# Indian Institute of Technology, Kharagpur

**End-Autumn Semester Examination, 2011**

Mechanical Engineering Department

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

Full Marks : 60 Time : 3 Hrs

1. The state of strain at a point of a homogeneous isotropic elastic solid body is given by
$\epsilon_x = 15\times10^{-6}$, $\epsilon_y = \epsilon_z = -4.5\times10^{-6}$, $\gamma_{xy} = \gamma_{xz} = 13\times10^{-6}$ and $\gamma_{yz} = 26\times10^{-6}$.
Compute the *von Mises* stress at the point. The Young's modulus and the Poisson's ratio of the solid are 200 **GPa** and 0.3, respectively. (10)

2. (a) Two thick-walled cylinders made of two different homogenous isotropic elastic solids are assembled without any interference. Initially, the inner and the outer radii of the inner cylinder are **a** and **b**, respectively whereas the outer radius of the outer cylinder is **c**. The inner cylinder is subjected to an internal pressure **p**. Derive the expression for the interface pressure at the interface between the two cylinders. (6)

(b) A steel disc of 80 cm diameter is shrunk on a steel shaft of 10cm diameter. The interference on the diameter at standstill position is 0.005cm. Determine the rotational speed of the assembled shaft and disc at which the contact pressure will be zero. Also, determine the maximum tangential stress in the disc at this rotational speed. Assume plane stress state of deformations. The Young's modulus and the Poisson's ratio of the steel are 200 **GPa** and 0.3, respectively. (10)

[Hints: The distributions of the radial and the tangential stresses in a thick walled cylinder under plane stress state of deformations are given by

$$\sigma_r = -\frac{3+\nu}{8}\rho\omega^2 r^2 + A + \frac{B}{r^2} \text{ and } \sigma_\theta = -\frac{1+3\nu}{8}\rho\omega^2 r^2 + A - \frac{B}{r^2}$$

where the symbols have the usual meaning and are self explanatory].

3. (a) Considering Fig. 1, determine the horizontal deflection of the prismatic curved beam **AB** at the point **A** along the line **OA**. The plane **AOB** is horizontal while the line of action of the applied force **F** is normal to the plane **AOB**. The beam is made of homogeneous isotropic elastic solid. (10)

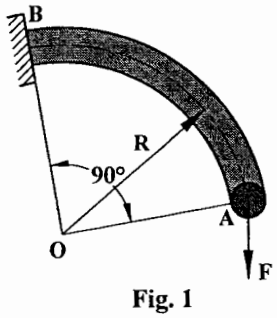

Fig. 1

(b) Determine the reactions at the supports of the thin prismatic homogeneous isotropic elastic beam as shown in Fig. 2. The intensity of the distributed load per unit length is **q**. (8)

4. Derive the Euler's formula for the critical buckling load of a fixed-free column. (6)

5. State the first order shear deformation theory for a beam. Using this theory and applying the virtual work principle derive the governing equilibrium equations and the boundary conditions of the prismatic homogeneous isotropic elastic beam shown in Fig. 2. (2+8)

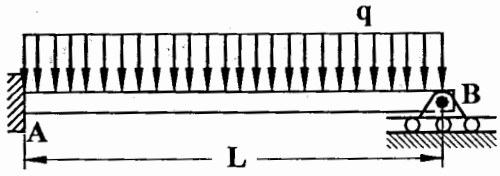

Fig. 2