(b) A vertical venturimeter carries water and has inlet and throat diameters of 150 mm and 75 mm respectively. The pressure connection at the throat is 250 mm above that at the inlet. If the actual rate of flow is 40 litre/s and the coefficient of discharge is 0.96, calculate
(i) the pressure difference between inlet and throat, and
(ii) the difference in the levels of mercury in a vertical U-tube mercury manometer connected between these points, the tubes above the mercury being full of water.

(1 + 1 + 1) + (6 + 3) = 12

7. (a) State Euler's equation of motion along a streamline with assumptions made. What forces are taken into consideration for deriving the equation? Compare venturimeter and orificemeter as flow measurement devices in pipe flow.

(b) Find the displacement thickness (δ^*) and the momentum thickness (θ) for the velocity distribution in the boundary layer given by $\frac{u}{U_\infty} = \frac{y}{\delta}$, where, u is the velocity (parallel to the plate) at a distance y (measured vertically upward) from the plate and $u = U_\infty$ at $y = \delta$, where, δ is the boundary layer thickness.

(2 + 2 + 2) + 6 = 12

Group – E

8. (a) A straight pipeline ABC, which consists of 2 pipes AB and BC, connects two reservoirs with a difference in water surface elevation of 10 m. AB and BC are joined in series. Pipe AB is 10 cm in diameter, 20 m long and has a value of Darcy's friction factor f = 0.02. Pipe BC is 16 cm in diameter, 25 m long and has a value of Darcy's friction factor f = 0.018. The junctions with the reservoirs and between the pipes are abrupt to include respective minor losses. Calculate the discharge.

(b) A 6 cm diameter pipe has a discharge of 450 litre/min of water. At a section the pipe has a sudden expansion to size of 9 cm diameter. If the pressure just upstream of the expansion is 20 kN/m^2, calculate the pressure just after the expansion. Assume the pipe to be horizontal at the expansion region.

7 + 5 = 12

9. (a) An oil of specific gravity 0.9 and viscosity 0.06. Poise is flowing through a pipe of diameter 200 mm at the rate of 60 litre/s. Check whether the flow is laminar or turbulent and find the head loss due to friction for a 500 m length of pipe.

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

4 + 8 = 12

B.TECH/ME/3RD SEM/MECH 2102/2019

FLUID MECHANICS & HYDRAULICS
(MECH 2102)

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) Poise is the unit of
(a) Specific volume (b) Dynamic viscosity
(c) Kinematic viscosity (d) Compressibility.

(ii) A metal block is thrown into a deep lake. As it sinks deeper in water, the buoyant force acting on it
(a) increase (b) remains the same
(c) decreases (d) first increase and then decreases.

(iii) Example of unsteady, 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.

(iv) The piezometric head in a static liquid
(a) remains constant only on a horizontal plane
(b) increases linearly with depth below a free surface
(c) remains constant at all points in the liquid
(d) decreases linearly with depth below a free surface.

(v) In a two-dimensional velocity field with velocity u and v along the x and y directions respectively, the convective acceleration along the x-direction is given by
(a) $u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$ (b) $u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial y}$ (c) $u\frac{\partial v}{\partial x} + v\frac{\partial u}{\partial y}$ (d) $v\frac{\partial u}{\partial x} + u\frac{\partial u}{\partial y}$.

(vi) Minor losses in a pipe flow are those losses
(a) which are always insignificantly small
(b) which can be neglected always

(c) caused by local disturbance due to pipe fittings
(d) caused by frictional resistance.

(vii) Three parallel pipes connected at the two ends have flow-rates Q_1, Q_2 and Q_3 respectively, and the corresponding frictional head losses are h_{L1}, h_{L2} and h_{L3} respectively. The correct expressions for total flow rate (Q) and frictional head loss across the two ends (h_L) are
(a) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(b) $Q = Q_1 + Q_2 + Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$
(c) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} + h_{L2} + h_{L3}$
(d) $Q = Q_1 = Q_2 = Q_3$; $h_L = h_{L1} = h_{L2} = h_{L3}$.

(viii) Consider steady laminar incompressible axi-symmetric fully developed viscous flow through a straight circular pipe of constant cross section area at a Reynolds number of 5. The ratio of inertia force to viscous force on a fluid particle is

(a) 5 (b) $\frac{1}{5}$ (c) 0 (d) ∞

(ix) Flow separation in flow past a solid object is caused by
(a) a reduction of pressure to vapour pressure
(b) a negative pressure gradient
(c) positive pressure gradient
(d) the boundary layer thickness reducing to zero.

(x) Moody's diagram depicts variation of friction factor f with
(a) Reynolds number and relative roughness
(b) relative roughness only
(c) Reynolds number and absolute roughness
(d) Reynolds number only.

Group – B

2. (a) Distinguish between (i) Compressible and Incompressible fluid (ii) Gauge pressure and Vacuum pressure.

(b) How does compressibility is related to modulus of elasticity?

(c) An incompressible fluid (kinematic viscosity 7.4×10^{-7} m²/s, specific gravity 0.88) is held between two parallel plates. If the top plate is moved with a velocity of 0.5 m/s while the bottom one is held stationary, then fluid attains a linear velocity profile in the gap of 0.5 mm between these plates. Find out the shear stress on the surface of top plate.

(2 + 2) + 2 + 6 = 12

3. (a) A closed tank contains 0.5 m of mercury (specific gravity 13.6) at bottom, above which there are 2 m of water, 3 m of oil of specific gravity 0.6 and there is air space above the oil at the top part, inside the tank. If the gauge pressure at the bottom of the tank is 196.2 kPa, what is the pressure of the air at the top part of the tank?

(b) Determine the gauge pressure at P in the Fig.1 which shows a compound manometer. Take all the dimensions in metres.

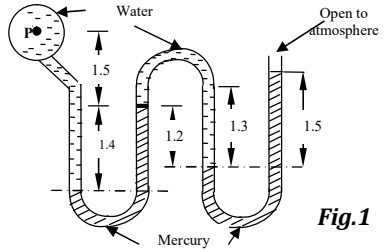

Fig.1

5 + 7 = 12

Group – C

4. (a) Find the horizontal and vertical components of the total force acting on a curved surface AB, which is in the form of a quadrant of a circle of radius of 2 m as shown in Fig.2. Take width of the gate as 2 m.

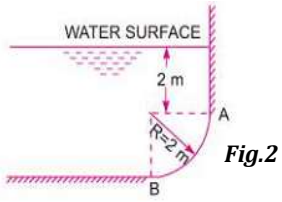

Fig.2

(b) A wooden cylinder (density 650 kg / m³) of diameter 2 m and height 1.5 m floats in water with its axis vertical. Determine its metacentric height and also comment on its equilibrium.

6 + 6 = 12

5. (a) (i) For a steady, incompressible flow, the velocity components are given by $u = -x/(x^2 + y^2)$ and $v = -y/(x^2 + y^2)$. Show that the flow is possible.
(ii) Distinguish between streamline and pathline.

(b) The velocity for a steady, incompressible fluid flow in the ***x-y*** plane is given by $\overline{V} = \left(\frac{2}{x}\right)i + \left(\frac{2y}{x^2}\right)j$ where, velocity is in m/s and the coordinates are measured in meter.
(i) Obtain an equation for the streamline that passes through the point (x, y) = (1, 3).
(ii) Calculate the time required for a fluid particle to move from x = 1 m to x = 3 m in this flow.

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

Group – D

6. (a) Briefly discuss the terms (i) local acceleration (ii) convective acceleration and (iii) stagnation pressure, referred in case of fluid motion.