# Department of Applied Mechanics, IIT Delhi

## AML-150 Mechanics of Solids and Fluids (2009-2010 Second Semester)

## Major Test, 05 May 10, 10:30 a.m. to 12:30 p.m., Room IV-LT3

## Maximum marks: 60

### Part A: Mechanics of Fluids

1. A thin flat plate of size 55.0 cm by 110.0 cm is immersed in 6.0 m/s stream of SAE oil at 20°C. Compute the total friction drag if the stream is parallel to (a) the long side and (b) the short side. For SAE oil, take $\rho$ = 891.0 kg/m$^3$ and $\mu$ = 0.29.0 kg/(m-s). [10]

2. Air flows through the device shown in Fig. 1. If the flow-rate is large enough, the pressure within the constriction will be low enough to draw the water up into the tube. Determine the flow rate Q and the pressure needed at section 1 to draw the water into section 2. Neglect compressibility and viscous effects. $\gamma_{air}$ = 12 N/m$^3$ and $\gamma_{water}$ = 9800 N/m$^3$. [10]

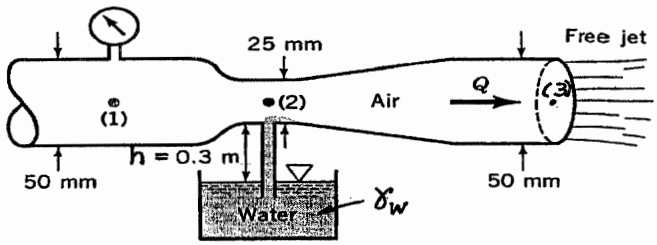

Fig. 1

3. In a certain viscous, incompressible flow field with zero body forces the velocity components are $u = ay - b\,(cy\text{-}y^2)$ and $v = w = 0$, where a, b and c are constants. (a) Determine an expression for the pressure gradient in the x-direction. (b) For what combinations of the constants a, b and c will the shearing stress ($\tau_{xy}$) be zero at y = 0 ? [10]

### Part B: Mechanics of Solids

4. A rigid bar **BD** is hinged at **B** and supported by two steel wires of same cross-sectional area. The wires are attached to the vertical wall at **A** (Fig. 2). Find the tensile forces $\mathbf{S_1}$ and $\mathbf{S_2}$ produced by the application of load **P**. [8]

5. Consider a simply supported rectangular beam of length "*L*" under a concentrated load "$P_1$" at the centre and an axial load "$P_2$" at the right edge as shown in Fig. 3. Explain the assumptions of the elementary theory for the bending of beams. Derive the relationship between
   (a) the bending moment $M(x)$ and the transverse displacement $v(x)$; and
   (b) external load and transverse displacement $v(x)$.
   Find the central displacement of the beam-column. [2+4+4+4 = 14]

6. Consider a prismatic bar of length "*L*'" is subjected to a twisting moment of 50000 Nm. The modulus of rigidity $G$ = 8.0 × 10$^5$ N/mm$^2$. Estimate the angle of twist per unit length if the cross-section of the bar is
   (a) A hollow circular shaft of outer diameter 60 mm and inner diameter 40 mm.
   (b) A hollow square cross-section as shown in Fig. 4.
   (c) "I" section as shown in Fig. 4. [2+3+3=8]

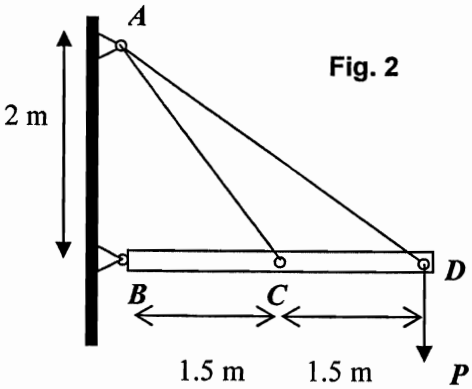

Fig. 2

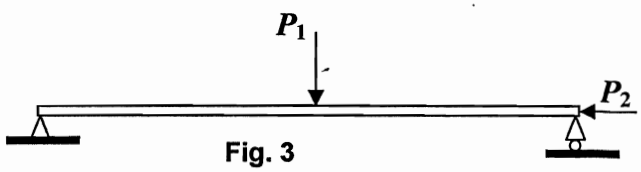

Fig. 3

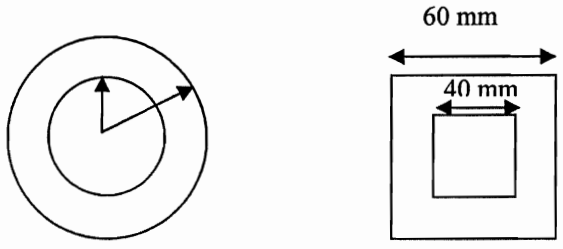

Fig. 4