Solutions to Mechanics of Materials Problems

Civil Engineering Licensure Exam - Day 42

March 4, 2025

Section A: Multiple Choice Questions (MCQs)

1. The modulus of rigidity (shear modulus) is given by:
Answer: (a) The ratio of shear stress to shear strain
Video Explanation: Shear Modulus, Shear Stress and Shear Strain

2. In a cantilever beam subjected to a point load at the free end, the maximum bending moment occurs at:
Answer: (a) The fixed support
Video Explanation: Cantilever Beam With Point Load At Free End

3. The shear force at the midpoint of a simply supported beam subjected to a uniform load is:
Answer: (a) Zero
Video Explanation: Simply Supported Beam Carrying Uniformly Distributed Load

4. The stress-strain curve of a ductile material consists of:
Answer: (a) Elastic and plastic regions
Video Explanation: Stress-Strain Curve — Elastic Plastic Region

5. The maximum normal stress in a beam subjected to pure bending occurs:
Answer: (a) At the extreme fibers of the section
Video Explanation: Flexure, Normal Stresses due to Bending

Section B: Problem-Solving

1. A circular rod with a diameter of 25 mm is subjected to an axial tensile force of 50 kN. Determine the normal stress in the rod.
Solution:

$$\sigma = \frac{F}{A}$$

$$A = \frac{\pi d^2}{4}$$

$$A = \frac{\pi(0.025)^2}{4} = 4.9087 \times 10^{-4}\,\text{m}^2$$

$$\sigma = \frac{50000}{4.9087 \times 10^{-4}} = 101.86\,\text{MPa}$$

Video Explanation: Normal Stresses in an Axial Rod

2. A simply supported beam with a span of 4 m carries a concentrated load of 30 kN at midspan. Determine the maximum bending moment.

Solution:

$$M_{\max} = \frac{P \times L}{4}$$

$$M_{\max} = \frac{30000 \times 4}{4} = 30\,\text{kN} \cdot \text{m}$$

Video Explanation: Proof of Maximum Bending Moment for a Simply Supported Beam

3. A cantilever beam of length 3 m carries a uniform load of 5 kN/m. Determine the maximum bending moment.

Solution:

$$M_{\max} = \frac{w \times L^2}{2}$$

$$M_{\max} = \frac{5000 \times (3)^2}{2} = 22.5\,\text{kN} \cdot \text{m}$$

Video Explanation: Cantilever Beam with Uniformly Distributed Load

4. A structural element is subjected to a normal stress of 80 MPa in the x-direction and 40 MPa in the y-direction, with a shear stress of 30 MPa. Determine the principal stresses using Mohr's Circle.

Solution:

$$\sigma_{\text{avg}} = \frac{\sigma_x + \sigma_y}{2} = \frac{80 + 40}{2} = 60\ \text{MPa}$$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$R = \sqrt{(20)^2 + (30)^2} = \sqrt{1300} \approx 36.06\ \text{MPa}$$

$$\sigma_1 = \sigma_{\text{avg}} + R = 60 + 36.06 = 96.06 \text{ MPa}$$

$$\sigma_2 = \sigma_{\text{avg}} - R = 60 - 36.06 = 23.94 \text{ MPa}$$

Video Explanation: Mohr's Circle: Principal Stresses in 2 Minutes!

5. A shaft is subjected to a torque of 2000 N·m. If its polar moment of inertia is 6×10^6 mm^4 and its outer radius is 50 mm, determine the maximum shear stress.

Solution:

$$\tau_{\max} = \frac{T \cdot r}{J}$$

$$\tau_{\max} = \frac{2000 \times 10^3 \times 50}{6 \times 10^6}$$

$$\tau_{\max} = \frac{100 \times 10^6}{6 \times 10^6} = 16.67 \text{ MPa}$$

Video Explanation: Shear Stress Due to Torsion, Polar Moment of Inertia