

**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) Which fluid does not experience shear stress during flow?
(a) Pseudoplastic (b) Dilatant
(c) Inviscid (d) Newtonian
- (ii) The hydrostatic pressure in a liquid at rest
(a) remains constant only on a vertical plane
(b) increases linearly with depth below a free surface
(c) remains constant at all points in the fluid
(d) decreases linearly with depth below a free surface
- (iii) 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) $v \frac{\partial u}{\partial x} + u \frac{\partial u}{\partial y}$
- (iv) In a 2-D incompressible fluid flow, if u and v the components of velocity in x and y direction are given by $u=cx+by$ and $v=dx+ay$ respectively, (a, b, c, d are constants) then for possible flow, the condition to be satisfied is
(a) $a+c=0$ (b) $b+d=0$
(c) $a+b+c+d=0$ (d) $a+d=0$
- (v) A stagnation point is a point in fluid flow where
(a) pressure is zero (b) velocity of flow is zero
(c) total energy is zero (d) total energy is maximum
- (vi) 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

- (vii) In boundary layer flow, a negative pressure gradient is called
 (a) adverse pressure gradient (b) unstable pressure gradient
 (c) separation pressure gradient (d) favorable pressure gradient
- (viii) The shear stress in a fully developed laminar flow in a circular pipe is
 (a) constant over the cross section (b) varies parabolically across the section
 (c) maximum at the pipe wall (d) maximum at the pipe centre
- (ix) Three pipes are connected in series. Then
 (a) the head loss in each pipe is the same
 (b) the total discharge is the sum of the discharge in the individual pipes
 (c) the discharge through each pipe is the same
 (d) the Reynolds number for each pipe is the same
- (x) When a body is immersed in a flow field, the component of the resultant force acting on it in the direction of the relative velocity is called
 (a) lift force (b) shear force
 (c) body force (d) drag force

Fill in the blanks with the correct word

- (xi) Specific gravity of 1 litre of a liquid having weight 7N, is _____. (Take “g” to be 9.8 ms⁻²)
- (xii) The relationship between Absolute pressure and Vacuum pressure is given by _____
- (xiii) The dimension of stream function is _____
- (xiv) Euler’s equation of motion is based on principle of conservation of _____
- (xv) 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 _____

Group - B

2. (a) Distinguish between (i) ideal and real fluid (ii) Newtonian fluids and Non Newtonian fluid (iii) compressible fluid and incompressible fluid. [[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 mm² /s. What is the viscous force resisting the motion when the ram moves at a speed of 120 mm/s. [[CO3](Apply/IOCQ)]
6 + 6 = 12
3. (a) A plate having 0.06 mm distant from a fixed plate moves at 1.2 m/s and needs a force of 2 N per unit area in m² to maintain its speed. Calculate the viscosity of the fluid in Poise used between the planes. [[CO3](Apply/IOCQ)]
- (b) Two small vessels are connected to a U-tube manometer containing mercury (relative density 13.6) and the connecting tubes are filled with oil (relative density 0.82). The vessel at the higher pressure is 2 m lower in elevation than the other.
 (i) What is the pressure difference between the vessels when the steady difference between mercury meniscus is 225 mm?

(ii) What is the difference of piezometric head?

[[CO3](Apply/IOCQ)]

6 + 6 = 12

Group - C

4. (a) Determine the total hydrostatic force on a circular plate of diameter 1.5 m which is placed vertically in water in such a way that the centre of the plate is 3 m below the free surface of water. Also find the position of centre of pressure.

[[CO3](Analyse/IOCQ)]

(b) The velocity along the centerline of a nozzle of length L is given by $V = 2t \left(1 - \frac{x}{2L}\right)^2$, where V = velocity in m/s, t = time in seconds from commencement of flow, x = distance from inlet to nozzle. Find the convective acceleration, local acceleration and total acceleration when $t = 3$ s, $x = 0.5$ m and $L = 0.8$ m.

[[CO5](Apply/IOCQ)]

6 + 6 = 12

5. (a) The gate as shown in Fig 1 is 3 m wide and 5 m long is hinged at the base and it is inclined at an angle of 60° with the horizontal. The upper end of the gate is kept in position by a weight of 2500 kg acting perpendicularly to the gate through a pulley system. If the weight of the gate and the friction at the hinge and pulley is neglected, then for what depth (h) of water will this rectangular gate be in equilibrium?

