B.Tech/ME/3rd Sem/MECH-2103/2015

2015

FLUID MECHANICS

(MECH 2103)

Time Alloted : 3 Hours *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 alternatives for the following : **[10×1=10]**

   i) The piezometric head in a static liquid
   (a) remains constant only on a horizontal 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

   ii) Stream line, path line and streak line are identical when
   (a) the flow is uniform
   (b) the flow is steady
   (c) the flow velocities do not change steadily with time
   (d) the flow is neither steady nor uniform

iii) For stable equilibrium of floating bodies, the centre of gravity has to
(a) be always below the centre of buoyancy
(b) be always above the centre of buoyancy
(c) be always above the metacentre
(d) be always below the metacentre

iv) Velocity potential exists for
(a) flow of perfect fluid only
(b) steady, irrotational flow only
(c) all irrotational flows
(d) all 3-D flows

v) Bernoulli's equation is applicable between any two points
(a) in any rotational flow of an incompressible fluid
(b) in any type of irrotational flow of fluid
(c) in steady rotational flow of an incompressible fluid
(d) in steady irrotational flow of an incompressible fluid

vi) 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

vii) Which of following instrument can be used for measuring speed of an aeroplane?
(a) Venturimeter (b) Orificemeter
(c) Rotameter (d) Pitot tube

viii) Which of the following is not a dimensionless parameter?

(a) Friction factor
(b) Specific speed
(c) Thomas's cavitation parameter
(d) Pressure co-efficient

ix) The separation of a boundary layer occurs when

(a) the flow is accelerated past a boundary
(b) the boundary layer comes to rest
(c) any adverse pressure is encountered
(d) the fluid is ideal.

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

GROUP - B

2. (a) Derive the expression $h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h}$ where the symbols have their usual meanings.

(b) A solid cylinder of diameter 5 m has a height of 5 m. Find the meta-centric height of the cylinder if the specific gravity of the material of the cylinder is 0.7 and it is floating in water with its axis vertical. State whether the equilibrium is stable or unstable. **7+5 = 12**

3. (a) 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; 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.

(b) The velocity vector is an incompressible flow is given by, $V = (6xt + yz^2)\mathbf{i} + (3t + xy^2)\mathbf{j} + (xy - 2xyz - 6tz)\mathbf{k}$.

(i) Verify whether flow is possible.
(ii) Determine the acceleration vector at point A (1,1,1) at $t = 1.0$ sec

6+(2+4) = 12

GROUP - C

4. (a) With necessary assumptions deduce Bernoulli's equation and write the significance of each terms of the Bernoulli's equation.

(b) Water flows up a vertical venturimeter whose inlet and throat diameters are 250 mm and 125 mm respectively, the throat section being 0.30 m above the inlet section. The pressure at inlet and the throat sections are 60 kPa and 20 kPa respectively. Find the steady rate of flow through the venturimeter. Take the value of coefficient of discharge = 0.98. **6+6 = 12**

5. (a) A 45° reducing pipe-bend in a horizontal plane (shown in Fig.1) tapers from 600 mm diameter at the inlet to 300 mm diameter at the outlet. The pressure at the inlet is 140 kPa gauge and rate of flow of water through the bend is 0.425 m^3/s. Neglecting friction, calculate the

magnitude and direction of net resultant horizontal force exerted by water on the bend. Assume uniform conditions with straight and parallel streamlines at inlet and outlet and the fluid to be frictionless.

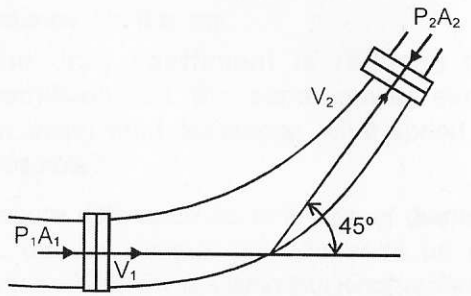

Fig.1

(b) Water flows through a triangular right angled weir first and then over a rectangular weir of 1 m width. The discharge coefficients of the triangular and rectangular weirs are 0.6 and 0.7 respectively. If the depth of water over the triangular weir is 360 mm, find the depth of water over the rectangular weir. **6+6 = 12**

Group - D

6. (a) Oil of specific gravity 0.92 and viscosity 0.082 Pa-s, flows in an 80mm diameter duct over a length of 20m. The flow has a head loss of 2m. Calculate
   (i) average velocity;
   (ii) velocity and shear stress at a radial distance of 38 mm;
   (iii) wall shear stress;
   (iv) discharge;
   (v) power required to maintain the flow.

(b) The difference in water surface levels in two tanks, which are connected by three pipes in series of lengths 300 m, 170 m and 210 m and of diameters 30 cm, 20 cm and 40 cm respectively, is 12 m. Determine the rate of flow of water if coefficient of friction are 0.005, 0.0052 and 0.0048 respectively. **6+6 = 12**

7. (a) An oil of sp. gr. 0.7 is flowing through a pipe of diameter 30cm at the rate of 500 litre/sec. Find the head loss due to friction and power required to maintain the flow over a length of 1000 m. Take ν = 0.29 stokes.

$$\left[\text{Given, } f = \frac{0.079}{(R_e)^{1/4}}\right]$$

(b) (i) What are the purposes of Moody's diagram?
(ii) Write the expression of Hagen-Poiseuille equation stating the assumption. **6+(3+3) = 12**

GROUP - E

8. (a) Explain Growth of boundary layer over a flat plate with neat sketch.

(b) Find the displacement thickness (δ^*), the momentum thickness (θ), shear stress at wall (τ_w) for the velocity distribution in the boundary layer given by $u/U = y/\delta$, where u is the velocity (parallel to the plate) at a distance y (measured vertically upward) from the plate and u = u at y = δ, where δ is the boundary layer thickness. Also calculate the value of (δ^*/δ). **4+8 = 12**

9. (a) A car has a frontal projected area of 1.6 m^2 and travels at velocity 60 km/h. It has a drag coefficient of 0.35 based on frontal area.

   (i) Calculate the power required to overcome the wind resistance by the car.

   (ii) If the drag coefficient is reduced to 0.3 by streamlining, for the same power expended in overcoming wind resistance, what speed of the car is possible?

   (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.

(2+2)+8 = 12