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) Which of the following method is used exclusively in fluid mechanics?
(a) Eulerian method
(b) Lagrangian method
(c) Neither Lagrangian nor Eulerian method
(d) Both Lagrangian and Eulerian methods.

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

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

(iv) The flow field represented by the velocity vector $V = ax\mathbf{i} + by^2\mathbf{j} + czt^2\mathbf{k}$ where a, b and c are constants, is
(a) three-dimensional and unsteady (b) two-dimensional and steady
(c) three-dimensional and steady (d) two-dimensional and unsteady.

(v) Which of the following is the correct relation between centroid (G) and the centre of pressure (P) of a plane fully submerged in a liquid?
(a) G is always below P (b) P is always below G
(c) G is either at P or below it (d) P is either at G or below it.

(vi) Two pipes, each of diameters d, converge to form a pipe of diameter D. What should be the relation between d and D such that the flow velocity in the third pipe becomes double of that in each of the two pipes?
(a) D = d (b) D = 2d (c) D = 3d (d) D = 4d.

(vii) In boundary layer flow a negative pressure gradient is called
(a) adverse pressure gradient (b) unstable pressure gradient
(c) separation pressure gradient (d) favourable pressure gradient.

(viii) Reynolds number is the ratio of
(a) inertia force and gravity force
(b) inertia force and pressure force
(c) pressure force and viscous force
(d) inertia force and viscous force.

(ix) 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.

(x) 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.

Group – B

2. (a) What is the difference between dynamic viscosity and kinematic viscosity? State their units of measurements? [(CO1)(Remember/LOCQ)]
(b) A hydraulic ram of 200 mm diameter and 1.2 m long moves within a concentric cylinder 200.2 mm diameter. The annular clearance is filled with oil of specific gravity 0.85 and kinematic viscosity 400 mm^2/s. What is the viscous force resisting the motion when the ram moves at a speed of 120 mm/s?
(c) How does viscosity of gas change with temperature? [(CO1)(Understand/LOCQ)]

4 + 6 + 2 = 12

3. (a) What are the benefit of U-tube manometer over piezometer? Why mercury has widely used as manometric fluid? [(CO2)(Understand/LOCQ)]
(b) Determine the pressure difference between points A and B, as shown in Fig.1. Specific gravities of benzene, kerosene, mercury and air are 0.88, 0.82, 13.6 and 1.2×10^{-3} respectively. Consider air as incompressible fluid. [(CO2)(Evaluate/HOCQ)]

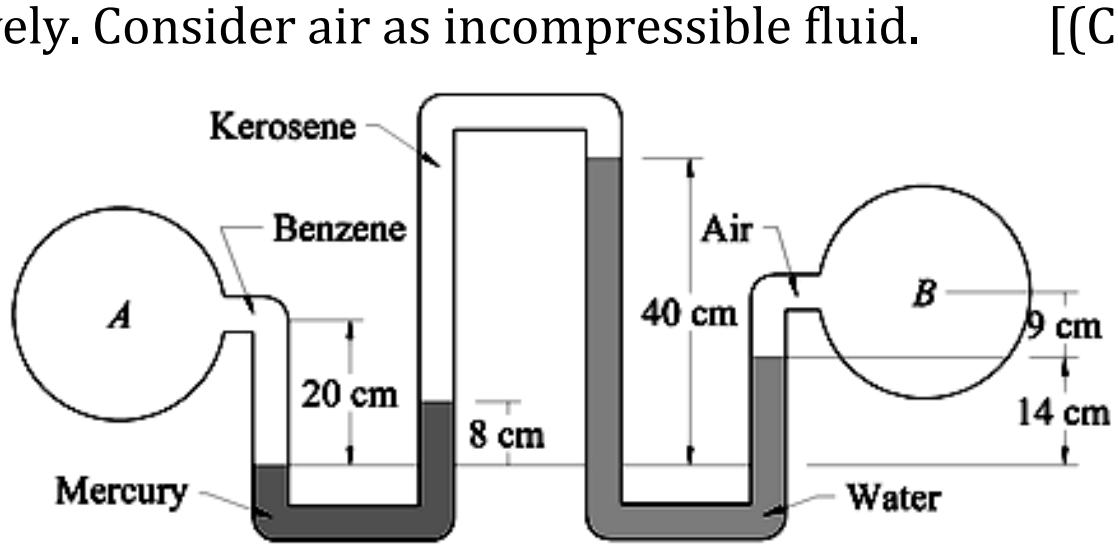

Fig. 1

6 + 6 = 12

Group - C

4. (a) Distinguish between (i) Steady Flow and Unsteady Flow (ii) Uniform flow and Non uniform flow. [(CO3)(Remember/LOCQ)]

(b) The pipeline 60 cm in diameter bifurcates at a Y junction into two branches 40 cm and 30 cm in diameter. If the rate of flow in the main pipe is 1.5 m^3/s, and the mean velocity of flow in the 30 cm pipe is 7.5 m/s, determine the rate of flow and velocity in the 40 cm pipe. [(CO3)(Analyze/IOCQ)]

6 + 6 = 12

5. (a) A gate having a shape of a quadrant of a circle 1m radius has to resist liquid (specific gravity 0.92) force as shown in Fig.2. If the width of the gate is unity, then determine the magnitude and direction of the resultant pressure force on the gate.