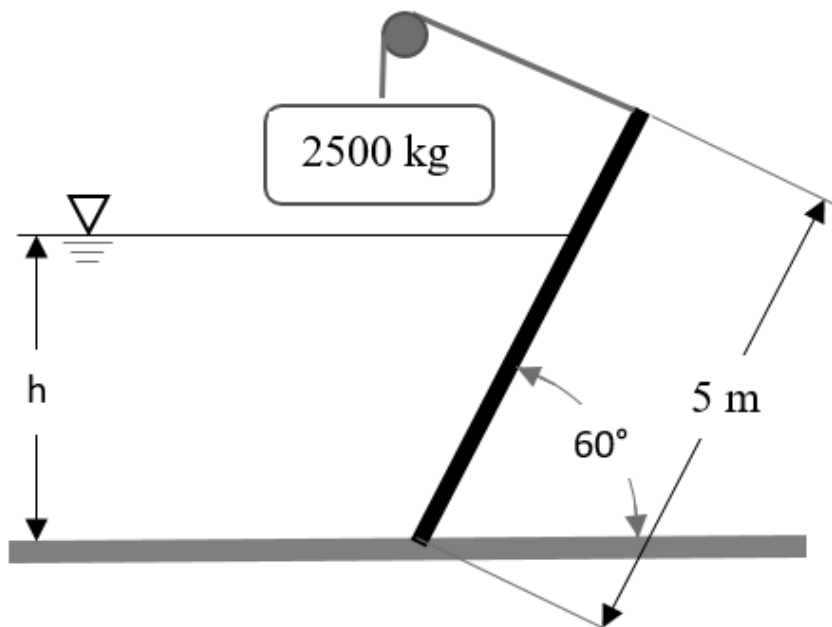


Fig. 1

[[CO3](Evaluate/HOCQ)]

(b) Discuss briefly with example (i) Flow field (ii) Non-Uniform flow (iii) Steady flow.

[[CO2](Remember/LOCQ)]

6 + 6 = 12

Group - D

6. (a) A horizontal pipe of diameter 200 mm converges to a diameter of 100 mm. The pipe conveys water, the pressure intensities being 400 kPa and 250 kPa at the larger and the smaller sections respectively. Ignoring energy losses, find the discharge.

[[CO5](Analyse/IOCQ)]

- (b) A 20 cm diameter inclined water pipe has in it a venturimeter of throat diameter 12.5 cm, which is connected to a differential mercury manometer showing a deflection of mercury 86.5 cm. Assuming water as ideal fluid, find the velocity of water in throat, and the discharge. [[CO5](Analyse/IOCQ)]
6 + 6 = 12
7. (a) For flow over a flat plate of length L, the velocity profile in the laminar boundary layer is given by $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$. The symbols have their usual meanings. Find the expressions for the displacement thickness (δ^*) and momentum thickness (θ) in terms of boundary layer thickness (δ). [[CO4](Apply/IOCQ)]
- (b) The efficiency η of a fan depends on density ρ , viscosity μ , angular velocity ω , diameter D of the rotor and the discharge Q. Using Buckingham's π theorem, obtain an expression for η in terms of ρ , μ , ω , D, Q. [[CO4](Apply/IOCQ)]
6 + 6 = 12

Group - E

8. (a) Discuss briefly (i) Critical Reynolds Number (ii) Laminar Flow (iii) Turbulent flow [[CO1](Remember/LOCQ)]
- (b) A viscous liquid is flowing in a laminar regime in a 12 cm diameter, circular horizontal pipe. A Pitot tube at a radial distance of 2 cm from the axis indicates a velocity of 0.6 m/s. Calculate the maximum velocity and the discharge in the pipe. If dynamic viscosity of the liquid is 0.1 N-s/m², find the shear stress at the pipe wall. [[CO6](Evaluate/HOCQ)]
6 + 6 = 12
9. (a) A crude oil (specific gravity 0.9) flows through a horizontal pipe 100 mm in diameter and 10m long and 1000 kg of oil is collected in 5 min. If the pressure difference at the two ends is 14.715 kPa, calculate the viscosity of the oil. [[CO6](Evaluate/HOCQ)]
- (b) A man descends to the ground with the help of a parachute from an aeroplane against the resistance of air with a uniform velocity of 10 m/s. The parachute is negligible in weight and hemispherical in shape and is having diameter of 5m. Find the weight of the man if $C_d = 0.5$ and $\rho_{\text{air}} = 1.25 \text{ kg/m}^3$. [[CO4](Apply/IOCQ)]
6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18.75	56.25	25