B. E. CIVIL ENGG. SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM - 2023

FLUID MECHANICS

Time: Three Hours **Full Marks: 100**

Assume any relevant data** if necessary **with suitable justifications.

***SYMBOLS** should be **properly described** along with the **necessary SKETCHES** whenever applicable.*

Symbols used in this question paper carry their usual meanings.

Answer any FIVE Questions.

All the parts of a question** must be **answered together.

1. (i) With the proper unit, define viscosity, temporal acceleration, convective acceleration, pressure head, and Reynolds number.

   (ii) Explain all kinds of fluids with the help of a neat diagram, illustrating Newtonian and non-Newtonian fluids with suitable examples.

   (iii) A shaft (of 80 mm diameter) rotates at 900 rpm in a bearing sleeve (of 80.2 mm diameter and 0.3 m long). The clearance space between the shaft and bearing is flooded with lubricating oil of viscosity 0.1 kg/ms and specific gravity 0.9. With proper assumptions, estimate the resisting torque exerted by the oil and the power required to rotate the shaft. **[6+7+7]**

2. (i) State and prove Pascal's law of hydrostatic pressure with appropriate sketches.

   (ii) Derive the expressions for the hydrostatic force and the centre of pressure of a submerged flat surface of an elliptical shape.

   (iii) A circular plate 2.5 m in diameter is immersed in water its greatest and least depth below the free surface being 4 m and 2 m respectively. Find the total pressure on the side of the plate and the position of the centre of pressure. **[6+7+7]**

3. (i) Define streamline, path line, irrotational flow, and laminar flow.

   (ii) If $u = 2x^2 + 3y$, $v = -2xy + 3y^2 + 3zy$, and $w = -(3/2)z^2 + 2xz - 9y^2z$ are the components of flow velocity, find the magnitudes and directions of (i) translational velocity, (ii) rotational velocity, (iii) acceleration, and (iv) the vorticity of a fluid element at (1, 1, 1). Is it irrotational flow? **[8+(3×4)]**

4. (i) With neat sketches and usual symbols, derive Euler and Bernoulli equations for a flow along a streamline; clearly state all the assumptions and explain all the terms in Bernoulli equations.

   (ii) A venturi meter has its axis vertical, the inlet and throat diameters being 150 mm and 75 mm respectively. The throat is 225 mm and located above the inlet and Cd = 0.96. Petrol of specific gravity 0.78 flows up through the meter at a rate of 0.029 m^3/s. Find the pressure difference between the inlet and the throat, and the manometer reading. **[10+10]**

5. (i) An oil (specific gravity 0.83 and viscosity 0.08 kg/ms) passes through a pipe of 12 mm diameter with a maximum velocity of 4.6 m/s. Determine (a) Reynolds number, (b) mass flow rate in kg/s, (c) friction coefficient *f*, and (d) pressure gradient along the pipe.

   (ii) A bend in a pipeline conveying water gradually reduces from 0.6 m to 0.3 m in diameter and deflects the flow through an angle of 60°. At the larger end, the gauge pressure is 171.675 kN/m^2. If the frictional head in this bend is 0.5 m, determine the magnitude and direction of the force exerted on the bend when the flow is 876 litres/second. **[6+14]**

6. Derive the Hagen-Poiseuille's velocity profile and pressure drop for pipe flow, clearly mentioning all the assumptions used during the derivation. **[20]**

7. (i) For the case of open channel flow, derive Chezy's equation and relate it to Manning's formula, with a neat sketch indicating all the forces.

(ii) A channel of the trapezoidal section, having side slopes 3 horizontal to 2 vertical, is to carry a flow of 10 m^3/s on a longitudinal slope of 1 in 5000. The channel is to be lined for which the value of friction coefficient in Manning's formula is n = 0.012. Find the dimensions of the economic channel section and identify the state of flow (whether rapid or tranquil). **[10+10]**

8. Answer **ANY FOUR** **[5×4 = 20]**

Write short notes on the following topics.

i) Scale of pressure measurement
ii) Metacentre
iii) Steady non-uniform flow
iv) Sudden expansion losses in a pipe
v) Pipes in parallel
vi) Hydraulic Jump