Indian Institute of Technology, Kharagpur

Mid-Autumn Semester Examination, 2011

Mechanical Engineering Department

Subject: Mechanics of Solids Subject No. : ME 31013 / ME 21103

Full Marks : 40 Time : 2 Hrs

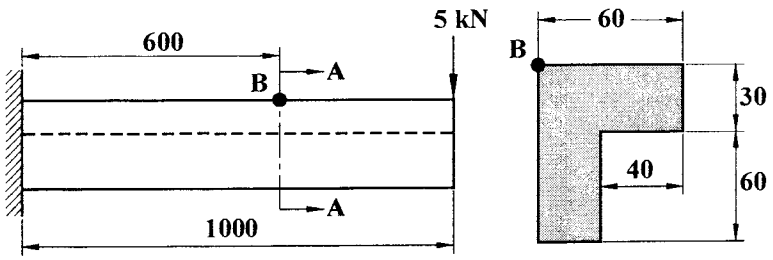
1. (a) What are called principal stresses and principal planes? Why principal stresses are important? How are the principal planes related? (1+1+1+1)
   (b) What are called octahedral stresses? Prove that the octahedral shear stress at a point of a solid is smaller than the maximum shear stress at the same point. (1+3)
   (c) State all 15 equations of theory of elasticity. (2)
   (d) How are plane stress problems and plane strain problems defined? Prove that the elastic constants of plane strain elastic problems are greater than those of plane stress elastic problems. (1+1+3)

2. 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

   $$\sigma_1 = 5 \text{ MPa}, \ \sigma_2 = 4 \text{ MPa}, \ \sigma_3 = 1 \text{ MPa}, \ \mathbf{n}_1 = \frac{1}{2}\mathbf{i} - \frac{\sqrt{3}}{2}\mathbf{j}, \ \mathbf{n}_2 = \mathbf{k}, \ \mathbf{n}_3 = \mathbf{n}_1 \times \mathbf{n}_2$$

   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. (5)

3. A straight prismatic beam is loaded as shown in Fig. 1. The line of action of the load passes through the centroid of the beam cross section. 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. (3+3)



Enlarged Section A-A

Fig. 1

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

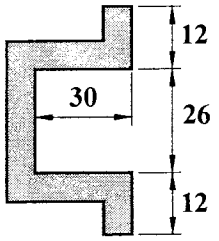
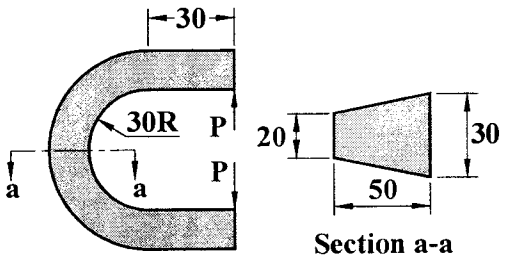


Fig. 2

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

   (b) For a circular curved beam of rectangular cross section subjected to a bending couple, derive the expression for the radial stress at the neutral surface. (4)



Section a-a

Fig. 3