Seat No./Enrollment No.: _____

GUJARAT TECHNOLOGICAL UNIVERSITY
BACHELOR OF ENGINEERING – SEMESTER 3 – EXAMINATION – SUMMER 2026

Subject Code: 3132606 **Date: 03/07/2026**

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.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	List the three moduli of elasticity and write the formula for each.	**03**
	(b)	A steel rod of 20 mm diameter and 1 m length is subjected to an axial pull of 30 kN. Calculate the stress, strain and elongation if E = 200 GPa.	**04**
	(c)	Derive the generalized Hooke's law for an isotropic, homogeneous, linearly elastic solid using the principle of superposition.	**07**
Q.2	**(a)**	Define an 'ideal rubber'. List any two assumptions of the ideal rubber model.	**03**
	(b)	Describe the molecular structure of an ideal rubber with a neat diagram.	**04**
	(c)	Compare the kinetic theory of rubber elasticity with the classical theory of elasticity of metals. Highlight the role of entropy, internal energy and temperature.	**07**
		OR	
Q.2	**(c)**	Discuss the elasticity of a polymer network in detail. Explain the role of cross-link density on the modulus of rubber.	**07**
Q.3	**(a)**	Define intrinsic viscosity and specific viscosity.	**03**
	(b)	Explain the experimental procedure for determining the intrinsic viscosity of a polymer solution using an Ostwald viscometer.	**04**
	(c)	Describe in detail the experimental procedure for the determination of molecular weight of a polymer by viscosity measurement. Discuss the sources of error.	**07**
		OR	
Q.3	**(a)**	Define viscosity. State its SI and CGS units.	**03**
	(b)	A polymer solution of concentration 0.5 g/dL takes 240 s to flow through a viscometer while the pure solvent takes 100 s. Determine the relative, specific and reduced viscosity.	**04**
	(c)	Summarize the various factors that influence the viscosity of polymer melts and solutions. Discuss the role of temperature, molecular weight and concentration.	**07**
Q.4	**(a)**	Define viscoelasticity. Give one example of a viscoelastic material.	**03**
	(b)	Describe the glassy state of polymers. How does it differ from the crystalline state?	**04**
	(c)	Discuss the molecular mechanism of glass transition in amorphous polymers. Explain how segmental motion changes with temperature.	**07**
		OR	
Q.4	**(a)**	List any three factors affecting the glass transition temperature.	**03**
	(b)	Explain the free volume theory of glass transition.	**04**
	(c)	Compare and contrast viscous flow, elastic deformation and viscoelastic deformation of polymers with neat stress vs time and strain vs time curves.	**07**
Q.5	**(a)**	Draw the spring-dashpot representation of the Voigt (Kelvin) element.	**03**

(b) A Maxwell model has spring constant E = 2 GPa and dashpot viscosity $\eta = 10^{10}$ Pa·s. Calculate the relaxation time and the stress remaining after 5 s if the initial strain is 0.01. **04**

(c) State and explain Boltzmann's superposition principle. Apply it to derive the strain response of a linear viscoelastic material subjected to a step-stress history. **07**

OR

Q.5 **(a)** Define the Deborah number. State its physical significance. **03**

(b) Derive the governing differential equation of the Voigt element and obtain its creep response. **04**

(c) Develop the four-parameter (Burger's) model. Derive the creep response and identify the contributions of instantaneous, delayed and viscous components. **07**

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