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

(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) The material acceleration is zero for a
(a) steady flow (b) steady and uniform flow
(c) unsteady and uniform flow (d) unsteady and non-uniform flow.

(v) 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) and (b) are correct.

(vi) The cylindrical portion of short length, which connects converging and diverging section of venturimeter, is called as
(a) diffuser (b) connector
(c) throat (d) manometer tube.

(vii) For a fully developed laminar flow in a circular pipe, if the diameter of the pipe is halved, keeping the flow rate and pipe length constant, the head loss due to friction increases by a factor of
(a) 4 (b) 8 (c) 16 (d) 32.

(viii) At the point of separation of boundary layer
(a) pressure gradient is positive (b) pressure gradient is negative
(c) pressure gradient is zero (d) pressure gradient is infinite.

(ix) For hydrodynamically smooth pipes, the friction factor *f* is a
(a) function of Reynolds number only
(b) function of relative roughness only
(c) function of Reynolds number and relative roughness
(d) constant.

(x) If there are 6 physical quantities and 3 fundamental units, then the number of π-terms are
(a) 1 (b) 2 (c) 3 (d) 4.

Group – B

2. (a) A vertical cylinder of diameter 16 cm rotates concentrically inside another cylinder of dimeter 16.1 cm. The clearance between the cylinders is filled with a liquid of unknown viscosity which has a linear viscosity profile and both cylinders are 24 cm long. Find the viscosity of the liquid if a torque of 10 Nm is required to rotate the inner cylinder at a speed of 50 rpm. Assume the outer cylinder is fixed.

(b) Define compressibility of fluid. How does it related to modulus of elasticity? Discuss how viscosity of liquid varies with temperature.

6 + (2 + 1 + 3) = 12

3. (a) What is Pascal's law? What do you understand by Hydrostatic law?

(b) A conical vessel having its outlet at A to which a U-tube manometer is connected as shown in the following Fig.1. The reading of the manometer indicated shows when the vessel is empty. Find the corresponding reading when the vessel is completely filled with water.

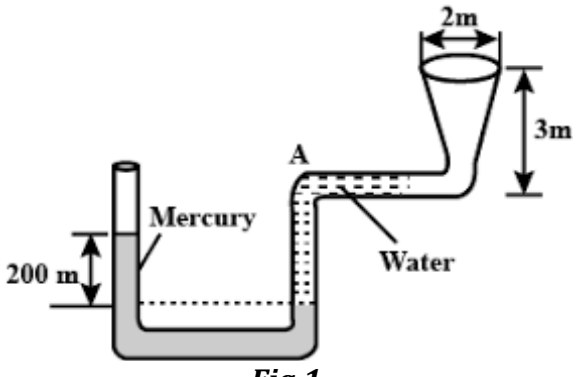

Fig.1

(2 + 2) + 8 = 12

Group – C

4. (a) Fig.2 illustrates an inclined rectangular sluice gate PQ of size 1m×3 m hinged at point P and rest on Q which controls the discharge of water. Determine the force (F_Q shown in the figure) normal to the gate applied at Q to open it. (Assuming the gate is weightless).

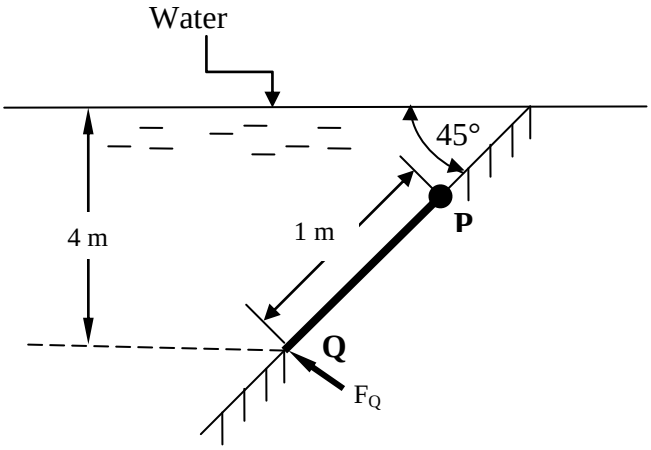

Fig.2

(b) A rectangular barge of dimensions 10 m × 3 m weighs 75000 kg and its centre of gravity lies 1.3 m above the bottom. Determine the metacentric height when it floats in fresh water.

7 + 5 = 12

5. (a) For a three-dimensional flow the velocity distribution is given by $u = -x$, $v = 3 - y$ and $w = 3 - z$. What is the equation of a streamline passing through (1,2,2)?

(b) With appropriate examples explain the following types of fluid flow:
(i) Steady but Non-uniform flow, (ii) Uniform flow, (iii) Two-dimensional flow.

6 + 6 = 12

Group – D

6. (a) A conical tube is fixed vertically with its smaller end upwards and it forms a part of pipeline. The velocity at the smaller end is 4.5 m/s and at the large end 1.5 m/s. Length of conical tube is 1.5 m. The pressure at the upper end is equivalent to a head of 10 m of water. Neglecting friction, determine the pressure at the lower end of the tube if flow direction is downwards.

(b) Consider a 3-D flow field. Given, $u = ln\ (y^2 + z^2)$ and $w = ln\ (x^2 + y^2)$. Find out the expression of v (component of velocity along y axis) so that the flow is possible for a steady incompressible fluid flow.

6 + 6 = 12

7. (a) A reducer-bend having an outlet diameter of 15 cm discharges water at a rate of $0.3 m^3/s$ freely into atmosphere. The bend, connected to a pipe of 20 cm diameter has a deflection of 60° and lies in a horizontal plane. Determine the magnitude and direction of force on the anchor block supporting the pipe.

(b) For flow over a plate of length L, the velocity profile in the laminar boundary layer is given by $\frac{u}{U_\infty} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$. The symbols have their usual meanings. Find the displacement thickness (δ^*) and the momentum thickness (θ) in terms of boundary layer thickness (δ).

6 + 6 = 12

Group – E

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

(b) An oil of viscosity 0.1N-s/m^2 and specific gravity 0.9 flows through a horizontal pipe of 50 mm diameter and 300 m length. If the rate of flow through the pipe is 3.5 litre/s, find (i) the pressure drop in 300 m length of the pipe (ii) the wall shear stress and (iii) head loss due to friction.

5 + (3 + 2 + 2) = 12

9. (a) For a laminar flow of viscous fluid in circular pipe, show that shear stress distribution at wall is linearly varying with radius of pipe.

(b) The pressure difference ΔP in a pipe of diameter D and length L due to viscous flow depends on the velocity V, viscosity μ and density ρ. Using Buckingham's π-theorem, obtain an expression for ΔP.

4 + 8 = 12

Department & Section	Submission Link
ME A	https://classroom.google.com/w/MTIyNDY1Njk2NTY2/t/all
ME B	https://classroom.google.com/c/Mjc0NDMwNjA1NzU5/a/Mjc0NDMwNjA1NzY0/details