Ref. No. Ex/ChE/AM/ME/T/3/2019

B.E. Chemical Engineering First Year Second Semester Exam 2019 (Old)

Strength of Materials

Full Marks 100 Duration 3 hrs

Answer any five questions. Symbols have their usual meanings. Assume suitable values for any missing data

1. Answer the following questions- [10+10]
   a. The steel rod *ABC* is attached to rigid supports and is unstressed at a temperature of 25°C. The steel is assumed elastic with E =200 GPa. The temperature of both portions of the rod is then raised to 150°C. Knowing that $\alpha = 11.7 \times 10^{-6}$/°C, determine (a) the stress in both portions of the rod, (b) the deflection of point *C*.
   b. Link *BD* is made of brass (*E*=105 GPa) and has a cross-sectional area of 240 mm^2. Link *CE* is made of aluminum (*E*=72 GPa) and has a cross-sectional area of 300 mm^2. Knowing that they support rigid member *ABC*, determine the maximum force P that can be applied vertically at point *A* if the deflection of *A* is not to exceed 0.35 mm.
2. The aluminum rod *AB* (*G*=27 GPa) is bonded to the brass rod *BD* (*G*=39 GPa). Knowing that portion *CD* of the brass rod is hollow and has an inner diameter of 40 mm, determine the angle of twist at *A*. Also determine the radial stress distribution for each segment, i.e., *AB*, *BC*, *CD*. [20]

[Turn over

3. Answer the following questions- [10+10]

   a. What is pure bending? What is a section modulus? Determine the section modulus of a hollow circular beam cross section with $r_i = 8mm$ and $r_o = 10mm$.

   b. Knowing that the couple shown acts in a vertical plane, determine the stress at (i) point A, (ii) point B.

4. What is a point of contraflexure? Using free body diagrams and equations of equilibrium draw the shear force and bending moment diagrams for each segment and determine the location of the point of contraflexure if any. Determine the expressions for deflection and slope in each segment. Also determine the maximum deflection. [2+10+6+2]

5. The pressure tank shown has a 8-mm wall thickness and butt-welded seams forming an angle β=20° with a transverse plane. For a gage pressure of 600 kPa, determine (i) the normal stress perpendicular to the weld (ii) the shearing stress parallel to the weld. If the failure stress in each case is 100 MPa for the weld material, determine the factor of safety for each mode of failure. [18+2]

6. Answer the following questions- [8+4+8]

   a. Using equilibrium equations derive the expressions for the normal and shear stresses at an arbitrary plane as functions of the general planar stress components $\sigma_x, \sigma_y, \tau_{xy}$ and the cutting plane angle θ.

   b. Derive the expressions for the principal stresses and the maximum shear stress.

   c. Using Mohr circle determine the value of τ_{xy} for which the maximum shearing stress is (i) 60 MPa, (ii) 78 MPa.

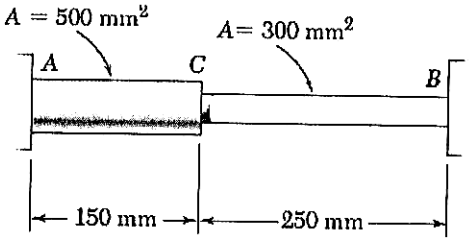

Fig. 1a

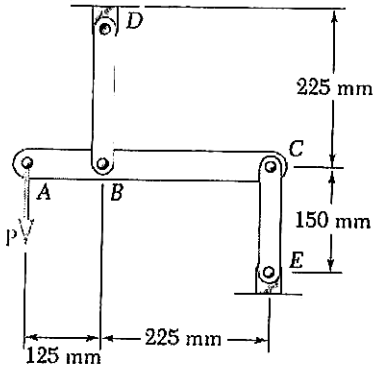

Fig. 1b

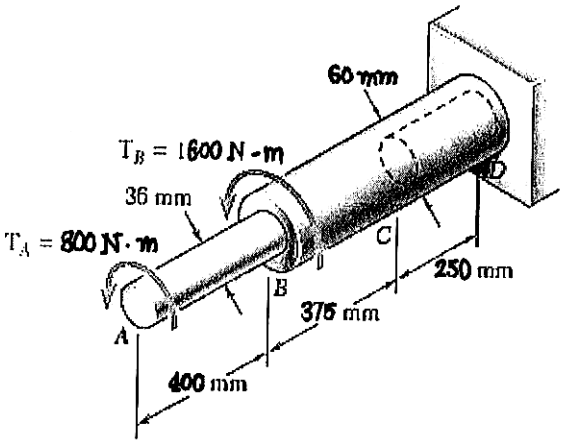

Fig. 2

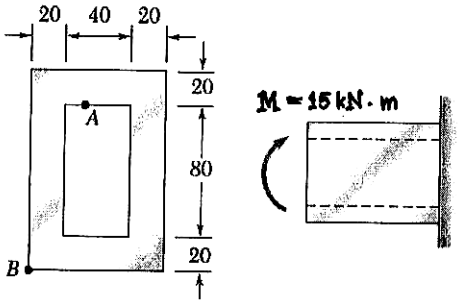

Fig. 3b

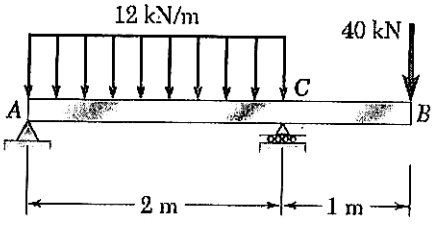

Fig. 4

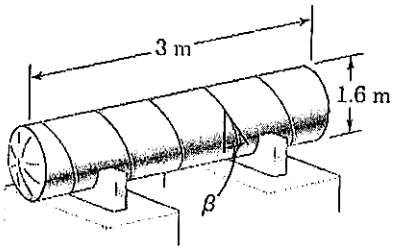

Fig. 5

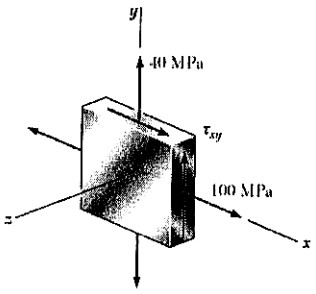

Fig. 6

7. Write short notes on the following showing mathematical derivations and/or schematic diagrams wherever applicable- [4+4+4+4+4=20]

   a. Hoop stress and longitudinal stress of a thin pressure vessel.

   b. Construction of Mohr circle for a general planar stress state and determination of principal stresses.

   c. Symmetry of the shear stresses, i.e., $\tau_{xy} = \tau_{yx}$.

   d. $E = 2G(1 + \nu)$.

   e. Failure theories: Maximum principal stress theory, Maximum shear stress theory.