FLUID MECHANICS & HYDRAULICS
(MEC2102)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) For a Newtonian fluid
(a) shear stress is proportional to shear strain
(b) rate of shear stress is proportional to shear strain
(c) shear stress is proportional to rate of shear strain
(d) rate of shear stress is proportional to rate of shear strain.

(ii) 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.

(iii) Non-zero value of temporal acceleration indicates
(a) Non-uniform flow (b) Turbulent flow
(c) Steady flow (d) Unsteady flow.

(iv) 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 steady flows whether compressible or incompressible
(c) is valid for incompressible fluids whether the flow is steady or unsteady
(d) is valid for ideal fluid flow only.

(v) 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 constant diameter pipe
(c) variable rate in a conically tapered pipe
(d) variable rate in a constant diameter pipe

(vi) Pitot Tube is used to measure
(a) flow rate in a pipe (b) temperature of fluid
(c) velocity at a point in fluid flow (d) viscosity of fluid.

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

(viii) The repeating variables in dimensional analysis should
(a) be equal in number to that of the fundamental dimensions involved in the problem variables
(b) collectively contain all the fundamental dimensions
(c) include the dependent variable
(d) both (a) & (b) are correct.

(ix) The velocity in a fully developed laminar flow in a circular pipe is
(a) constant over the cross section (b) varies linearly across the section
(c) maximum at the pipe wall (d) maximum at the pipe centre.

(x) For hydrodynamically smooth pipes the friction factor *f* is a
(a) function of Reynolds number only
(b) function of relative roughness only
(c) function of Reynolds number and relative roughness
(d) constant.

Fill in the blanks with the correct word

(xi) The dimension of Kinematic viscosity is _____.

(xii) Hydraulic Grade Line (H.G.L) represents the sum of Pressure head and _____.

(xiii) The linear momentum equation is based on the principle of _____.

(xiv) The Reynolds number for flow of oil in a certain pipe is 640. The Darcy-Weisbach friction factor *f* for this flow is _____.

(xv) When a body is immersed in a flow field, the component of the resultant force acting on it in the direction normal to the relative velocity is called_____ force.

Group - B

2. (a) The volume of a liquid is decreased by 0.2% when the pressure of the liquid is increased from 8 MPa to 20 MPa. Determine the bulk modulus of elasticity and compressibility of the liquid. *[(CO3)(Analyse/IOCQ)]*

(b) A cylindrical shaft of 90 mm diameter rotates inside a fixed journal bearing of length 50 cm and 95 mm internal diameter. If the space between the bearing and the shaft is filled by a lubricant of dynamic viscosity 2.0 Poise, determine the power required to overcome the viscous resistance when the shaft is rotated at a speed of 240 rpm. *[(CO3)(Evaluate/HOCQ)]*

6 + 6 = 12

3. (a) A differential U-tube mercury manometer is used to measure the pressure difference between points 1 and 2 in a pipeline, conveying water. The point 1 is 0.5m lower than the point 2. The difference in the level of manometric fluid (mercury) on the two limbs is 0.8m. Calculate the pressure difference between

points 1 and 2. Assume, density of water is 1000 kg/m^3, Specific gravity of mercury is 13.6. *[(CO3)(Apply/IOCQ)]*

(b) Discuss in brief: (i) Inverted tube manometer (ii) Inclined tube manometer. *[(CO2)(Remember/LOCQ)]*

6 + 6 = 12

Group - C

4. (a) A plane area in the form of a right angle triangle of vertical height '*h*' and horizontal base '*b*' is immersed vertically in water with its vertex touching at the water surface. Calculate the total force on one side of the triangular plane and the location (x_p, y_p) of the centre of pressure. *[(CO3)(Analyse/IOCQ)]*

(b) The velocity vector in a two dimensional flow field is given by the equation $\overline{V} = 2x^3\hat{i} - 6x^2y\hat{j}$. Determine the equation of streamline when it passes through a point A (3, 2). *[(CO5)(Apply/IOCQ)]*

6 + 6 = 12

5. (a) A rectangular plane 1.2 m × 1.8 m is submerged in water and makes an angle of 30^0 with the horizontal, the 1.2 m 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) 500 mm below the water surface. *[(CO3)(Evaluate/HOCQ)]*

