FLUID MECHANICS & HYDRAULICS
(MECH 2102)

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) Which one of the following is the dimension of specific weight of a liquid?
(a) $[ML^{-3}T^{-2}]$ (b) $[ML^{3}T^{-2}]$
(c) $[ML^{-2}T^{-2}]$ (d) $[ML^{2}T^{-2}]$.

(ii) According to Newton's law of viscosity, the shear stress on a layer of a fluid is _____ to the rate of shear strain.
(a) equal (b) directly proportional
(c) inversely proportional (d) none of these

(iii) Non-zero value of convective acceleration indicates
(a) non-uniform flow (b) turbulent flow
(c) laminar flow (d) unsteady flow.

(iv) Metacentric height is given as the distance between
(a) the centre of gravity of the body and the metacenter
(b) the centre of gravity of the body and the center of buoyancy
(c) the centre of gravity of the body and the and center of pressure
(d) center of buoyancy and metacenter.

(v) 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.

(vi) The flow field represented by the velocity vector $\bar{V} = \left(\frac{A}{x}\right)i + \left(\frac{Ay}{x^2}\right)j$ where A is constant, is
(a) three-dimensional and unsteady (b) two-dimensional and steady
(c) three-dimensional and steady (d) two-dimensional and unsteady

(vii) The Reynolds number for flow of oil in a certain pipe is 640. The Darcy-Weisbach friction factor 'f' for this flow is
(a) 0.64 (b) 0.01 (c) 0.1 (d) 0.064.

(viii) In a laminar flow through a circular pipe of diameter 20 cm, the maximum velocity is found to be 1 m/s. The average velocity of flow through the pipe will be
(a) 0.25 m/s (b) 0.50 m/s
(c) 0.75 m/s (d) 1 m/s.

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

(x) Kinematic similarity is said to exist between the model and the prototype, if both of them
(a) have identical velocities (b) are equal in size and shape
(c) are identical in shape, but differ only in size (d) have identical forces.

Fill in the blanks with the correct word

(xi) Stagnation pressure is the summation of static pressure and_____.

(xii) Dynamic Viscosity (μ) has the dimension of_____.

(xiii) The ratio of actual discharge to ideal discharge is called _____.

(xiv) For a two-dimensional flow field, the equation of a stream line is given by _____.

(xv) The horizontal component of buoyant force is_____.

Group - B

2. (a) How does a fluid differ from a solid? State Newton's law of viscosity. Give examples of Newtonian fluid. *[(CO1)(Understand/LOCQ)]*

(b) An oil layer thickness of 1.4 mm having viscosity of one poise is being used between a shaft of diameter 0.5 m and a sleeve of length 10 cm. Determine the power lost in the bearing when the shaft is revolving at a speed of 250 rpm. *[(CO2)(Evaluate/HOCQ)]*

6 + 6 = 12

3. (a) What are the benefits of U-tube manometer over piezometer? Why mercury widely used as manometric fluid? *[(CO1)(Remember/LOCQ)]*

(b) The inclined-tube manometer as shown in Fig.1 has D = 76 mm and d = 8 mm, and is filled with Meriam red oil. Compute the angle θ that will give a 15cm oil deflection along the inclined tube for an applied pressure of 25 mm of water (gauge). Specific gravity of Meriam red oil = 0.827. *[(CO2)(Evaluate/HOCQ)]*

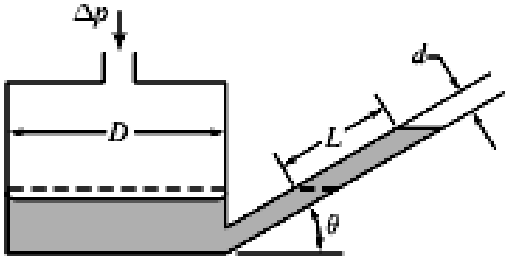

Fig. 1

6 + 6 = 12

Group - C

4. (a) Explain the effect of temperature on viscosity of liquids. What is meant by an ideal fluid? *[(CO1)(Understand/LOCQ)]*

