Department of Applied Mechanics, IIT Delhi
APL-107 Mechanics of Fluids (2016-2017, First Sem)
Major Test
21 Nov 16, 1:00 pm to 3:00 pm, Room LH-121
Maximum marks: 35

1. An inverted right circular cone of angle 60° floats in water. Find (a) the location of metacentre and (b) specific gravity of the cone for the condition of stable equilibrium (Note: The centre of gravity of the cone is at a distance of *H*/4 (*H* denotes the height of cone) from the base and volume of cone is $\frac{\pi R^2 H}{3}$ (*R* denotes the radius of base). The area moment of inertia I_o of a circle of radius *r* is $\pi r^4/4$. **[4 + 2 = 6]**

2. Consider a turbulent boundary layer on a flat plate. Suppose only two variables are known: $C_{f,x} = 0.059 \times (\mathrm{Re}_x)^{-1/5}$ and $\theta = 0.097\delta$. Use the integral equations derived in the lecture class to obtain an expression for δ/x. All symbols have the standard meanings. **[5]**

3. Consider steady, incompressible, parallel, laminar flow of a viscous fluid falling between two infinite, vertical walls (*Fig. 1*). The distance between the walls is *h*, and gravity acts in the negative z-direction (downward). There is no applied (forced) pressure driving the flow; the fluid falls by gravity alone. The pressure is constant everywhere in the flow field. Obtain expressions for (a) velocity and (b) the volume flow rate per unit width. **[6 + 2 = 8]**

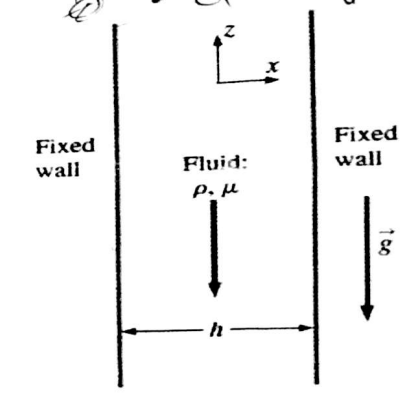

Fig. 1

4. A liquid jet of velocity V_j and area A_j strikes a single 180° bucket on a turbine wheel rotating at angular velocity Ω (*Fig. 2*). (a) Derive an expression for the power *P* delivered to this wheel at this instant as a function of the system parameters. (b) At what angular velocity is the maximum power delivered and P_{max}? (c) Clearly show the control volume and state all assumptions. **[4 + 3 + 1 = 8]**

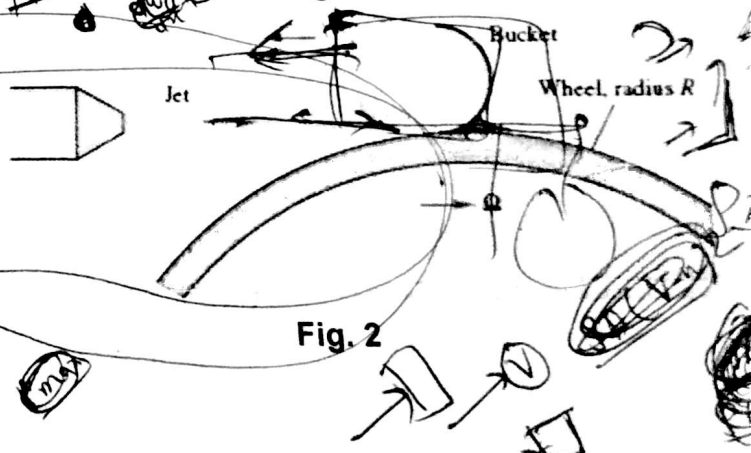

Fig. 2

5. *SAE 30 oil (ρ = 891 kg/m³ and μ = 0.29 kg/m.s) flows in the 3-cm-diameter pipe in Fig. 3, which slopes at 37°. For the pressure measurements shown and assuming laminar flow, determine (a) whether the flow is up or down and (b) the flow rate. (c) suppose it is desired to add a pump between A and B to drive the oil upward from A to B at a rate of 3 kg/s. At 100% efficiency, what pump power is required? (d) Check for laminar flow.*

[3 + 2 + 2 + 1 = 8]

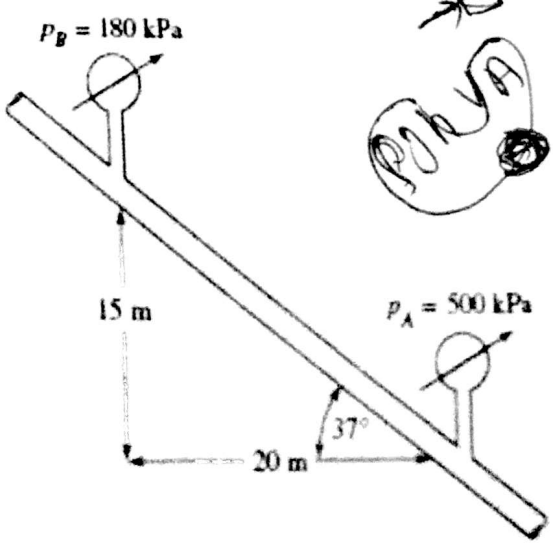

Fig. 3