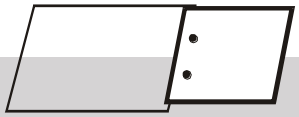
High Level Problems (HLP)

SUBJECTIVE QUESTIONS

1. A wire loaded by a weight of density 7.6 g cm^{-3} is found to measure 90 cm. On immersing the weight in water, the length decreases by 0.18 cm. Find the original length of wire.

2. Two long metallic strips are joined together by two rivet each of radius 2.0 mm (see figure). Each rivet can withstand a maximum shearing stress of 1.5×10^9 Pa. What is the maximum tensile force that the strip can exert, assuming each rivet shares the stretching load equally?



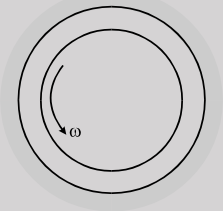
3. Eight rain drops of radius one mm each falling down with a terminal velocity of 5 cm s^{-1} coalesces to form a bigger drop. Calculate the terminal velocity of the bigger drop.

4. An air bubble of radius 1 cm is rising at a steady rate of 0.5 cm s^{-1} through a liquid of density 0.8gcm^{-3}. Calculate the coefficient of viscosity of the liquid. Neglect the density of air.

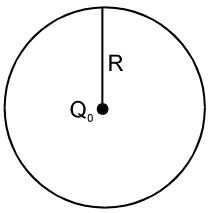
5. Two rods 'A' & 'B' of equal free length hang vertically 60 cm apart and support a rigid bar horizontally. The bar remains horizontal when carrying a load of 5000 kg at 20 cm from 'A'. If the stress in 'B' is 50 N/mm^2, find the stress in 'A' and the areas of 'A' and 'B'. Given $Y_B = 9 \times 10^4$ N/mm^2, $Y_A = 2 \times 10^5$ N/mm^2, g = 10 m/sec^2

6. A vertical rod 2 m long, fixed at the upper end, is 13 cm^2 in area for '1m' and 20 cm^2 in area for 1 m. A collar is attached to the free end. Through what height can a load of 100 kg fall on to collar to cause maximum stress of 50 N/mm^2. Y = 200000 N/mm^2. (g = 9.8 m/s^2)

7. A cylinder of 150 mm radius rotates concentrically inside a fixed cylinder of 155 mm radius. Both cylinders are 300 mm long. Determine the viscosity of the liquid which fills the space between the cylinders if a torque of 0.98 N-m is required to maintain an angular velocity of 60 r.p.m.



8. In a ring having linear charge density λ, made up of wire of cross-section area A, young modulus y, a charge Q_0 is placed at it's centre. If initial radius is 'R', then find out change in radius



9. A thin rod of negligible mass and area of cross-section 4×10^{-6} m^2, suspended vertically from one end has a length of 0.5 m at 10°C. The rod is cooled at 0°C, but prevented from contracting by attaching a mass at the lower end. Find **[JEE - 1997]**

(i) This mass and (ii) The energy stored in the rod.

Given for this rod, Y = 10^{11} Nm^{-2}, coefficient of linear expansion = 10^{-5} K^{-1} and g = 10ms^{-2}.

10. A long cylinder of radius R_1, is displaced along its axis with a constant velocity V_0 inside a stationary co-axial cylinder of radius R_2. The space between the cylinders is filled with viscous liquid .Find the velocity of the liquid as a function of the distance r from the axis of the cylinders. The flow is laminar.

11. A fluid with viscosity η fills the space between two long co-axial cylinders of radii R_1 and R_2 with $R_1 < R_2$. The inner Cylinder is stationary while the outer one is rotated with a constant angular velocity ω_2. The fluid flow is laminar. Taking into account that the friction force acting on a unit area of a cylindrical surface of radius r is defined by the formula $\sigma = \eta r (\partial\omega/\partial r)$, find:
(a) the angular velocity of the rotating fluid as a function of radius r;
(b) the moment of the friction forces acting on a unit length of the outer cylinder.

12. A tube of length ℓ and radius R carries a steady flow fluid whose density is ρ and viscosity η. The fluid flow velocity depends on the distance r from the axis of the tube as $v = v_0 (1 - r^2/ R^2)$ Find:
(a) the volume of the fluid flowing across the section of the tube per unit time;
(b) the kinetic energy of the fluid within the tube's volume;
(c) the friction force exerted on the tube by the fluid;
(d) the pressure difference at the ends of the tube.

HLP Answers

1. 88.632cm **2.** 3.77×10^4 N **3.** 20 cm/s **4.** 35.55 poise

5. $\frac{1000}{9}$ N/mm^2 , 300 mm^2 , $\frac{1000}{3}$ mm^2 **6.** 1.33 cm **7.** η = 0.77 N-sec/m^2.

8. $\Delta R = \frac{k\lambda Q_0}{AY}$ **9.** (i) 4.0kg (ii) 0.001 J **10.** $v = v_0 \frac{\ell n(r/R_2)}{\ell n(R_1/R_2)}$

11. (a) $\omega = \omega_2 \frac{R_1^2R_2^2}{R_2^2 - R_1^2}\left(\frac{1}{R_1^2} - \frac{1}{r^2}\right)$; (b) $N = 4\pi\eta\omega_2 \frac{R_1^2R_2^2}{R_2^2 - R_1^2}$

12. (a) $Q = 1/2\pi v_0 R^2$; (b) $T = 1/6\ \pi\ell R^2\rho\, v_0^2$; (c) $F_{fr} = 4\pi\eta\ell v_0$; (d)$\Delta p = 4\pi\eta\ell v_0/R^2$