   (b) A wooden solid cylinder (specific gravity = 0.65) 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. *[(CO2)(Analyse/IOCQ)]*

6 + 6 = 12

5. (a) What is streamline? Distinguish between streamline and pathline. *[(CO3)(Remember/LOCQ)]*

   (b) A pipe 1 m in diameter carrying water at a velocity of 4 m/s is branched into two pipes. The first branch is 0.6 m in diameter and it carries one-third of the total flow rate. In the second branch the flow velocity is 3 m/s, determine the flow velocity in the first branch pipe and the diameter of the second branch. *[(CO3)(Apply/IOCQ)]*

6 + 6 = 12

Group - D

6. (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. *[(CO3)(Analyse/IOCQ)]*

   (b) The top and bottom diameter of a 2 m long vertical tapering pipe are 100 mm and 50 mm respectively. Water flows down the pipe at 30 litre per second. Find the pressure difference between the two ends of the pipe. *[(CO3)(Evaluate/HOCQ)]*

6 + 6 = 12

7. (a) A reducer-bend having an outlet diameter of 15 cm discharges water at a rate of 0.3 m^3/s freely into atmosphere. The bend, connected to a pipe of 20 cm diameter has a deflection of 60^0 and lies in a horizontal plane. Determine the magnitude and direction of force on the anchor block supporting the pipe. *[(CO3)(Analyse/IOCQ)]*

   (b) The velocity distribution in the boundary layer is given by $\frac{u}{U} = \left(\frac{y}{\delta}\right)^{0.22}$. At a section, the free-stream velocity (U) is measured to be 20 m/s and boundary layer thickness (δ) was estimated as 30 mm. If the discharge passing over the spillway was 2 m^3/s per metre length of spillway, then calculate the displacement thickness (δ^*) and the momentum thickness (θ) where u is the velocity (parallel to the plate) at a distance y (measured vertically upward) from the plate and δ is the boundary layer thickness. *[(CO4)(Apply/IOCQ)]*

6 + 6 = 12

Group - E

8. (a) Oil of specific gravity 0.9 and viscosity 0.08 Pa-s, flows in an 80 mm diameter horizontal duct over a length of 20 m. The flow has a head loss of 2 m. Calculate (i) average velocity; (ii) wall shear stress; (iii) power required to maintain the flow. *[(CO5)(Evaluate/HOCQ)]*

   (b) An oil of specific gravity 0.9 and viscosity 6×10^{-4} 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. *[(CO 5)(Analyse/IOCQ)]*

6 + 6 = 12

9. (a) Two reservoirs are connected by two cast iron pipes in series. The discharge is 0.11 m^3/s. 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 respectively. The density and viscosity of water are 1000 kg/m^3 and 1.1×10^{-3} $N\text{-}s/m^2$ 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 2 and the adjacent reservoir but neglect the minor loss due to sudden expansion. *[(CO5)(Analyse/IOCQ)]*

   (b) The pressure difference Δp in a pipe of diameter D and length L due to viscous flow depends on velocity V, viscosity μ and density ρ. Using Buckingham's π theorem, obtain an expression for Δp in terms of ρ, μ, V, D, L. *[(CO6)(Analyse/IOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	25	50	25

Course Outcome (CO):

After the completion of the course students will be able to

CO1 Examine and use different properties of fluid
CO2 Apply the fundamental laws to solve problems in fluid statics.
CO3 Analyze fluid flow problems with application of fluid kinematics and fluid dynamics principles in engineering systems.
CO4 Describe the concept of boundary layer growth and boundary layer separation.
CO5 Relate different flow parameters for viscous flow through pipe and evaluate different losses in pipe flow.
CO 6 Implement the dimensional analysis method for fluid flow problems.

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