20 May, 2024
Time: 10.00 AM to 1.00 PM

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination — Summer Semester: A.Y. 2022-2023
Course No.: ME 4403 — Time: 3 hours
Course Title: Mechanics of Materials — Full Marks: 150

There are 6 (Six) Questions. Answer all of them.

Marks in the Margin indicate full marks. Programmable calculators are not allowed. Marks of each Question and the corresponding CO and PO are written in the brackets.

Assume reasonable values for any missing data(if any).

1. Two forces are applied to the pipe *AB* as shown in **Figure. 1** Knowing that the pipe has inner and outer diameters equal to 35 and 42 mm, respectively, determine the stresses at (a) point *a*, (b) point *b*. (25) CO2 PO2

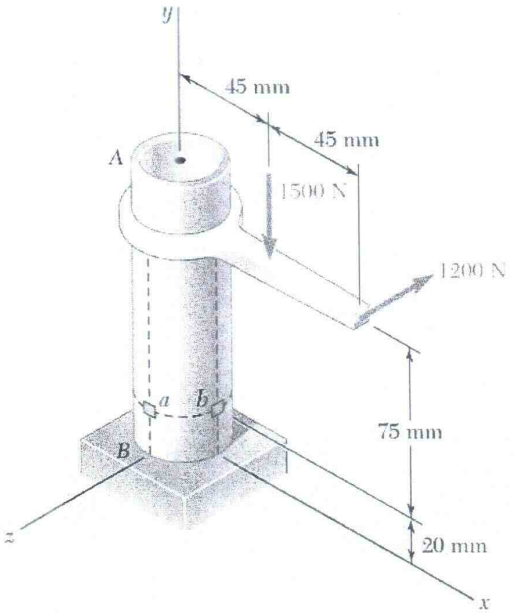


Figure. 1

2. Express the internal shear and moment in terms of *x* and then draw the shear and moment diagrams for the overhanging beam shown in **Figure. 2.** Consider roller support at C. (25) CO2 PO2

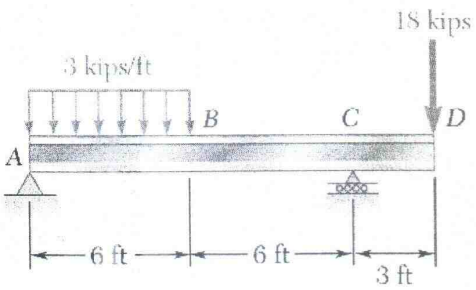


Figure. 2

3. a) A Beam has a square cross section and is subjected to a resultant internal bending moment of M = 300 N.m as shown in **Figure. 3** Determine the stresses at the top two corners. (13) CO2 PO2

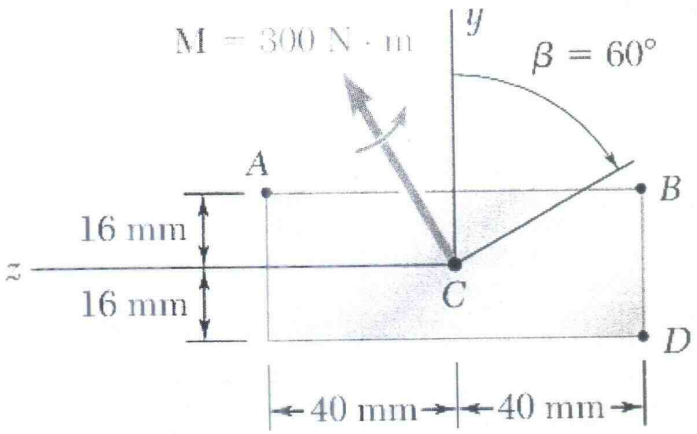


Figure. 3

b) Determine the maximum shear stress in the T-beam as shown in **Figure. 4** at the critical section where the internal shear force is maximum. (12) CO2 PO2

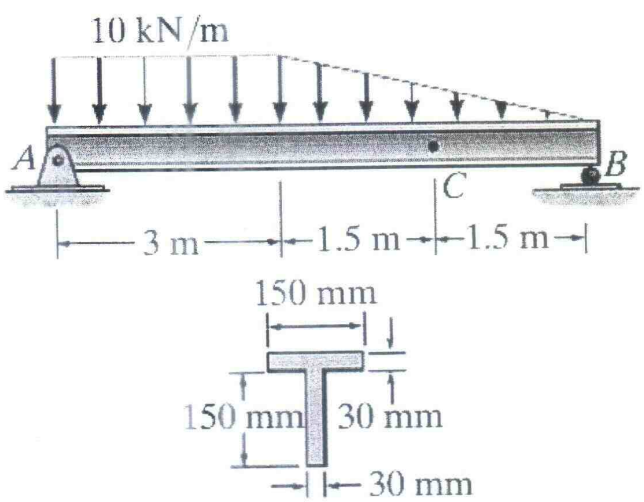
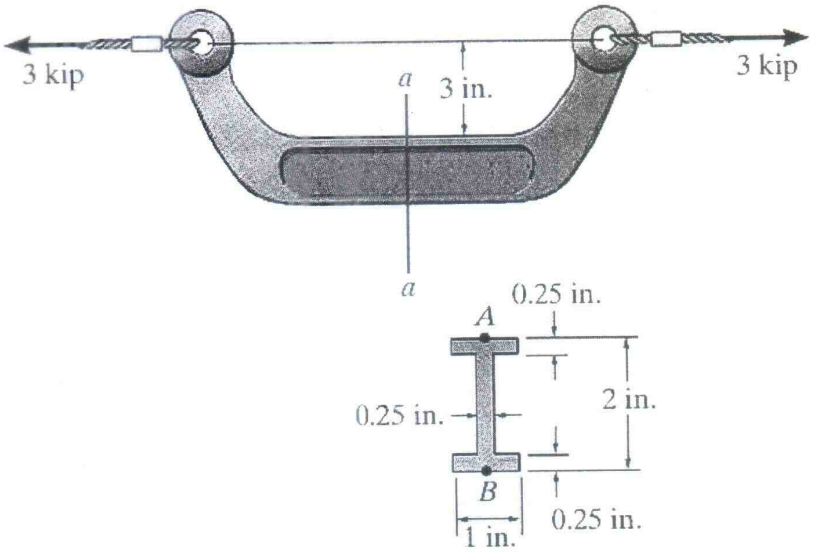


