APL 105

Mechanics of Solids and Fluids

MAJOR

Answer all questions. Maximum marks : 50. Time : 2 hours

1. Answer in brief. Answer all of Q1 in the same place.

   i. For a flow between parallel plates, the velocity field is given by $\vec{V} = U\frac{y}{h}\hat{i}$. Calculate the rate of rotation and the rate of angular deformation at y = 4mm for U = 4mm/s (2)

   ii. The temperature T in a long tunnel is known to vary approximately as $T = T_0 - \alpha e^{-x/L}\sin(2\pi t/\tau)$, where T_0, α, L and τ are constants. And x is measured from the entrance. Determine the rate of change in temperature experienced by a particle moving with a speed U along the tunnel. (2)

   iii. The y component of an incompressible two-dimensional flow field is given by $v = -Axy$. There is no velocity component or variation in the z direction. Find the simplest x component for this flow field. (2)

   iv. Consider the velocity field $\vec{V} = xy^2\hat{i} - y^3/3\,\hat{j} + xy\,\hat{k}$. Determine (a) if it is a possible incompressible flow and (b) the acceleration of fluid particle at (1,2,3). (2)

   v. Consider 2-D steady incompressible flow through a plane converging Chanel. The velocity on the horizontal centreline (x-axis) is given by $\vec{v} = V_1(1+x/L)\hat{i}$. Find the acceleration of the particle moving along the centreline. (2)

2. A continuous belt moves up at a velocity U_o taking a film of liquid of thickness h with it (see fig. P2). The density and viscosity of the liquid are ρ and μ respectively. Assume the flow is laminar and fully developed with zero pressure gradient. What are the boundary conditions at the belt and at the free surface of the film? Derive an expression for the velocity profile. (10)

3. A water jet with cross section area a_j and with a speed of V_j to the right, is deflected by a cone that moves to the left at a speed V_c (see fig. P3). Determine (a) the thickness of the jet sheet at a radius of R and (b) the external horizontal force needed to move the cone. (10)

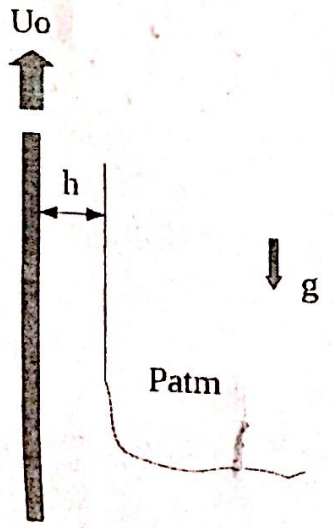

Fig. P2

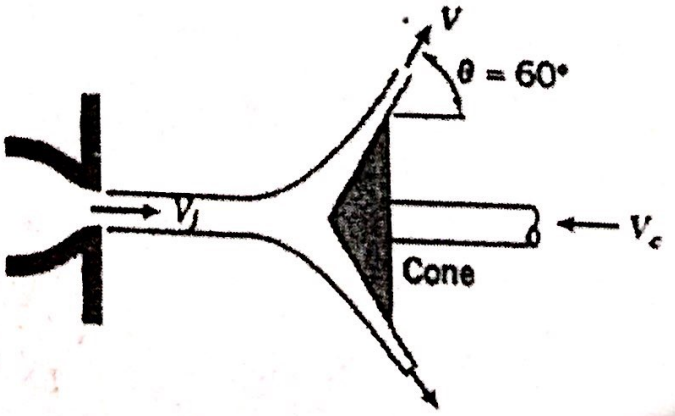

Fig. P3

Question 4: A torque of magnitude $T = 100$ N·m is applied to shaft AB of the gear train shown. Knowing that the diameters of the three solid shafts are, respectively, $d_{AB} = 21$ mm, $d_{CD} = 30$ mm, and $d_{EF} = 40$mm, determine the maximum shearing stress in (*a*) shaft AB, (*b*) shaft CD, (*c*) shaft EF. [Ref. Fig 1] (10)

Question 5: A 6-kg collar has a speed $v_0 = 4.5$ m/s when it strikes a small plate attached to end A of the 20 mm-diameter rod AB. Using $E = 200$ GPa, determine the equivalent static load, (*b*) the maximum stress in the rod, (*c*) the maximum deflection of end A. [Ref. Fig 2] (10)

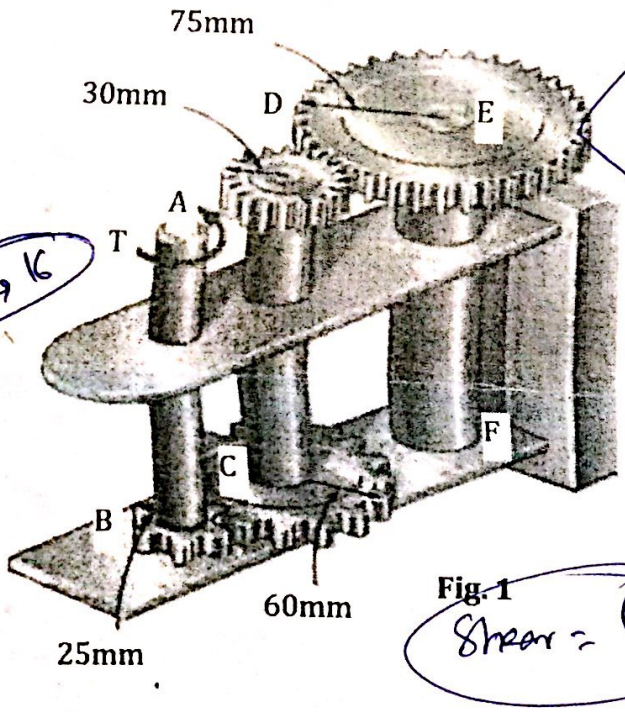

Fig. 1

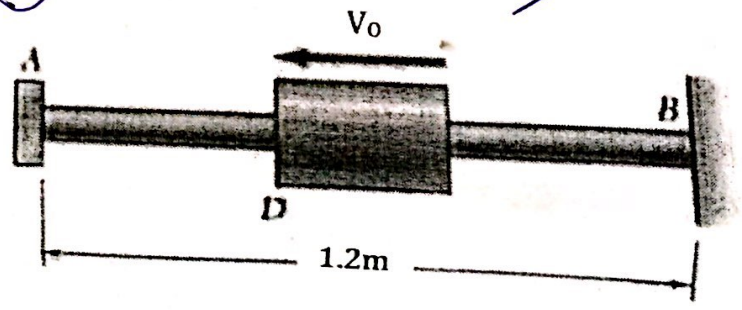

Fig. 2

NOTE: IF you think something is missing, please feel free to assume the data. But do not forget to clearly mention your assumption/s.