(iii) head loss over a length of 12 m (iv) power expended by the flow in a distance of 12 m.

(2 + 2) + 8 = 12

Group – E

8. (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).

   (b) For the velocity profiles given below, state with reason whether the boundary layer has separated or on the verge of separation or will remain attached with the surface:

   (i) $\frac{u}{U}=2\left[\frac{y}{\delta}\right]-\left[\frac{y}{\delta}\right]^2$ (ii) $\frac{u}{U}=\frac{3}{2}\left[\frac{y}{\delta}\right]^2+\frac{1}{2}\left[\frac{y}{\delta}\right]^3$

(4 + 4) + 4 = 12

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

   (b) Fluid of density ρ and viscosity μ flows at an average velocity V through a circular pipe of diameter D. The shear stress at pipe wall τ_w depends on ρ, μ, V and D. Using Buckingham's π theorem, obtain an expression for τ_w in terms of ρ, μ, V and D.

4 + 8 = 12

B.TECH/ME/3RD SEM/MECH 2103(BACKLOG)/2019

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) Dynamic viscosity has dimension of
   (a) $L^{-2}T^{1}$ (b) $M\,LT^{-1}$ (c) $ML^{-1}T^{-1}$ (d) $L^{-1}T^{2}$.

   (ii) The centroid of the volume of liquid displaced by a submerged body is called
   (a) centre of gravity (b) centre of buoyancy
   (c) metacentre (d) centre of volume.

   (iii) 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.

   (iv) Streamlines, Pathlines and Streaklines are identical when
   (a) the flow is uniform (b) the flow is steady
   (c) the flow is unsteady (d) the flow is non-uniform.

   (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) The number by which laminar and turbulent flow is characterized is called
   (a) Prandtl number (b) Reynolds number
   (c) Froude number (d) Mach number.

   (vii) The velocity in a fully developed laminar flow in a circular pipe is
   (a) constant over the cross section

(b) varies linearly across the section
(c) maximum at the pipe wall
(d) maximum at the pipe centre.

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

(ix) The separation of boundary layer takes place when the pressure gradient is
(a) negative (b) positive (c) zero (d) infinite.

(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) State Newton's law of viscosity. Why does the viscosity of gas increase with increase in temperature, while that of liquid decrease with increase in temperature?

(b) A rectangular plane surface 3 m wide and 4 m deep lies in water in such a way that its plane makes an angle 30^o with the free surface of water. Determine the total hydrostatic force on position of centre of pressure, when upper edge of the plane is 2 m below the free surface.

(2 + 4) + 6 = 12

3. (a) The velocity vector in a fluid flow is given by: $\boldsymbol{V} = 4x^3\boldsymbol{i} - 10x^2y\,\boldsymbol{j} + 2t\,\boldsymbol{k}$. Find the velocity and acceleration of a fluid particle at (2, 1, 3) at time t = 1 sec.

(b) In a two-dimensional 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.

(3 + 3) + 6 = 12

Group – C

4. (a) Write Bernoulli's equation, stating the assumptions.

A pipe of diameter 250 mm conveys water at the rate of 2.4 m^3/min and has a pressure of 20 kPa at a certain section. Find the total energy head with respect to a datum 4000 mm below the pipe.

(b) A vertical venturimeter has an area ratio of 5 (Pipe cross section area/throat area). It has a throat diameter of 1 cm. When oil of sp. gr. 0.8 flows through it, the mercury in the differential gauge indicates a difference in height of 12 cm. Find the discharge through the pipe.

(3 + 3) + 6 = 12

5. (a) A pipe of 300 mm diameter conveying 0.3 m^3/s of water has a right angled bend in a horizontal plane as shown in Fig.1. Find the resultant force exerted on the bend if the pressure at inlet and outlet of the bend are 24.525 N/cm^2 and 23.544 N/cm^2.

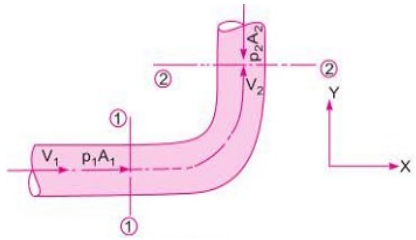

Fig.1

(b) Water flows over a triangular right angled weir first and then over a rectangular weir of 1m width. The depth of water over the triangular weir is 360 mm. Taking C_d for the triangular and the rectangular weir as 0.6 and 0.7 respectively, find the depth of water over the rectangular weir.

6 + 6 = 12

Group – D

6. (a) Oil of sp. gravity 0.9 and viscosity 2.5 Poise is pumped through a 100 mm diameter pipe – 500 m long – at a rate of 2 litre/s. Find (i) Reynolds number of flow (ii) the pressure required at the pipe inlet if the pipe outlet is open to the atmosphere and is 20 m above the inlet.

(b) For fully developed laminar, steady flow through pipe show that $U_{max} = 2U_{avg}$ where U_{max} = maximum velocity and U_{avg} = average velocity.

7 + 5 = 12

7. (a) What is Moody's diagram? State its significance in pipe flow analysis.

(b) Glycerine (μ = 1.5 Pa-s and ρ = 1260 kg/m^3) flows at an average velocity of 5 m/s in a 10 cm diameter pipe. Find (i) the regime of flow (laminar/turbulent) (ii) the wall shear stress in the pipe due to the flow