

**Uva Wellassa University of Sri Lanka**  
**Faculty of Science and Technology**  
**Department of Science and Technology**  
**200 level 1<sup>st</sup> Semester Examination – June/July 2017**  
**SCT 241-2 Mechanics of Materials**



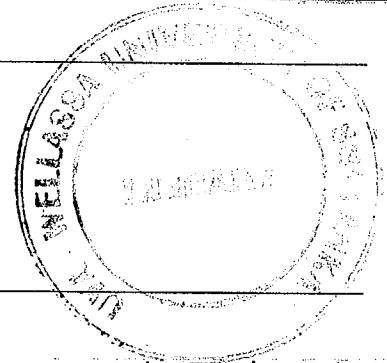
**Instructions to candidates**

**Duration:** Two (02) hours

**Number of questions:** Four (04)

**Mark allocation:** 100

**Answer all questions**



1. The horizontal beam ABCD shown in Figure 1(a) has a uniform cross-section as shown in Figure 1(b). It is simply supported at A and is continuous over the support at C.
  - a. Draw free body diagram of ABCD beam. (04 marks)
  - b. Calculate reactions of point A and C. (06 marks)
  - c. Obtain shear force (V) and momentum (M) variation equations for AB, BC and CD part of the beam. (08 marks)
  - d. Draw shear force and bending moment diagrams of the beam by showing all principal values. (08 marks)
  - e. Calculate second moment of area,  $I_{zz}$  for the beam section. (02 marks)
  - f. Mark position of neutral axis of cross section from the bottom surface. (01 marks)
  - g. Determine maximum and minimum bending moment of the beam by Referring part (d) bending moment diagram. (02 marks)
  - h. Calculate maximum value of normal stress in the beam due to bending moment. (04 marks)

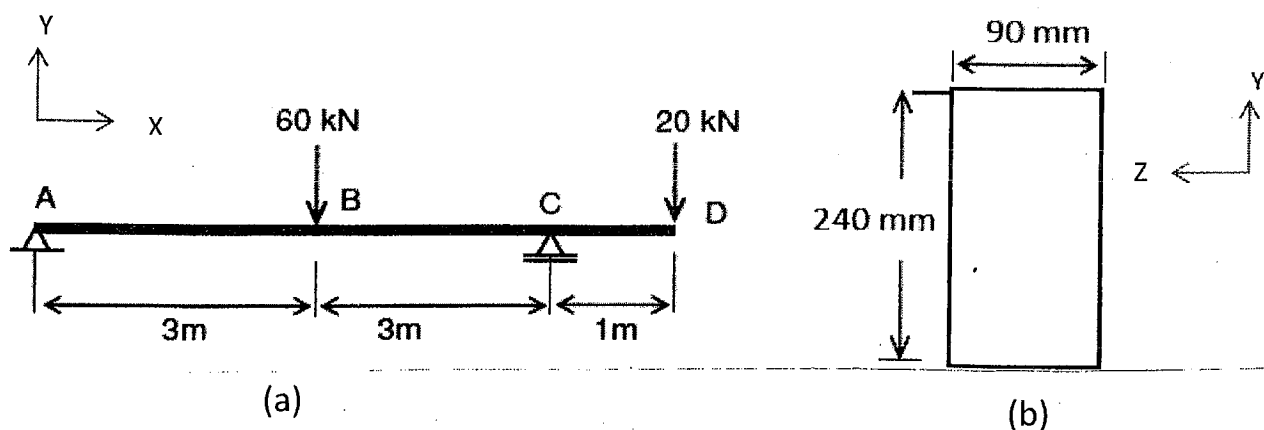


Figure 1

2. A hollow aluminum shaft is used in a roof structure and the inner diameter ( $d_1$ ) is 85 mm and outer diameter ( $d_2$ ) is 104 mm [see Figure 2(a)]. The shaft is 2.75 m long, and shear modulus ( $G$ ) of aluminum is 28 GPa.

a. Shaft is twisted in pure torsion by torques acting at the ends and maximum shear stress is 48 MPa. Calculate,

- I. Polar moment of inertia ( $J$ ) for the shaft. (03 marks)
- II. Applied torques on the shaft. (04 marks)
- III. Angle of twist of the shaft (in degrees). (05 marks)

b. A hollow aluminum shaft is replaced with aluminum solid shaft as shown in Figure 2(b). Applied torque and maximum stress are same with part (a).

