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) For a Newtonian fluid (CO1)
- (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) In a differential manometer, a head of 1.8 m of fluid A in limb 1 is found to balance a head of 0.9 m of fluid B in limb 2. The ratio of specific gravity of A to B is (CO2)

(a) 2.0 (b) 0.5 (c) 3.0 (d) 0.18

(iii) Non-zero value of convective acceleration indicates (CO2)
- (a) Laminar flow
- (b) Turbulent flow
- (c) Non-uniform flow
- (d) Unsteady flow.

(iv) A metal block is thrown into a deep lake. As it sinks deeper in water, the buoyant force acting on it (CO2)
- (a) increase
- (b) remains the same
- (c) decreases
- (d) first increase and then decreases

(v) Streamline and Pathline are identical when the flow is (CO3)
- (a) uniform
- (b) steady
- (c) laminar
- (d) turbulent.

(vi) Example of steady, non-uniform flow is the flow of a liquid at (CO3)
- (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.

(vii) Boundary layer thickness is the distance from the boundary to the point where velocity of the fluid is (CO4)
(a) equal to 10% of free stream velocity
(b) equal to 50% of free stream velocity
(c) equal to 90% of free stream velocity
(d) equal to 99% of free stream velocity.

(viii) Minor losses in a pipe flow are those losses (CO5)
(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.

(ix) In flow through pipes, the transition from laminar to turbulent flow does not depend on (CO5)
(a) lengthof pipe (b) density of fluid
(c) diameterof pipe (d) velocity of flow.

(x) Dimension of kinematic viscosity is (CO6)
(a) $[M^0L^{-1}T^{-1}]$ (b) $[M^{-1}L^{-1}T^{-1}]$
(c) $[M^0L^2T^{-1}]$ (d) $[M^0L^{-2}T^{-1}]$.

Group–B

2. (a) A block having dimensions 250 mm on each edge is pulled up an inclined surface on which there is an oil film of viscosity 0.037 kg/ms. Weight of the block is 45 N. If the speed of the block is 0.6 m/s and the oil film is 0.025 mm thick, find the force required to pull the block. The surface is inclined at an angle of 25° from the horizontal. [(CO1)(Evaluate/HOCQ)]
(b) How viscosity change with temperature for liquid and gas? Explain with reasons. [(CO1)(Understand/LOCQ)]

6 + 6 =12

3. (a) A simple U-tube manometer is used to measure the pressure of water in a pipe line, which isin excess of atmospheric pressure. The right limb of the manometer contains mercury and it is open to atmosphere. The contact between water and mercury is in the left limb. Determine the pressure of water in the main line, if the difference in level of mercury in the limbs of U-tube is 10 cm and the free surface of mercury is in level with the centre of the pipe. [(CO2) (Evaluate/HOCQ)]
(b) What do you mean by piezometric head? What are the limitations of piezometer? [(CO2) (Remember/LOCQ)]

7 + (2 + 3) = 12

Group - C

4. (a) A vertical rectangular gate 3.5 m wide and 5 m high contains water on one side to a depth of 2.4 mand an oil (specific gravity =0.9) to a depth of 1.5 m on the

other side. Determine the resultanthydrostatic pressure force on the gate and its point of application with respect to the bottom. [(CO2) (Analyze/IOCQ)]

(b) A barge with flat bottom and square ends has a draft of 2.0 m when fully loaded and floating in theupright position. The length of the barge is 15 m and its width is 8.0 m. The centre of gravity of thebarge when fully loaded is on the axis of symmetry and is 1.5 m above the water surface. Find out that whether the barge is in stable equilibrium or not? [(CO2) (Analyze/IOCQ)]

6 + 6 = 12

5. (a) A 40 cm diameter pipe, conveying water, branches into two pipes of diameters 30 cm and 20 cm respectively. If the average velocity in the 40 cm diameter pipe is 3 m/s, find the dischargein this pipe. Also determine the velocity in 20 cm diameter pipe if the average velocity in the30cm diameter pipe is 2 m/s. [(CO3) (Analyze/IOCQ)]

(b) In a two-dimensional incompressible flow over a solid plate, the velocity component perpendicular to the plate is given by: $v = 2x^2y^2 + 3y^3x$, where x is the coordinate along the plate and y is perpendicular to the plate. Hence find out the velocity component u, along the plate, assuming x=0, u=0.
[(CO3) (Analyze/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) (Analyze/IOCQ)]

(b) A vertical venturimeter carries water and has inlet and throat diameters of 150 mm and 75mm respectively. The pressure connection at the throat is 250 mm above that at the inlet. If the actual rate of flow is 40 litre/sec 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. [(CO3)(Evaluate/HOCQ)]

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

7. (a) A 0.3 m diameter pipe carries water under a head of 20.6 m with a velocity of 4 m/s. If the axis of the pipe turns through 45° in horizontal plane, then find the magnitude and direction of the resultant force on the bend.
[(CO3) (Analyze/IOCQ)]

(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. [(CO4)(Understand/LOCQ)]

6 + 6 = 12

Group – E

8. (a) A crude oil of kinematic viscosity 0.4 stoke is flowing through a pipe of diameter 300 mm at the rate of 300 litres per sec. Estimate the head loss due to friction for a length of 50 m of the pipe. [(CO5) (Evaluate/HOCQ)]

(b) Two reservoirs are connected by three cast iron pipes in series. 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. 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. The discharge is 0.11m^3/s. Determine the difference in elevation between the top surfaces of the reservoirs. Include the entry loss to pipe 1 and exit loss between pipe 3 and its adjacent reservoir but neglect the minor loss due to sudden expansion. [(CO5) (Evaluate /HOCQ)]

6 + 6 = 12

9. (a) The Reynolds No. for flow through a 5 cm diameter pipe is 1700. If the kinematic viscosity of oil is ν =1.02×10^{-6} m^2/s, find the velocity at a point 0.625cm from the wall. [(CO5) (Analyse /IOCQ)]

(b) The variables controlling the motion of a floating vessel through water are the drag force ***F***, speed ***V***, length ***L***, density ***ρ***, and dynamic viscosity ***μ*** of water and acceleration due to gravity ***g***. Using Buckingham's π theorem, obtain an expression for drag force ***F*** in terms of ***ρ***, ***μ***, ***V***, ***L*** and ***g***. [(CO6)(Analyse/IOCQ)]

4 + 8 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	30%	43.33%	26.67%

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 staticsof 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

Department & Section	Submission Link
ME - A	https://classroom.google.com/c/NDAxNTA2MTc3MTQz/a/NDc1MTQ2MDI2NTYx/details
ME - B	https://classroom.google.com/c/NDAzODMwNDI1MjQ1/a/NDc1MTQ3ODA0Njgy/details
BACKLOG	https://forms.gle/4X3arTTM88RWY51TA