



B.E DEGREE EXAMINATIONS: NOV/DEC 2024

(Regulation 2018)

Third Semester

MECHATRONICS ENGINEERING

U18MCT3103: Mechanics of Solids

COURSE OUTCOMES

- CO1:** Recognize the elastic response of the materials and calculate the stresses and deflection in simple and compound bars
- CO2:** Calculate the thermal stresses and the material response due to temperature variations
- CO3:** Find the stresses in bi-axial load system and strain energy for different loads
- CO4:** Develop the shear force, bending moment diagram and locate maximum values of shear force and bending moments induced in various types of beams.
- CO5:** Estimate the slope and deflection of beams under various loading conditions and crippling load for a column with different end conditions.

Time: Three Hours

Maximum Marks: 100

Answer all the Questions:-

PART A (10 x 2 = 20 Marks)

(Answer not more than 40 words)

- | | | |
|--|-----|-------------------|
| 1. Define the term 'elastic limit' and state its significance. | CO1 | [K ₁] |
| 2. Write the relation between elastic constants. | CO1 | [K ₁] |
| 3. Explain the concept of thermal stress. | CO2 | [K ₂] |
| 4. What is creep, and how does it affect material performance? | CO2 | [K ₁] |
| 5. Define principal stress. | CO3 | [K ₁] |
| 6. Explain Mohr's circle and its significance in stress analysis. | CO3 | [K ₂] |
| 7. Compare Hoop stress and longitudinal stress. | CO6 | [K ₂] |
| 8. Differentiate between simply supported and cantilever beams. | CO4 | [K ₂] |
| 9. Describe the importance of slope and deflection in beam analysis. | CO6 | [K ₁] |
| 10. How does the torsion equation apply to circular shafts? | CO6 | [K ₂] |

Answer any FIVE Questions:-

PART B (5 x 16 = 80 Marks)

(Answer not more than 400 words)

11. **Scenario:** You are working as a mechanical engineer for a construction company, and you need to design a circular steel rod to support a 200 kN of compressive load applied axially. The rod will operate in an environment where the temperature fluctuates between -10°C and 50°C, and it must account for thermal expansion. Take length of the rod as 2m.
- a) Calculate the diameter of the steel rod required if the allowable stress is 120 MPa. Also find the deflection due to the applied load and temperature change.
- | | | |
|---|-----|-------------------|
| 7 | CO1 | [K ₃] |
|---|-----|-------------------|

- b) Determine the thermal stress that will be developed due to temperature changes. Assume the coefficient of thermal expansion is $12 \times 10^{-6} / ^\circ\text{C}$ and Young's modulus for steel is 200 GPa. What will be the increase in length of the rod if it is free to expand? 7 CO2 [K₃]
- c) Explain how the steel rod could be protected from excessive thermal stresses. 2 CO2 [K₂]
12. **Scenario:** A horizontal beam of 6 meters in length, subjected to a 20 kN point load at its midpoint, is fixed at both ends. You are required to analyze the beam's behavior for an industrial application.
- a) Draw the shear force and bending moment diagrams for the beam and determine the maximum bending moment. 7 CO4 [K₃]
- b) Calculate the maximum stress induced in the beam's cross-section if the beam has a rectangular section of 200 mm width and 300 mm depth. 7 CO4 [K₃]
- c) Provide suggestions for enhancing the beam's load-bearing capacity. 2 CO4 [K₂]
13. a) Derive the expression for the strain energy stored in a bar due to a suddenly applied load. 7 CO3 [K₂]
- b) Calculate the energy stored in a steel bar of 4 meters length and 25 mm diameter when subjected to a 10 kN load. Young's modulus for steel is 200 GPa. 7 CO3 [K₃]
- c) What are the limitations of using strain energy methods for stress analysis? 2 CO3 [K₁]
14. a) Explain the concept of flexural strength and how the shape of a beam affects the stress distribution during bending. 7 CO5 [K₂]
- b) A cantilever beam of 4 meters length is subjected to a uniform load of 15 kN/m. Calculate the slope and deflection at the free end using the double integration method. 7 CO5 [K₃]
- c) What are the assumptions made in the theory of simple bending? 2 CO4 [K₁]
15. a) Derive the expression for the buckling load of a column hinged at both ends, with different end conditions. 7 CO5 [K₂]
- b) Calculate the critical load for a steel column hinged at both ends, with a slenderness ratio of 120 and a radius of gyration of 50 mm. Use Euler's formula. Take Young's modulus=210GPa. 7 CO5 [K₃]
- c) Mention two factors that affect the buckling strength of a column. 2 CO5 [K₂]
16. a) Derive the torsion equation for a hollow circular shaft and explain its significance in design. 7 CO6 [K₂]
- b) A hollow shaft of 2 meters length, with an outer diameter of 100 mm and inner diameter of 80 mm, is subjected to a torque of 10 kNm. Determine the angle of twist per meter. Use $G = 80 \text{ GPa}$ for steel. 7 CO6 [K₃]
- c) List two advantages of using hollow shafts over solid shafts. 2 CO6 [K₁]