- I. Calculate required diameter ( $d$ ) for a solid shaft. (07 marks)
- II. If weight of hollow shaft and solid shaft are  $W_H$  and  $W_S$  and density of aluminum is  $\rho_{Al}$ , Obtain formulas for  $W_H$  and  $W_S$ . (03 marks)
- III. Calculate weight ratio of the hollow shaft to the solid shaft. (03 marks)

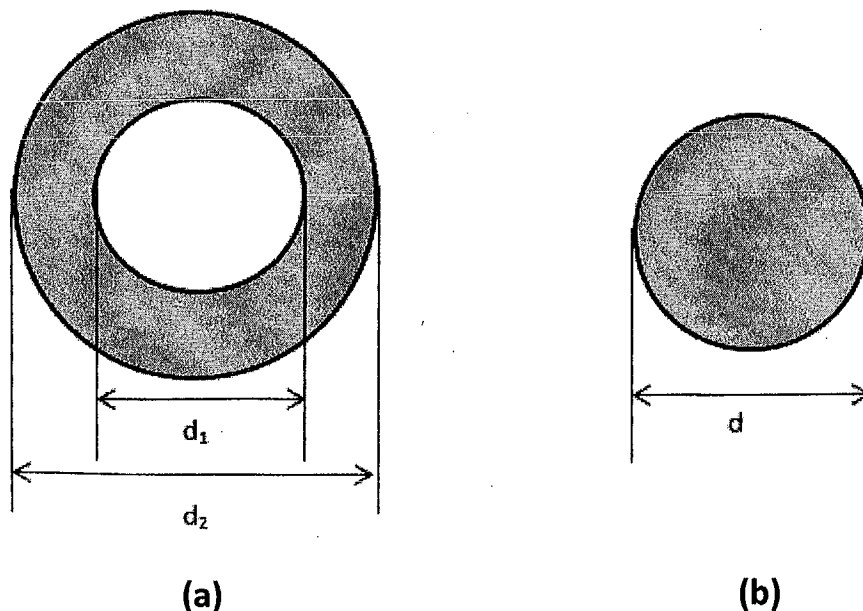


Figure 2

3. Two solid cylindrical rods are welded at B and loaded as shown in Figure 3. Rod AB is made of steel and rod BC is made of brass. Length of rods are,  $AB=25$  cm and  $BC=45$  cm. Diameter of AB and BC rods are  $d_{AB}=6$  mm,  $d_{BC}=9$  mm. Modulus of elasticity of steel and brass are  $E_{Steel}=200$  GPa,  $E_{Brass}=105$  GPa.  $P_1$  load is applied on top surface of the AB rod and  $P_2$  load is applied on top surface of the BC rod. Poisson ratio ( $\nu$ ) of the steel and brass are 0.29 and 0.33. Determine,
- Internal forces acting on rod AB and BC. (05 marks)
  - Normal stresses applied on AB and BC rods. (04 marks)
  - Axial elongation of AB and BC rods. (06 marks)
  - Total elongation of composite rod ABC. (02 marks)
  - Axial and lateral strains of rod AB and BC. (04 marks)
  - Final diameter of rod AB and BC. (04 marks)

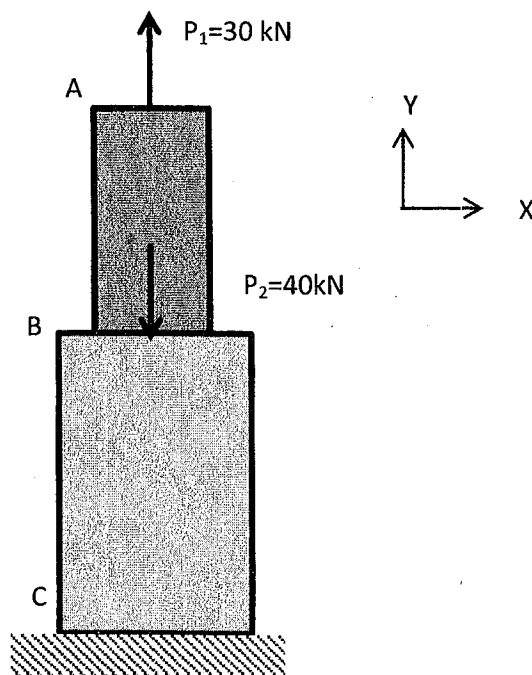
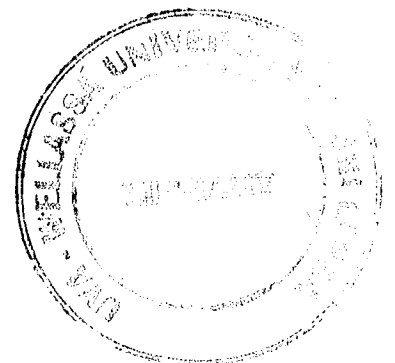


