(b) Oil of dynamic viscosity 1.5 Poise and specific gravity 0.85 flows through a 30cm diameter horizontal pipe. If the head loss in 300m length of pipe is 20m, find :
(i) the shear stress at the pipe wall.
(ii) discharge through the pipe.
(iii) Darcy's friction factor f by assuming the flow to be laminar.

6 + (2 + 2 + 2) = 12

7. (a) What is Moody's diagram? State its significance in pipe flow analysis.

(b) Two reservoirs are connected by three cast iron pipes in series. The discharge is 0.11m^3/s. The length and diameter of the pipes are L_1 = 600m, D_1= 0.3m; L_2 = 900m, D_2= 0.4m; L_3 =1500m, D_3=0.45m respectively. Find out the Reynolds Number in each of the pipe. The density and viscosity of water are 1000kg/m^3 and 1.1× 10^{-3} N-s/m^2, respectively. The friction factor in each pipe is 0.02. Determine the difference in elevation between the top surfaces of water in the reservoirs. Include the entry loss to pipe 1 and exit loss between pipe 3 and the adjacent reservoir but neglect the minor loss due to sudden expansion.

(2 + 2) + (3 + 5) = 12

Group - E

8. (a) Briefly describe the phenomenon of boundary layer separation for flow over a curved surface. What is the effect of pressure gradient on boundary layer separation?

(b) Given that the velocity distribution in a laminar boundary layer due to flow over a flat plate is $\frac{u}{U} = 2\eta - \eta^2$ where $\eta = \frac{y}{\delta}$, calculate the displacement and momentum thicknesses in terms of the nominal boundary layer thickness δ. All symbols have their usual meanings.

(3 + 2) + 7 = 12

9. (a) If the power required to overcome aerodynamic drag of an aircraft remains the same, what percentage increase in the velocity of aircraft is reflected by 15% reduction in drag coefficient?

(b) Using Buckingham's π Theorem, obtain an expression of the velocity through a circular orifice ***V*** in terms of **H**, **D**, μ, ρ and **g** where **H** is the head causing the flow, **D** is the diameter of the orifice, μ is coefficient of viscosity, ρ is the mass density and **g** is the acceleration due to gravity.

4 + 8 = 12

FLUID MECHANICS
(MECH 2103)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) For a fluid, the shear stress was found to be directly proportional to the rate of angular deformation. The fluid is classified as
(a) Dilatant fluid (b) Inviscid fluid
(c) Newtonian fluid (d) Pseudoplastic.

(ii) For a fluid at rest
(a) the shear stress depends upon the coefficient of viscosity
(b) the shear stress is maximum on a plane inclined at 45^0 to horizontal
(c) the shear stress is zero at all points
(d) the shear stress is zero only on horizontal planes.

(iii) The resultant hydrostatic force on a body submerged in static fluid, acts through a point known as
(a) centre of pressure (b) centre of gravity
(c) centre of buoyancy (d) metacentre

(iv) Example of steady, non-uniform flow is the flow of a liquid at
(a) constant rate in a conically tapered pipe
(b) constant rate in a straight pipe
(c) variable rate in a conically tapered pipe
(d) variable rate in a straight pipe

(v) The flow rate per unit width between two streamlines with stream function values ψ_1 and ψ_2 is given by
(a) $\psi_1 + \psi_2$ (b) $\psi_1 \times \psi_2$
(c) $\psi_1 - \psi_2$ (d) $C\psi_1 + \psi_2$ [C is a constant]

(vi) The continuity equation $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$

(a) is not valid for unsteady, incompressible fluids
(b) is valid for incompressible fluids whether the flow is steady or unsteady
(c) is valid for steady flows whether compressible or incompressible
(d) is valid for ideal fluid flow only.

(vii) The linear momentum equation is based on
(a) Newton's law of viscosity (b) Newton's first law
(c) Newton's second law (d) Newton's third law.

