under deformation?	**03**
	(b)	Discuss how the presence of side groups in polymer chains influences the glass transition temperature.	**04**
	(c)	Evaluate the factors that influence the glass transition temperature in polymers, including molecular structure, intermolecular forces, and processing conditions.	**07**
		OR	
	(a)	Explain the concept of relaxation time in viscoelastic materials.	**03**
	(b)	Analyze the impact of polymer chain flexibility on the glass transition temperature.	**04**
	(c)	Discuss the significance of Tg in determining the mechanical properties of polymers and their suitability for various applications.	**07**

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