

2125  
B.E. (Mechanical Engineering)  
Third Semester  
MEC-302: Mechanics of Materials

Time allowed: 3 Hours

Max. Marks: 50

**NOTE:** Attempt five questions in all, including Question No. 1 which is compulsory and selecting two questions from each Part. Assume suitably the missing data, if any. Use usual notations and symbols for derivations. All questions carry 10 marks.

x-x-x

**Q.1** Provide brief and clear answers to the following:

- Explain the failure of a piece of classroom chalk when twisted.
- Explain why raising the strength property (i.e. yield stress) does not raise the critical load of a slender column.
- What is the Bulk Modulus?
- What failure theory would you use for a brittle material? For plane stress show failure envelope on a  $\sigma_1$  vs.  $\sigma_2$  plot.
- Explain what is the stress developed when temperature is raised by  $\Delta T$  in an unconstrained bar of length  $L$ , cross-sectional area  $A$ , elastic modulus  $E$ , and a coefficient of thermal expansion  $\alpha$ .

Part A

**Q.2** Develop the relationship between the modulus of Elasticity  $E$  and the Poisson's ratio  $\nu$ , and modulus of rigidity  $G$ . Give explanation and justification for all steps. List necessary assumptions.

**Q.3** A nonprismatic bar ABC made up of segments AB (length  $L_1$ , cross-sectional area  $A_1$ ) and BC (length  $L_2$ , cross-sectional area  $A_2$ ) is fixed at end A and free at end C (see Figure 1). The modulus of elasticity of the bar is  $E$ . A small gap of dimension  $s$  exists between the end of the bar and an elastic spring of length  $L_3$  and spring constant  $k_3$ . If bar ABC only (not the spring) is subjected to temperature increase  $\Delta T$ , determine the following: (a) Write an expression for reaction forces  $R_A$  and  $R_D$  if the elongation of ABC exceeds gap length  $s$ . (b) Find expressions for the displacements of points B and C if the elongation of ABC exceeds gap length  $s$ .

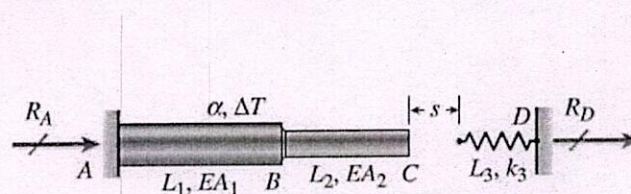


Figure 1

**Q.4** Derive a formula for the strain energy  $U$  of a cantilever bar (see Figure 2). The bar has circular cross sections and length  $L$ . It is subjected to a distributed torque of intensity  $t$  per unit distance. The intensity varies linearly from  $t=0$  at the free end to a maximum value  $t = t_0$  at the support.

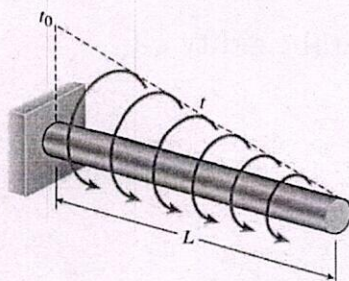


Figure 2

(2)

## Part B

**Q.5** A cantilever aluminum column (see Figure 3) has a square tube cross section with an outer dimension of 150 mm. The column has a length  $L=4$  m and is designed to support an axial load of 45 kN. Find the minimum required thickness of the section if the factor of safety  $n=2.5$  with respect to buckling. Assume that the modulus of elasticity is 72 GPa and the proportional limit is 480 MPa.

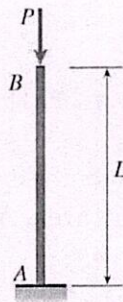


Figure 3

**Q.6** The rotor shaft of a helicopter drives the rotor blades that provide the lifting force and is subjected to a combination of torsion and axial loading (see Figure 4). It is known that normal stress  $\sigma_y = 68$  MPa and shear stress  $\tau_{xy} = -100$  MPa. Using Mohr's circle, determine the following: (a) The stresses acting on an element oriented at a counterclockwise angle  $\theta = 22.5^\circ$  from the  $x$  axis. (b) Find the maximum tensile stress, maximum compressive stress, and maximum shear stress in the shaft. Show all results on sketches of properly oriented elements.

**Q.7** Determine the equation of the deflection curve for a cantilever beam AB supporting a triangularly distributed load  $q$  of maximum intensity  $q_0$  at the fixed end A and zero at the free end B. Also, determine the deflection  $\Delta_B$  and angle of rotation  $\theta_B$  at the free end. Use the fourth-order differential equation of the deflection curve (the load equation). Note: The beam has length  $L$  and constant flexural rigidity  $EI$ .



Figure 4

beam has length  $L$  and constant flexural rigidity  $EI$ .