(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 m. Obtain an equation for the streamline that passes through the point (x, y) = (1, 3). Calculate the time required for a fluid particle to move from x = 1 m to x = 3 m in this flow. *[(CO4)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (a) State Euler's Equation of motion along a streamline, and also mention the assumptions. A pipe of diameter 250 mm conveys water at the rate of 2.4 m^3/min and has a pressure of 20 kPa at a certain section. Find the total energy head with respect to a datum 4000 mm below the pipe. *[(CO5)(Analyse/IOCQ)]*

(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 the pressure difference between inlet and throat. *[(CO5)(Evaluate/HOCQ)]*

6 + 6 = 12

7. (a) A nozzle of exit diameter 20 mm is fitted to a pipe of diameter 40 mm as shown in *Fig 1*. 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.

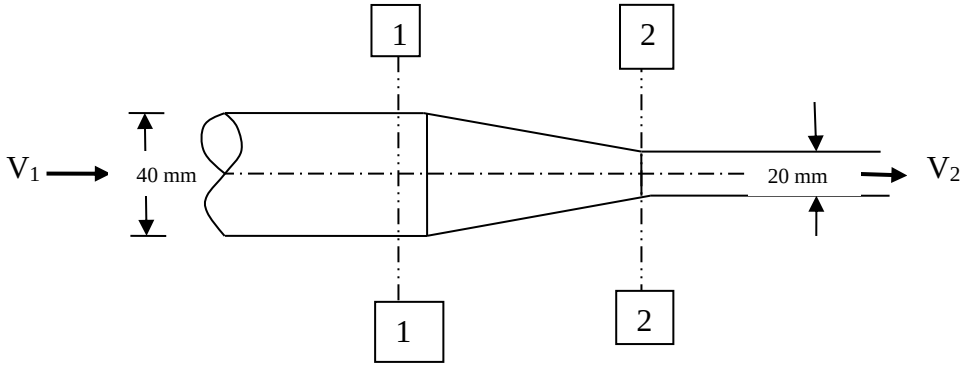

Fig. 1 *[(CO5)(Analyse/IOCQ)]*

(b) Fluid of density $\boldsymbol{\rho}$ and viscosity $\boldsymbol{\mu}$ flows at an average velocity $\boldsymbol{V}$ through a circular pipe of diameter $\boldsymbol{D}$. The shear stress at pipe wall $\boldsymbol{\tau_w}$ depends on $\boldsymbol{\rho}$, $\boldsymbol{\mu}$, $\boldsymbol{V}$ and $\boldsymbol{D}$. Using Buckingham's π theorem, obtain an expression for $\boldsymbol{\tau_w}$in terms of $\boldsymbol{\rho}$, $\boldsymbol{\mu}$, $\boldsymbol{V}$ and $\boldsymbol{D}$. *[(CO4)(Apply/IOCQ)]*

6 + 6 = 12

Group - E

8. (a) The Reynolds No. for flow through a 5 cm diameter pipe is 1700. If the kinematic viscosity of oil is $\nu = 1.02\times10^{-6}$ m^2/s, find the velocity at a point 0.625cm from the wall. *[(CO6)(Analyse/IOCQ)]*

(b) Two reservoirs are connected by three cast iron pipes in series. The length and diameter of the pipes are L_1 = 600 m, D_1= 0.3 m; L_2= 900 m, D_2= 0.4 m; L_3= 1500 m, D_3=0.45 m respectively. The density and viscosity of water are 1000 kg/m^3 and 1.1×10^{-3} N-s/m^2, respectively. The friction factor in each pipe is 0.02. The discharge is 0.11m^3/s. Determine the difference in elevation between the top surfaces of the reservoirs. Neglect the minor loss due to sudden expansion but include the entry loss to pipe 1 and exit loss between pipe 3 and the adjacent reservoir. *[(CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

9. (a) Oil of specific gravity 0.9 and viscosity 2.5 Poise flows through a 100mm diameter pipe, 500m long at a rate of 2 litre/sec. Find the Reynolds number of the flow. *[(CO6)(Apply/IOCQ)]*

(b) A straight pipeline, which consists of two pipes, connects two reservoirs, with a difference in water surface elevation of 20 m. Pipe 1 and 2 are joined in series. Pipe 1 is 10 cm in diameter, 20 m long and has a value of Darcy's friction factor f = 0.02. Pipe 2 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. *[(CO6)(Evaluate/HOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	6.25	62.5	31.25