Indian Institute of Technology, Kharagpur

End Semester Examination, 2012

Mechanical Engineering Department

Subject: Mechanics of Solids Subject No. : ME 31013

Full Marks : 50 Time : 3 Hrs

1. (a) Prove that the hydrostatic state of stress at a point in a solid is not responsible for the distortional energy of the solid.
   (b) The state of strain at a point of a homogeneous isotropic elastic solid body is given by
   $$\epsilon_x = 1\times10^{-6},\ \epsilon_y = 0,\ \epsilon_z = 3\times10^{-6},\ \gamma_{xy} = \gamma_{xz} = 0,\ \gamma_{yz} = -4\times10^{-6}$$
   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. (2+8)

2. (a) Derive the formula for the radial interface of the rotating assembled solid circular shaft and disc at any speed. (5)
   (b) Consider that a steel disc of 100 cm outer diameter is shrunk on a steel solid shaft of 20cm 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 at the interface between the shaft and the disc will be zero. The Young's modulus and the Poisson's ratio of the steel are 200 **GPa** and 0.3, respectively. Assume the density of steel as 8000 kg/m^3. (5)

   [Hints: Assume plane stress state of deformations. 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) A prismatic beam **ABC** is fixed at its end **C** such that the beam lies on the horizontal plane **OABC** as shown in Fig. 1. The portion **BC** of the beam is straight while the curved portion **AB** of the beam is circular. The cross-section of the beam is circular. The beam is subjected to a torque **T** at its end **A**. The line of action of the Torque vector is normal to the transverse cross-section at **A**. Determine the vertical deflection of the beam at the point **A**. The beam is made of homogeneous isotropic elastic solid. (10)

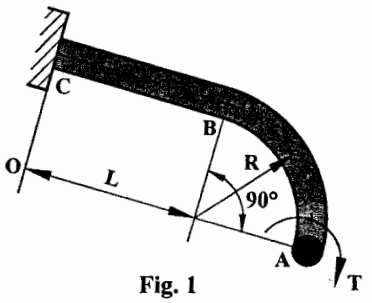

Fig. 1

4. Derive the Euler's formula for the critical buckling load of a fixed-free column. (10)

5. Using the classical beam theory and applying the virtual work principle, derive the governing equilibrium equations and boundary conditions of the prismatic homogeneous isotropic elastic cantilever beam subjected to a concentrated load as shown in Fig. 2. (10)

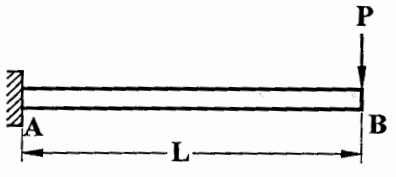

Fig. 2