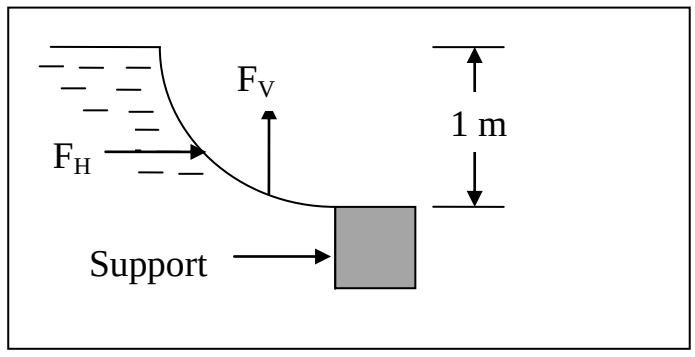

Fig. 2

[(CO2)(Analyze/IOCQ)]

(b) A rectangular barge of dimensions 10 m × 3 m weighs 75 tons and its centre of gravity lies 1.3 m above the bottom. Determine the metacentric height when it floats in fresh water. [(CO2)(Analyze/IOCQ)]

6 + 6 = 12

Group – D

6. (a) The velocity vector in an incompressible fluid flow is given by, $\mathbf{V} = (6xt + yz^2)\mathbf{i} + (3t + xy^2)\mathbf{j} + (xy - 2xyz - 6tz)\mathbf{k}$ (i) Verify whether flow is possible. (ii) Determine the acceleration vector at point A (1,1,1) at t= 1.0 sec.

[(CO3)(Analyze/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.

[(CO3)(Analyze/IOCQ)]

(2 + 4) + 6 = 12

7. (a) Explain the effect of pressure gradient on boundary layer separation. What are the methods of preventing the separation of boundary layer?

[(CO4)(Understand/LOCQ)]

(b) In a system, 260 litres/s of oil of specific gravity 0.9 is flowing in a pipe having a diameter of 0.3 m. If the pipe is bent by 135° and the pressure of oil flowing in the pipe is 400 kPa, then find the magnitude and direction of the resultant force on the bend. [(CO3)(Analyze/IOCQ)]

6 + (2 + 4) = 12

Group - E

8. (a) An oil of viscosity 0.1N-s/m^2 and specific gravity 0.9 flows through a horizontal pipe of 50 mm diameter and 300 m length. If the rate of flow through the pipe is 3.5

litre/s, find (i) the pressure drop in 300 m length of the pipe (ii) the wall shear stress and (iii) head loss due to friction.
[(CO5)(Evaluate/HOCQ)]

(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. (a) Calculate the discharge. [(CO5)(Evaluate/HOCQ)]

6 + 6 = 12

9. (a) Briefly discuss different types of minor losses that occur in pipe flow, with relevant expressions. [(CO5)(Remember/LOCQ)]

(b) The drag force $\boldsymbol{F}$ on a high speed aircraft depends on the velocity of flight $\boldsymbol{V}$, the characteristic length of the aircraft $\boldsymbol{L}$, density $\boldsymbol{\rho}$, viscosity $\boldsymbol{\mu}$ and bulk modulus of elasticity of ambient air $\boldsymbol{E}$. Using Buckingham's π theorem, obtain an expression for drag force $\boldsymbol{F}$ in terms of $\boldsymbol{\rho}$, $\boldsymbol{\mu}$, $\boldsymbol{V}$, $\boldsymbol{L}$ and $\boldsymbol{E}$. [(CO6)(Analyse/IOCQ)]

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.42	45.83	18.75

Course Outcome (CO):

After the completion of the course students will be able to

1. Examine and use different properties of fluid.
2. Apply the fundamental laws to solve problems in fluid statics of incompressible fluids.
3. Analyze fluid flow problems with application of fluid kinematics and fluid dynamics principles in engineering systems.
4. Develop the concept of boundary layer growth and boundary layer separation.
5. Examine different flow parameters for viscous flow through pipe and evaluate different losses in pipe flow.
6. Perform the dimensional analysis for fluid flow problems.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.