Figure 3



4. a. An element on surface of a pressurized cylinder, the material is subjected to stresses  $\sigma_x=84$  MPa,  $\sigma_y= -29$  MPa and  $\tau_{yx}= \tau_{xy}= 32$  MPa as shown on a stress element in Figure 4. Determine,

- I. Principal normal stress angle. (02 marks)
- II. Principle normal stress and sketch properly oriented element. (04 marks)
- III. Maximum shear stress angle. (02 marks)
- IV. Maximum shear stress and sketch properly oriented element. (02 marks)

b. Mohr's circle is drawn in Figure 5 for stresses acting on element A in machine shaft surface. Determine,

- I. Maximum and minimum normal stresses. (02 marks)
- II. Maximum and minimum shear stresses. (02 marks)
- III. Sketch a stress element for  $DD'$  plane and show all stresses acting on the element. (03 marks)

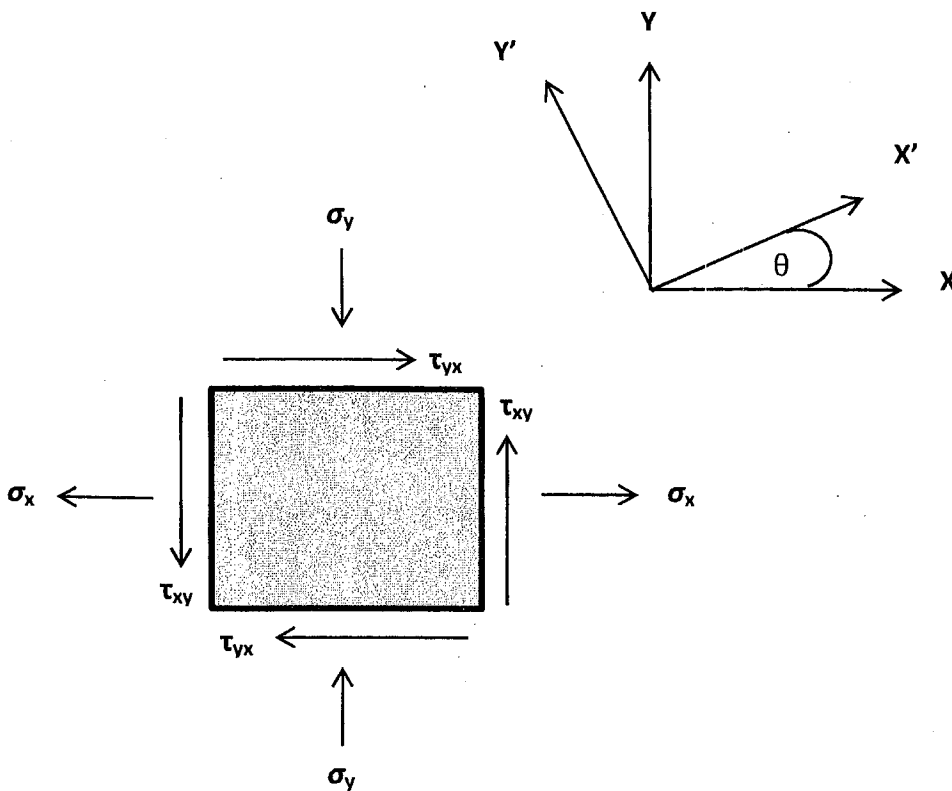


Figure 4: Element in plane stress

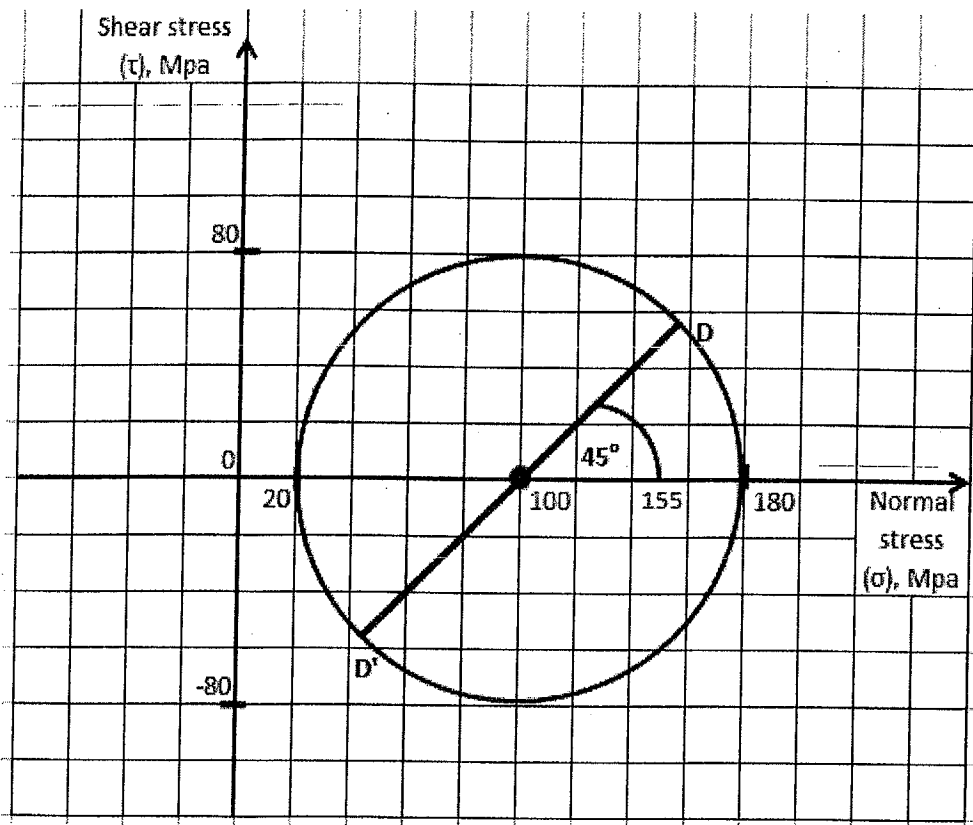
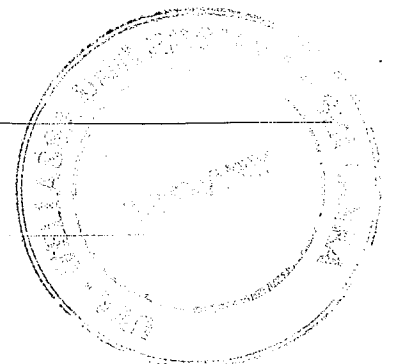


Figure 5: Mohr's circle



