Indian Institute of Technology Mandi

Sub: **Fluid Mechanics (**ME 210)

Final exam

Duration: 2.5 hours Marks: 50

Set C

Use g = 9.8 m/s² wherever necessary.

1. Answer in terms of true or false: (**Marks:** 0.5x10 = 5; -0.5 for wrong, +0.5 for correct answer)
   i. The Navier-Stokes equations are non-linear.
   ii. Dimples on the Golf ball increases its horizontal range.
   iii. The primary flow parameter that influences the drag around a blunt body is the Reynolds number.
   iv. Due to cavitation drag coefficient decreases.
   v. The streamlines and lines of constant potential intersect at right angles.
   vi. The difference of the stream functions between two streamlines gives the flow rate per unit depth between the two streamlines.
   vii. For a rectangular duct having cross section 4×6 m, the average flow velocity is 10 m/s. Taking kinematic viscosity of the fluid as 2 m^2/s, the Reynolds number of the flow is 24.
   viii. In hydrodynamically developing flow region in pipe, the velocity profile changes in both in radial as well flow direction.
   ix. At very large Reynolds numbers the friction factor curves in Moody chart, the friction factors are dependent of the Reynolds number.
   x. A Pitot-static probe measures both stagnation pressure and static pressure.
2. Suppose that the temperature field $T = 4x^2 - 3y^3$, in arbitrary units, is associated with a two-dimensional velocity field is given by $V = (x^2 - y^2 + x)i - (2xy + y)j$ in arbitrary units. Showing the necessary steps clearly, find the rate of change dT/dt at $(x, y) = (2, 1)$. Your choices are: (a) 100 units (b) 25 units (c) 225 units (d) 125 units (**Marks:** 4).
3. An idealized incompressible flow has the proposed three-dimensional velocity distribution $V = 4xy^2i + f(y)j - zy^2k$. Showing the necessary steps clearly find the appropriate form of the function f(y) which satisfies the continuity relation. One of the following choices is correct: (a) $-y^3$ + constant (b) $-2y^3$ + constant (c) $-y^3/3$ + constant (d) y^3 + constant (**Marks:** 3).
4. The wall shear stress τ_w for flow in a narrow annular gap between a fixed and a rotating cylinder is a function of density ρ, viscosity μ, angular velocity Ω, outer radius R, and gap width Δr. Using (ρ, Ω, R) as repeating variables, rewrite this relation in dimensionless form using using Buckingham π theorem. (**Marks:** 5).
5. Three pipes steadily deliver water at 20°C to a large exit pipe in Fig. 1 The velocity $V_2 = 5$ m/s, and the exit flow rate $Q_4 = 120$ m^3/h. Find (a) V_1; (b) V_3; and (c) V_4 if it is known that increasing Q_3 by 20% would increase Q_4 by 10%. (**Marks**: 1+1+2 = 4).
6. The water tank in Fig. 2 stands on a frictionless cart and feeds a jet of diameter 4 cm and velocity 8 m/s, which is deflected 60° by a vane. Compute the tension in the supporting cable showing

necessary steps. One of the following choices is correct: (a) 20 N (b) 30 N (c) 40 N (d) 50 N. (**Marks:** 5).

7. A 20°C water jet strikes a vane mounted on a tank with frictionless wheels, as in Fig. 3. The jet turns and falls into the tank without spilling out. If $\theta = 30°$, evaluate the horizontal force F required to hold the tank stationary. One of the following choices is *nearly* correct: (a) 63 N (b) 163 N (c) 370 N (d) 470 N. (**Marks:** 6).
8. Compute the horizontal F_H and vertical F_V components of the hydrostatic force on the quarter-circle panel at the bottom of the water tank in Fig. 4. One of the following choices is correct: (a) 705 kN, 638 kN (b) 705 kN, 705 kN (c) 505 kN, 805 kN (d) 305 kN, 905 kN. (**Marks:** 5).
9. The homogeneous 12-cm cube in Fig. 5 is balanced by a 2-kg mass on the beam scale when the cube is immersed in 20°C ethanol. What is the specific gravity of the cube? The specific weight of ethanol is 7733 N/m^3. One of the following choices is correct: (a) 9100 N/m^3 (b) 19100 N/m^3 (c) 29100 N/m^3 (d) 39100 N/m^3 . (**Marks:** 3).
10. The tank in Fig. 6 is filled with water and has a vent hole at point A. The tank is 1 m wide into the paper. Inside the tank, a 10-cm balloon, filled with helium at 130 kPa, is tethered centrally by a string. If the tank accelerates to the right at 5 m/s^2 in rigid-body motion, at what angle will the balloon lean? Will it lean to the right or to the left and why? (**Marks:** 2+2+1=5).
11. Two baseballs are connected to a rod 7mm in diameter and 56 cm long, as in Fig. 7. What power, in Watt, is required to keep the system spinning at 400 rev/min? Include the drag of the rod, and assume sea level standard air. For sea-level air, take $\rho = 1.225$ kg/m^3. Drag coefficient C_D on ball is 0.47 and for the rod is 1.2. One of the following choices is correct: (a) 3.15 W (b) 6.3 W (c) 9.3 W (d) 12.6 W. (**Marks:** 5)

