B. E. CIVIL ENGG. 2ND YR 1ST SEMESTER EXAMINATION 2025

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) State Newton's law of viscosity and obtain the dimension of viscosity from the mathematical expression of the law.

   (ii) Citing example for each classify Newtonian and Non-Newtonian fluids.

   (iii) The space between two large flat and parallel walls 25 mm apart is filled with a liquid of dynamic viscosity 0.7 Pas. Within this space a thin flat plate 250 mm × 250 mm is towed at a velocity of 150 mm/s at a distance of 6 mm from one wall, the plate and its movement being parallel to the walls. Draw the schematic of the situation showing the dimensions. Assuming linear variations of velocity between the plate and the walls, determine the force exerted by the liquid on the plate.

   [5+5+10]

2. (i) Using the principle of hydrostatic pressure variation, obtain the expression of hydrostatic thrust and its point of application (centre of pressure) for an inclined plane submerged surface. All notations for the derivation should be shown in a neat schematic diagram.

   (ii) A spherical balloon, of diameter 1.5 m and total mass 1.2 kg, is released in the atmosphere. Assuming that the balloon does not expand and that the temperature lapse rate (λ) in the atmosphere is 0.0065 K/m, determine the height above sea-level to which the balloon will rise. Atmospheric temperature and pressure at sea-level are 15°C and 101 kPa respectively; for air, R = 287 J/kg K.

   [10+10]

3. (i) With the help of an appropriate sketch explain how pressure can be measured using a simple U-tube mercury manometer.

   (ii) Water is raised from a reservoir through a vertical tube by the sucking action of a piston. Determine the force needed to raise the water to a specified height of 1.5 m. Take the density of water to be 1000 kg/m^3 and the diameter of piston as 0.3 m. Use the value of atmospheric pressure as 95 kPa.

   (iii) The cross-section of a dam is a quarter-circle having radius 10m. Find the hydrostatic force on the dam and its line of action if the dam is completely filled with water. Take the density of water to be 1000 kg/m^3 throughout.

   [5+5+10]

4. (i) Discuss Lagrangian and Eulerian approaches in describing fluid motion. Establish a correlation between these two approaches for acceleration of a fluid particle.

   (ii) A 2D flow field is given by $u = (1/3)y^3 + 2x - x^2y$ and $v = xy^2 - 2y - (1/3)x^3$. (a) Show that it is a case of irrotational flow (b), obtain expressions for stream function ψ and (c) velocity potential ϕ.

   [10+(2+4+4)]

5. (i) Define control volume. Derive continuity equation in differential form for a control volume in three dimensional Cartesian frame of reference.

(ii) A Venturi meter is installed in an inclined tube for measuring the flow rate. The meter is connected with a mercury U-tube manometer. Draw the complete installation and obtain the expression of the flow rate in terms of the reading of U-tube manometer.

[10+10]

6. (i) A horizontal pipe of 100 mm diameter connects a reservoir containing oil of relative density 0.8 and a nozzle whose exit diameter is 25 mm. The free surface of oil in the reservoir is 4 m above the axes of the pipe and the nozzle. Assuming the total head loss as $20V^2/(2g)$, V and g being the average flow velocity in the pipe and acceleration due to gravity respectively, find the discharge and the pressure at the nozzle base, where its diameter is 100 mm.

   (ii) A 7.5 cm diameter water jet having a velocity of 12 m/s impinges on a smooth plate at an angle of 60^0 to the normal to the plate. What will be the impact force when (i) the plate is stationary and (ii) when moving in the direction of the jet at 6 m/s?

   [10+(6+4)]

7. (i) With an appropriate schematic diagram and necessary assumptions, derive Hagen-Poiseuille equation.

   (ii) Oil, of relative density 0.83 and dynamic viscosity 0.08 kg/ms, passes through a circular pipe of 12 mm diameter with a flow rate of 15 lpm. Determine (a) Reynolds number, (b) maximum velocity, (c) pressure gradient along the pipe, (d) wall shear stress and (e) friction factor.

   [10+(2x5)]

8. Write short notes on the following (ANY FOUR)

   i) Streamlines and Path lines
   ii) Stability of floating bodies
   iii) Dynamic and stagnation pressure
   iv) Chezy's equation
   v) Moody's diagram
   vi) Rapid and Tranquil flow

   [5×4 = 20]