Indian Institute of Technology, Kharagpur

End Semester Examination, 2015

Mechanical Engineering Department

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

Full Marks : 50 Time : 3 Hrs

Adopt appropriate assumption or data if it is necessary.

1. The state of strain at a point of a homogeneous isotropic elastic solid body is given by

$$\epsilon_x = 1\times 10^{-6},\ \epsilon_y = 0,\ \epsilon_z = 3\times 10^{-6},\ \gamma_{xy} = \gamma_{xz} = 0,\ \gamma_{yz} = -4\times 10^{-6}$$

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. (6)

2. (a) Show that in case of bending of curved beam, the neutral axis is not a centroidal axis.

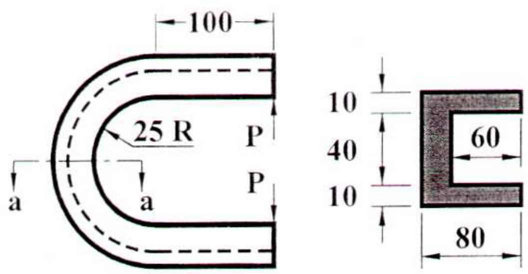

Fig. 1 Section a-a

(b) For the curved beam shown in Fig. 1, determine the maximum tensile stress in section **a-a**. Consider **P** = 30kN. In Fig. 1 all dimensions are in mm. (3+5)

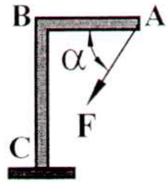

Fig. 2

3. A disc of inner radius **a** and outer radius **b** is fitted on a solid shaft of radius $\mathbf{r_0}$ ($\mathbf{r_0} > \mathbf{a}$). If the assembly of the shaft and the disc rotates, prove that the radial interference at the interface between the shaft and the disc at any rotating speed **ω** is given by

$$\delta = \frac{\rho(1-\upsilon)\omega^2}{4E}(r_0^3 - a^3) - \frac{3+\upsilon}{4E}\rho\omega^2 ab^2 + r_0 - a. \qquad (6)$$

4. (a) A prismatic homogeneous isotropic angle beam **ABC** is shown in Fig. 2. The length of the segment **BC** is **L** and that of the segment **AB** is 2**L**/3. Find the angle α such that the displacement at **A** is along the line of action of the force **F**.

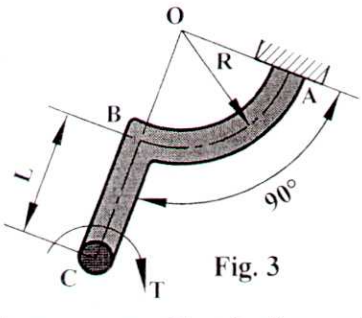

Fig. 3

(b) The prismatic homogeneous isotropic elastic beam **ABC** is fixed at its end **A** such that the plane **OABC** of the beam is horizontal as shown in Fig. 3. 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 free end **C**. The line of action of the torque is normal to the transverse cross-section at **C**. Determine the vertical deflection of the beam at the point **C.** (5+5)

5. Determine the critical load for the buckling of the column as shown in Fig. 4 using virtual work principle. (10)

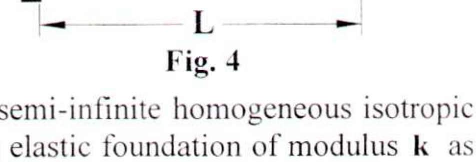

Fig. 4

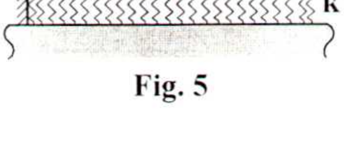

Fig. 5

6. Derive the solution for the deflection of the semi-infinite homogeneous isotropic elastic beam rested on an elastic foundation of modulus **k** as shown in Fig. 5. The beam is loaded with a uniformly distributed load **q** per unit length. Also find the location of the maximum bending moment and its magnitude. (10)