INDIAN INSTITUTE OF TECHNOLOGY

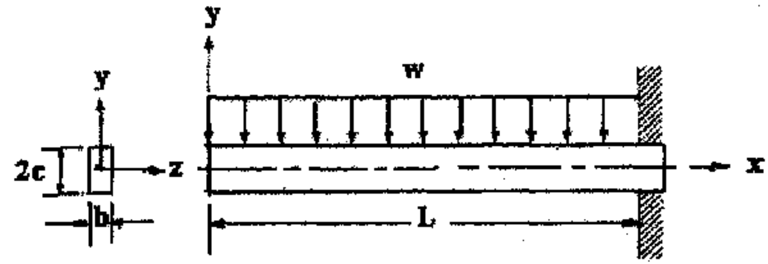
Date .... FN / AN Time : 3 Hrs. Full Marks 60 ...... No. of Students 173

Autumn / ~~Spring~~ Semester, 2010 Deptt. Mechanical Engineering Sub. No. ME31013

3rd Yr. B.Tech. (H) / B.Arch. (H) / M.Sc. Sub. Name Mechanics of Solids

Instruction: **Answer any six questions. All questions carry equal marks**

1. **(a)** For the beam shown in the figure below, if the weight is neglected, the bending moment as a function of x is $M_x = 0.5wx^2$ and from basic principles the bending stress is given by $\sigma_x = M_z y/I_z$. Find shear stress τ_{xy} as a function of x and y.



(b) The stress field in a body is as follows:

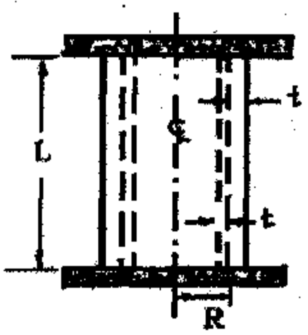
$\sigma_x = 80x^3 + y$ $\tau_{xy} = 100(1+y^2)$

$\sigma_y = 100(x^3 + 10)$ $\tau_{yz} = 0$

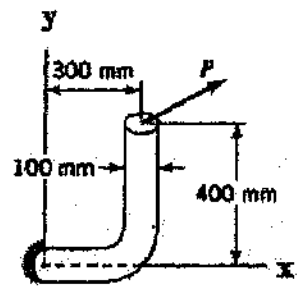
$\sigma_z = 10(9y^2 + 10z^3)$ $\tau_{zx} = x(z^3 + 100xy)$

Satisfying the equations of equilibrium find the body forces in arbitrary units at the point (1, 1, 5).

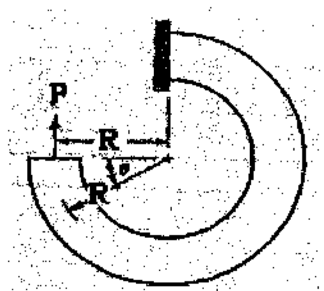
2. Consider a composite cylinder of length L formed from an inner thin cylinder of aluminum with outer radius R and an outer thin cylinder of steel with inner radius R, thickness t of both the cylinders being the same. The composite cylinder is supported snugly in an upright, unstressed state between rigid supports. An inner pressure *p* is applied to the cylinder and the entire assembly is subjected to a uniform temperature change ΔT. Determine the longitudinal (σ_l) and circumferencial (σ_θ) stresses in both the cylinders if the cylinder thickness t=0.02*R*. For aluminium E= 69 GPa, ν= 0.333 and $\alpha = 21.6 \times 10^{-6}$ /°C and for steel E = 207 GPa, ν = 0.280 and $\alpha = 10.8 \times 10^{-6}$/°C. Since both the aluminium and steel cylinders are thin you may assume that the circumferencial stresses σ_θ for both the cylinders are constant through the thickness.



3. The 100-mm diameter bent bar shown in figure below is made of a ductile steel that has a yield stress $\sigma_Y = 420$ MPa. The free end of the bar is subjected to a load P in x-y plane making equal angles with x and y axes. Using the octahedral shear-stress criterion of failure, determine the magnitude of P that will initiate yielding.



4. The curved beam in the figure below has a 30-mm square cross section and radius of curvature R = 65mm. The beam is made of a steel for which E = 200 GPa and v = 0.29. If P = 6 kN determine the deflection of the free end of the curved beam in the direction of P using energy method and taking into consideration shear, bending and axial load.



5. Find the maximum permissible speed of rotation for a steel disc of outer and inner radii of 150mm and 70mm respectively if the outer radius is not to increase in magnitude due to centrifugal force by more than 0.03 mm. For steel take density $\rho = 7470\ Kg/m^3$, Poisson's ratio $\nu = 0.3$, E = 207 GPa.

6. A steel tube is shrunk on to another steel tube to form a compound cylinder of 60mm internal diameter and 180mm external diameter. The initial radial compressive stress at the 120mm common diameter is 30 MPa. Calculate the shrinkage allowance taking E=200 GPa and $\nu = 0.3$

7. Show that the maximum bending moment acting on the laterally loaded column of length L and both ends hinged, as shown below, is

$$M_{max} = \frac{W}{2n} \tan \frac{nL}{2}$$

where $n = \sqrt{P/E}$ E being the elastic modulus of the column material