# FLUID MECHANICS
## (MECH 2103)

**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) Kinematic viscosity has dimension of
(a) $L^{-2}T^{1}$ (b) $MLT^{-1}$ (c) $L^{2}T^{-1}$ (d) $ML^{-1}T^{-1}$.

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

(iii) The line of action of the buoyancy force acts through the
(a) centre of gravity of any submerged body
(b) centroid of the volume of any floating body
(c) centroid of the displaced volume of fluid
(d) centroid of the volume of fluid vertically above the body.

(iv) The abscissa of rheological diagram represents
(a) ideal solid (b) pseudoplastic fluid
(c) ideal fluid (d) dilatant fluid

(v) The continuity equation $\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0$ is based on principle of conservation of
(a) mass (b) momentum
(c) energy (d) pressure.

(vi) Three pipes connected in series at the two ends have flow-rates $Q_1$, $Q_2$ and $Q_3$ respectively, and the corresponding frictional head losses are $h_{L1}$, $h_{L2}$ and $h_{L3}$ respectively. The correct expressions for total flow rate (Q) and frictional head loss across the two ends ($h_L$) are

(a) $Q = Q_1 + Q_2 + Q_3$ ; $h_L = h_{L1} + h_{L2} + h_{L3}$

(b) $Q = Q_1 + Q_2 + Q_3$ ; $h_L = h_{L1} = h_{L2} = h_{L3}$

(c) $Q = Q_1 = Q_2 = Q_3$ ; $h_L = h_{L1} + h_{L2} + h_{L3}$

(d) $Q = Q_1 = Q_2 = Q_3$ ; $h_L = h_{L1} = h_{L2} = h_{L3}$.

(vii) The differential equation for pressure variation in a static fluid may be written (y measured vertically upward)

(a) $dp = -\gamma dy$ (b) $d\rho = -\gamma dy$

(c) $dy = -\rho dp$ (d) $dp = -y d\rho$.

(viii) In a venturimeter, the pressure of liquid at throat is

(a) Equal to inlet pressure

(b) Higher than at inlet pressure

(c) Lower than at inlet pressure

(d) Equal to an outlet pressure.

(ix) The boundary layer exists due to

(a) Gravitational force (b) Surface tension

(c) Density of fluid (d) Viscosity of fluid.

(x) If there are 6 physical quantities and 3 fundamental units, then the number of dimensionless π term

(a)1 (b) 2 (c) 3 (d) 4 .

## Group – B

2. (a) The space between two square plates of side of 0.5 m is filled with an oil film of thickness 1.2 cm. The upper plate is moving with a velocity of 2.4 m/s needs a force of 98 N to maintain its speed. Calculate the dynamic viscosity of the oil.

(b) A triangular plate base of 1.5 m and height 2 m is submerged in oil (specific gravity =0.92). The plane of the plate is inclined at 30° with free oil surface and the base is parallel and it is at a depth of 1 m from the oil surface. Determine the total pressure and position of centre of pressure on one face of the plate.

**6 + 6 = 12**

3. (a) The velocity vector in a fluid flow is given by: $\overline{V} = 2x^3\hat{i} - 6x^2y\hat{j}$. Find the equation of streamline when it passes through a point A (3,2).

(b) In a 2-D incompressible flow over a solid plate, the velocity component perpendicular to the plate is $V = 2x^2y^2 + 3y^3x$, where x is the coordinate along the plate and y is perpendicular to the plate. Hence find out:

(i) The velocity component u, along the plate, assuming at x=0, u=0.

(ii) An expression for stream function.

(iii) Verify whether the flow is irrotational or not.

**5 + 7 = 12**

## Group – C

4. (a) What is an Orificemeter ? What are the merits and demerits of Orificemeter? Write down the assumptions of Bernoulli's equation.

(b) Water flows at a rate of 0.037 $m^3/s$ through a horizontal enturimeter having inlet diameter 300 mm and throat diameter 150 mm. The manometer connected with the venturimeter is deflected by 1 m. If the specific gravity of the manometric liquid is 1.25, determine the coefficient of discharge of the venturimeter.

**(1+ 2 + 3) + 6 = 12**

5. (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°, then find the magnitude and direction of the resultant force on the bend.

(b) A rectangular notch of length 1 m and height 40 cm discharges water. If the same quantity of water is allowed to flow over a right-angled V-notch, then determine the height to which water will rise above the apex of the notch. Take coefficient of discharge for both notches as 0.623.

**6 + 6= 12**

## Group – D

6. (a) An oil of viscosity 0.9 poise and specific gravity 0.89 flows through a horizontal pipe of diameter 90 mm and length 9 m. If oil is collected in a tank in $4.5\times10^{-4} m^3/s$ rate, then determine the pressure difference between the two ends of the pipe.

(b) What power will be required per km length of a pipeline, to overcome viscous resistance, to the flow of oil, of viscosity 2 Poise, through a horizontal 10 cm diameter pipe, at a rate of 200 litres/min. Find the Reynolds number of flow if the specific gravity of oil is 0.92.

**6 + 6= 12**

7. (a) Briefly discuss different types of minor losses that occur in pipe flow, with relevant expressions.

(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. Find out the Reynolds Number in each of the pipe. 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. 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.

**5 + 7 = 12**

## Group – E

8. (a) For flow over a flat plate of length L, the velocity profile is given by $\frac{u}{U} = \frac{y}{\delta}$. The symbols have their usual meanings. Find the expression for the displacement thickness (δ*) and momentum thickness (θ) in terms of boundary layer thickness (δ).

(b) Air of density 1.2 kg/m$^3$ moves at a speed of 40 km/hr in a stationary flat plate of size 1 m ×1 m. If the drag and lift coefficients are 0.16 and 0.8, respectively, then determine (i) the drag force and (ii) lift force.

**(4+4) + 4= 12**

9.(a) Define (i) Drag force & (ii) Lift force

(b) The velocity of flow V through a circular orifice depends on head causing flow H, diameter of the orifice D, coefficient of viscosity $\mu$, mass density $\rho$ and acceleration due to gravity g. Using Buckingham's $\pi$ theorem, obtain an expression for velocity V in terms of H, D, $\mu$, $\rho$ and g.

**4 + 8 = 12**

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