Indian Institute of Technology, Kharagpur

Mid-Autumn Semester Examination, 2012

Mechanical Engineering Department

Subject: Mechanics of Solids Subject No. : ME 31013

Full Marks : 30 Time : 2 Hrs

1. (a) Prove that the shear strain with respect to principal strain coordinate axes is zero.

   (b) Prove that the elastic constants of plane strain elastic problems are greater than those of plane stress elastic problems. (4+2)

2. (a) At a point of a solid body, the principal stresses (σ_1, σ_2 and σ_3) and the corresponding principal directions ($\mathbf{n}_1$, $\mathbf{n}_2$ and $\mathbf{n}_3$) i.e. the normals to the corresponding principal planes are given by

   $\sigma_1 = 4$ MPa, $\sigma_2 = 2$ MPa, $\sigma_3 = 1$ MPa, $\mathbf{n}_1 = \frac{1}{\sqrt{2}}(\mathbf{j}-\mathbf{k})$, $\mathbf{n}_2 = \frac{1}{\sqrt{2}}(\mathbf{j}+\mathbf{k})$ and $\mathbf{n}_3 = \mathbf{n}_1 \times \mathbf{n}_2$

   Determine the state of stress at the same point with respect to the coordinate axes ($\mathbf{x}$, $\mathbf{y}$ and $\mathbf{z}$) along which the unit vectors are $\mathbf{i}$, $\mathbf{j}$ and $\mathbf{k}$, respectively. (4)

   (b) The state of strain at a point with respect to $\mathbf{x}\,\mathbf{y}\,\mathbf{z}$ coordinate system in a deformed linear, homogenous and isotropic solid is given by

   $$\epsilon_x = 1\times10^{-6},\ \epsilon_y = 0,\ \epsilon_z = 3\times10^{-6},\ \gamma_{xy} = 0,\ \gamma_{xz} = 0,\ \gamma_{yz} = -4\times10^{-6}$$

   The Young's modulus and the Poisson's ratio of the solid are 200 **GPa** and 0.3, respectively. Compute the principal strains and the principal stresses at the point. (3+2)

3. A straight prismatic beam is loaded as shown in Fig. 1. The line of action of the load is vertical and passes through the centroid of the cross section of the beam. Find the neutral axis in the section **A-A** and compute the normal stress at the point **B** located as shown in Fig. 1. All dimensions in Fig. 1 are in mm. (2+3)

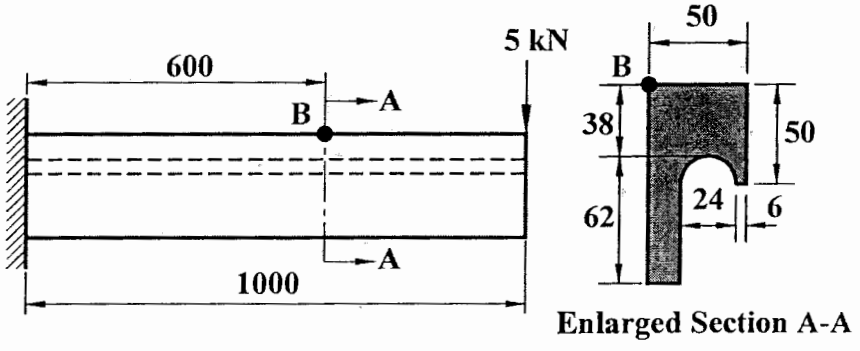

Fig. 1

4. Determine the location of the shear center for the cross section of a prismatic beam shown in Fig. 2. The thickness of all walls of the beam is 4 mm. All dimensions shown in Fig. 2 are in mm. (5)

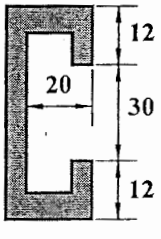

Fig. 2

5. For the beam, loaded as shown in Fig. 3, determine the maximum tensile stress in section **a-a**. Consider **P** = 10kN. All dimensions shown in Fig. 3 are in mm. (5)

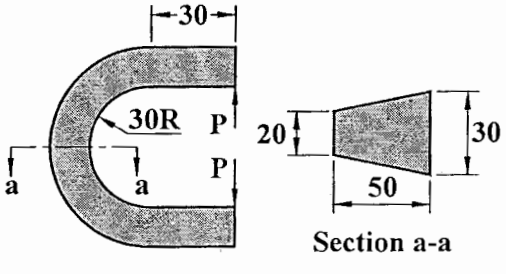

Fig. 3