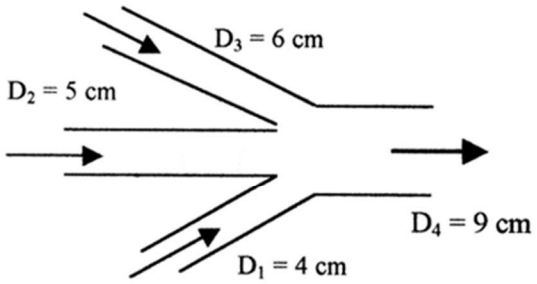

Fig. 1

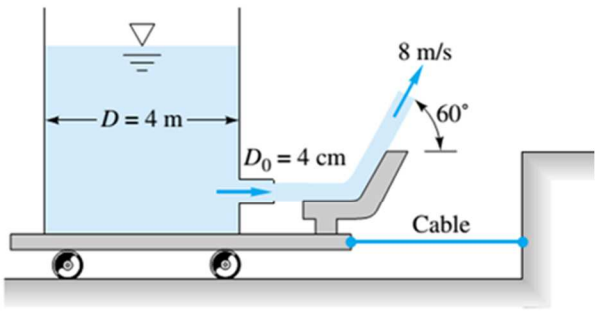

Fig. 2

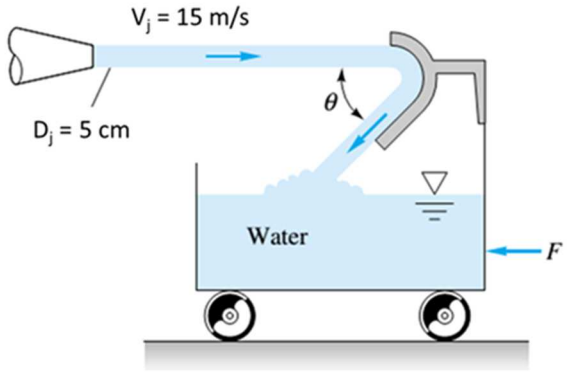

Fig. 3

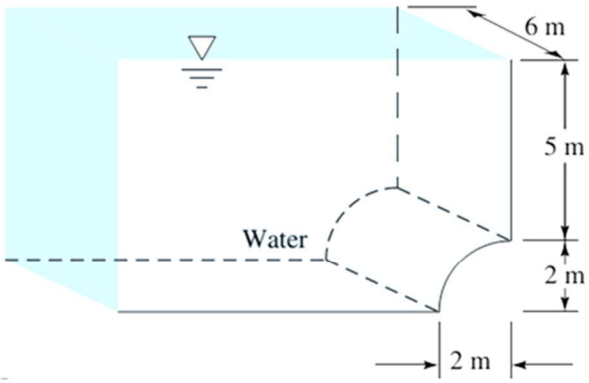

Fig. 4

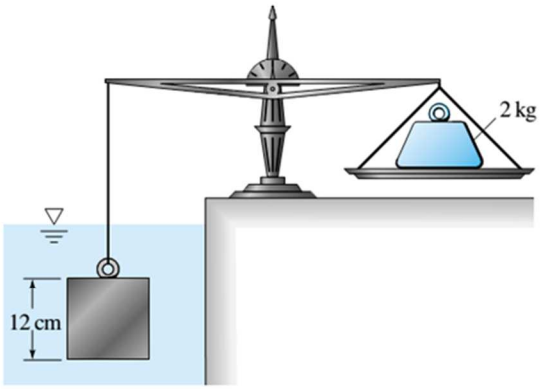

Fig. 5

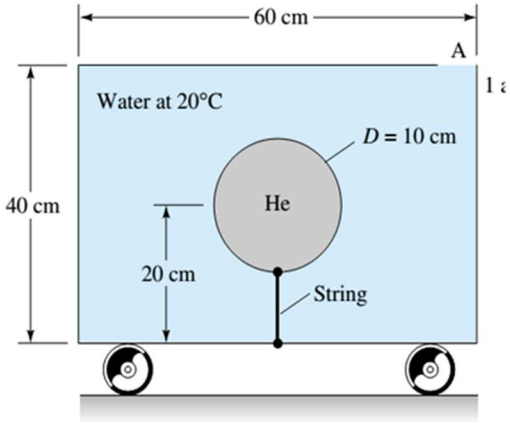

Fig. 6

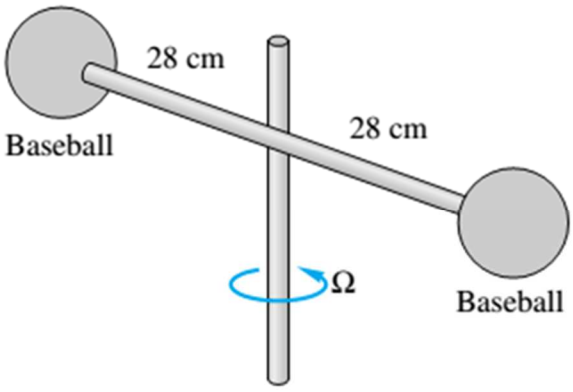

Fig. 7