(viii) At the point of separation of boundary layer
(a) the velocity is zero (b) the pressure is zero
(c) the pressure gradient is zero (d) the shear stress is zero.

(ix) When compared to a streamlined body, a bluff body will have
(a) more pressure drag but less friction drag
(b) more pressure drag and more friction drag
(c) less pressure drag and less friction drag
(d) less pressure drag but more friction drag.

(x) In hydraulic modeling of flow pattern around a body submerged in a fluid, the non-dimensional number that has to be kept same in the model and prototype is
(a) Weber number (b) Froude number
(c) Reynolds Number (d) Mach number.

Group – B

2. (a) A rectangular plate 1.2m × 1.8m is submerged in water and makes an angle of 30^0 with the horizontal, the 1.2m sides being horizontal. Calculate the magnitude of the hydrostatic force on one face of the plane and also the position of the center of pressure, when the top edge of the plane is (i) at the water surface (ii) 500mm below the water surface.

(b) A wooden block in the form of a rectangular prism floats in water with its shortest axis vertical. The block is 40 cm long, 20 cm wide and 15 cm deep with a depth of immersion of 12 cm. Find the metacentric height of the block and state whether the equilibrium is stable, neutral or unstable.

(3 + 3) + 6 = 12

3. (a) For a steady incompressible fluid flow through a nozzle, the velocity field is given by $\overline{V}=u_0\left(1+\frac{2x}{L}\right)i$ where x is the distance along the axis of the nozzle from its inlet plane and L is the length of the nozzle.
Find:
(i) an expression of the acceleration of a particle flowing through the nozzle and

(ii) the time required for a fluid particle to travel from the inlet to the exit of the nozzle.

(b) In a two dimensional flow, the velocity potential function is given by Ø = $5(x^2-y^2)$. Calculate the velocity components u and v at the point (4, 5) and obtain an expression of the relevant stream function.

(3 + 3) + (2 + 4) = 12

Group – C

4. (a) State the significance of Bernoulli's equation along a streamline.
The top and bottom diameter of a 2m long vertical tapering pipe are 100 mm and 50 mm respectively. Water flows down the pipe at 30 litre/s. Find the pressure difference between the two ends of the pipe.

(b) An orifice meter with orifice diameter 10cm is inserted in a pipe of 20cm diameter. The pressure gauges fitted upstream and downstream of the orifice meter give readings of 19.62 N/cm^2 and 9.81N/cm^2 respectively. Coefficient of discharge for the meter is given as 0.6. Find the discharge of water through pipe.

(2 + 4) + 6 = 12

5. (a) A nozzle of diameter 20 mm is fitted to a pipe of diameter 40 mm as shown in Figure 2. Find the force exerted by the nozzle on the water which is flowing through the pipe at the rate of 1.2 m^3 / minute.

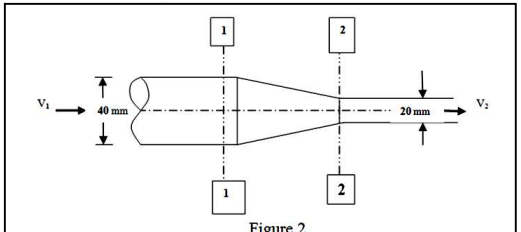

Figure 2

(b) Obtain an expression of discharge through a rectangular notch in terms of head over the notch. Hence, show that the error in discharge measurement due to error in measurement of head is given by $\frac{dQ}{Q}=\frac{3}{2}\frac{dH}{H}$ where Q= discharge through rectangular notch, H= head over rectangular notch.

6 + (4 + 2) = 12

Group – D

6. (a) Derive the Hagen-Poiseuille Equation for steady, laminar, fully-developed, incompressible fluid flow through a circular pipe, in the form $Q=\frac{\pi D^4}{128\,\mu L}\Delta p$ .All symbols have their usual meanings.