### Important Equation

1. Rectangular cross section of beam, width is  $b$  and height is  $h$ .  $I_{ZZ} = \frac{bh^3}{12}$
2.  $\sigma = -\frac{MY}{I}$
3. Solid shaft with radius  $a$ ,  $J = \frac{\pi}{2}a^4$
4. Hollow shaft with inner and outer radius are  $a$  and  $b$ ,  $J = \frac{\pi}{2}(b^4 - a^4)$
5.  $T = \frac{\tau_{\max} J}{C}$
6.  $\phi = \frac{TL}{JG}$
7. Poisson ratio ( $\nu$ ) =  $-\frac{\text{lateral strain } (\epsilon_x)}{\text{axial strain } (\epsilon_y)}$
8.  $\sigma_{x'} = \sigma_x \cos^2 \theta + \sigma_y \sin^2 \theta + 2\tau_{xy} \cos \theta \sin \theta$
9.  $\sigma_{y'} = \sigma_x \sin^2 \theta + \sigma_y \cos^2 \theta - 2\tau_{xy} \cos \theta \sin \theta$
10.  $\tau_{x'y'} = \tau_{xy} (\cos^2 \theta - \sin^2 \theta) - (\sigma_x - \sigma_y) \cos \theta \sin \theta$
11.  $\tan 2\theta_{p,normal} = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$
12.  $\tan 2\theta_{p,shear} = \frac{\sigma_x - \sigma_y}{2\tau_{xy}}$
13.  $\sigma_{Average} = \frac{\sigma_x + \sigma_y}{2}$
14.  $R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$