Mechanical Properties Of Solids

Very Short Answer Type Questions

1. The Young's modulus for steel is much more than that for rubber.
   For the same longitudinal strain, which one will have greater tensile stress?
2. Is stress a vector quantity?
3. Identical springs of steel and copper are equally stretched. On which, more work will have to be done?
4. What is the Young's modulus for a perfect rigid body?
5. What is the Bulk modulus for a perfect rigid body?

Short Answer Type Questions

1. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force f, its length increases by l. Another wire of the same material of length 2L and radius 2r, is pulled by a force 2f. Find the increase in length of this wire.
2. A steel rod ($Y = 2.0 \times 10^{11}$ Nm^{-2}; and $\alpha = 10^{-50}$ C^{-1}) of length 1 m and area of cross-section 1 cm^2 is heated from 0°C to 200°C, without being allowed to extend or bend. What is the tension produced in the rod?
3. To what depth must a rubber ball be taken in deep sea so that its volume is decreased by 0.1%. (The bulk modulus of rubber is 9.8×10^8 N m^{-2}; and the density of sea water is 10^3 kg m^{-3})
4. A truck is pulling a car out of a ditch by means of a steel cable that is 9.1 m long and has a radius of 5 mm. When the car just begins to move, the tension in the cable is 800 N. How much has the cable stretched? (Young's modulus for steel is 2×10^{11} Nm^{-2})
5. Two identical solid balls, one of ivory and the other of wet-clay, are dropped from the same height on the floor. Which one will rise to a greater height after striking the floor and why?

Long Answer Type Questions

1. Consider a long steel bar under a tensile stress due to forces F acting at the edges along the length of the bar (Fig. 9.5). Consider a plane making an angle θ with the length. What are the tensile and shearing stresses on this plane?

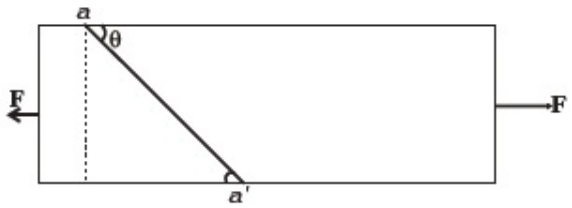

Fig. 9.5

   - (a) For what angle is the tensile stress a maximum?
   - (b) For what angle is the shearing stress a maximum?

2. (a) A steel wire of mass μ per unit length with a circular cross section has a radius of 0.1 cm. The wire is of length 10 m when measured lying horizontal, and hangs from a hook on the wall. A mass of 25 kg is hung from the free end of the wire. Assuming the wire to be uniform and lateral strains << longitudinal strains, find the extension in the length of the wire. The density of steel is 7860 kg m^{-3} (Young's modules $Y=2 \times 10^{11}$ Nm^{-2}).
   (b) If the yield strength of steel is 2.5×10^{8} Nm^{-2}, what is the maximum weight that can be hung at the lower end of the wire?
3. A steel rod of length 2l, cross sectional area A and mass M is set rotating in a horizontal plane about an axis passing through the centre. If Y is the Young's modulus for steel, find the extension in the length of the rod. (Assume the rod is uniform.)
4. An equilateral triangle ABC is formed by two Cu rods AB and BC and one Al rod. It is heated in such a way that temperature of each rod increases by ΔT. Find change in the angle ABC. [Coeff. of linear expansion for Cu is α_1, Coeff. of linear expansion for Al is α_2]
5. In nature, the failure of structural members usually result from large torque because of twisting or bending rather than due to tensile or compressive strains. This process of

structural breakdown is called buckling and in cases of tall cylindrical structures like trees, the torque is caused by its own weight bending the structure. Thus the vertical through the centre of gravity does not fall within the base. The elastic torque caused because of this bending about the central axis of the tree is given by $Y \pi r^4 / 4 R$. Y is the Young's modulus, r is the radius of the trunk and R is the radius of curvature of the bent surface along the height of the tree containing the centre of gravity (the neutral surface). Estimate the critical height of a tree for a given radius of the trunk.

6. A stone of mass m is tied to an elastic string of negligible mass and spring constant k. The unstretched length of the string is L and has negligible mass. The other end of the string is fixed to a nail at a point P. Initially the stone is at the same level as the point P. The stone is dropped vertically from point P.
    - (a) Find the distance y from the top when the mass comes to rest for an instant, for the first time.
    - (b) What is the maximum velocity attained by the stone in this drop?
    - (c) What shall be the nature of the motion after the stone has reached its lowest point?