Figure. 4

4. The bracket is subjected to the force of 3 kip as shown in **Figure. 5**. Determine the principal stress and maximum in-plane shear stress at point B on the cross section at section a–a . Specify the orientation of this state of stress and show the results on elements. (25) CO2 PO2



Section $a - a$

Figure. 5

5. a) If the 1.5-in.-diameter shaft of **Figure. 6** is made from cast iron having tensile and compressive ultimate strengths of 50 ksi and 75 ksi, respectively, determine if the shaft fails in accordance with Mohr's failure criterion. (18) CO2 PO2

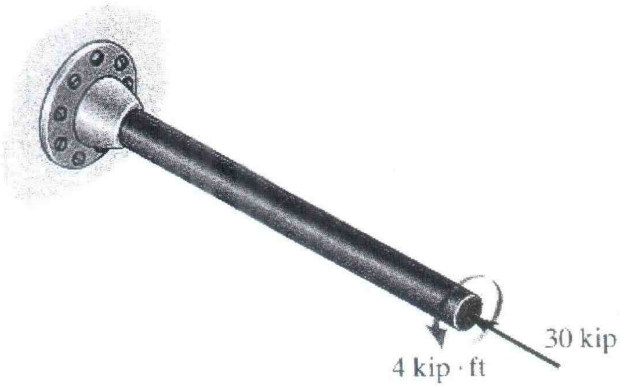


Figure. 6

b) The steel water pipe in **Figure 7** has an inner diameter of 14 in. and wall thickness 0.3 in. If the valve *A* is closed and the water pressure is 300 psi, determine the longitudinal and hoop stress developed in the wall of the pipe. (7) CO2 PO2

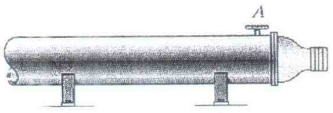


Figure 7

6. a) The pump in **Figure. 8** operates using the motor that has a power of 80 W. If the impeller at *B* is turning at 140 rev/min, determine the maximum shear stress developed in the 25-mm-diameter transmission shaft at *A*. (12) CO1 PO2

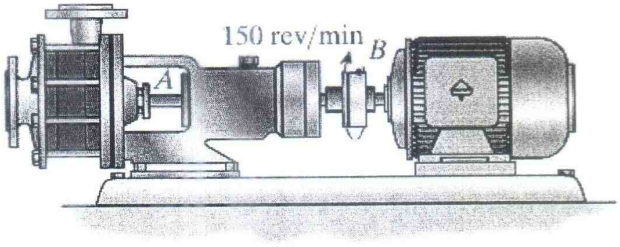


Figure 8

b) The 50-mm-diameter shaft in **Figure 9** is made of 6061-T6 aluminum. If the allowable shear stress is 85 MPa, and the angle of twist of disk *A* relative to disk *C* is limited so that it does not exceed 0.05 rad, determine the maximum allowable torque T . (13) CO1 PO2

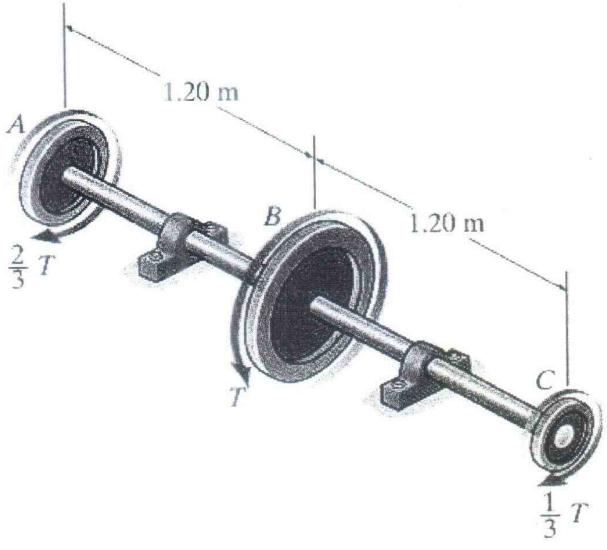


Figure 9

Some Formulas

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\tau_{x'y'} = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$\sigma_{y'} = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$$

$$\tan 2\theta_p = \frac{\tau_{xy}}{(\sigma_x - \sigma_y)/2}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tan 2\theta_s = \frac{-(\sigma_x - \sigma_y)/2}{\tau_{xy}}$$

$$\tau_{\substack{\max \\ \text{in-plane}}} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$