B. E. CONSTRUCTION ENGINEERING

SECOND YEAR FIRST SEMESTER - 2024

HYDRAULICS

Time : 3 Hours   **Full Marks : 100**

Answer <u>Question No. 1 (compulsory)</u> and <u>Any 4 Questions from the rest.</u>

### Answer to all parts of a Question must be presented together.

Assume any data, if not furnished, consistent with the problem.

1. (a) Explain the formation of boundary layer over a flat plate when the same is introduced in a free stream flow with the help of a neat and labelled diagram. **[5]**

    (b) Describe the variation of vapour pressure of a fluid with change in temperature of the fluid. Explain the phenomenon of cavitation. **[3 + 3]**

    (c) What is Stokes hypothesis? What assumptions are considered for a fluid flow when deriving Bernoulli's equation? **[2 + 2]**

    (d) Define absolute pressure, gauge pressure and vacuum pressure and show the relationship amongst them with the help of a neat and labelled diagram. **[5]**

2. (a) State Pascal's Law. State the Hydrostatic Law. **[2 + 2]**

    (b) Explain the term 'Fully Developed Flow' for a Plane Poiseuille flow with the help of a neat and labelled diagram. **[8]**

    (c) Describe the working principle of an U – Tube Manometer with the help of a neat and labelled diagram. State a situation (if any) when a piezometer is a better choice as a pressure measuring device than an U – Tube Manometer. **[6 + 2]**

3. (a) What is the Eulerian method of describing the motion of fluid in a fluid flow? **[2]**

    (b) A fluid flow is described using the following velocity field, $\vec{V} = (8 + xy^2)\hat{\imath} + (yt - 3zy)\hat{\jmath} + (zt^2 - 5zx^2 + xy)\hat{k}$. Find the acceleration vector and velocity magnitude at position coordinates (2,-1,-7) and t = 3. **[8]**

    (c) A fluid flow is described using the following velocity field, $\vec{V} = (-4xy^2)\hat{\imath} + (2y^2 - zx)\hat{\jmath} + (y^2z - 2zx^2)\hat{k}$, at coordinates (-1,1,-3). Find out (i) If the flow is compressible or incompressible? (ii) If the flow is rotational or irrotational? **[5 + 5]**

4. (a) Describe streamlines in a fluid flow and their primary characteristics. What is a stream tube? **[3 + 2]**

(b) Derive the Continuity Equation in its Three (3) – Dimensional Cartesian coordinate form. [Properly mention any assumptions or correlations taken during simplification] [10]

(c) What is an inviscid flow and in which region of a fluid flow is it observed? State Euler's equation of motion in either one of the coordinate directions. [3 + 2]

5. (a)
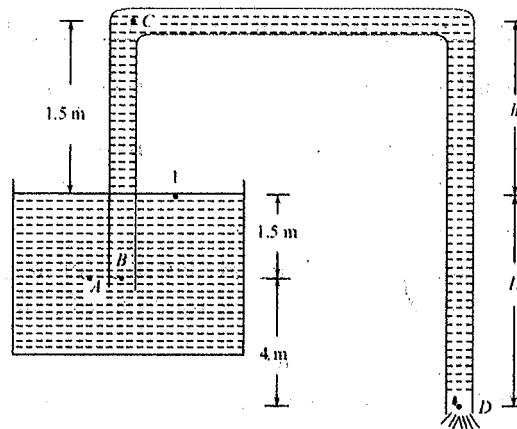
An uniform cross-section tube is used as a siphon to discharge an oil of specific gravity 0.8 from a large open vessel into a drain at atmospheric pressure as shown in the figure. Calculate (i) The velocity of oil through the siphon, (ii) The maximum height 'h' of 'C' above the vessel and (iii) The maximum vertical depth of the right limb of the siphon 'H'. Consider the vapour pressure of the oil at the working temperature to be 29.5 kPa. [3 + 4 + 4]

(b) A pipe system has three pipes in series (i) 300 m long, 150 mm in diameter (ii) 150 m long, 100 mm in diameter and (iii) 250 m long, 200 mm in diameter. Determine the discharge through the pipe system which is connected between two large tanks with a difference of 20 m in water level. Take $f = 0.02$ and $C_c = 0.6$ [9]

6. (a) Find the discharge through a trapezoidal channel of width 8 m and side slope of 1 horizontal to 3 vertical. The depth of flow of water is 2.4 m and value of Chezy's constant $C = 50$. The slope of the bed of the channel is given 1 in 4000. [7]

(b) Derive an expression for the actual discharge over a V – notch placed in an open channel with the help of a neat and labelled diagram. [8]

(c) Explain the phenomenon of 'Hydraulic Jump' in an open channel flow. [5]

7. (a) The pressure difference Δp in a pipe due to turbulent flow depends on the velocity V, diameter D, length l, viscosity μ, density ρ and roughness (in metres) k. Using Buckingham's π – theorem, obtain an expression for Δp. [15]

(b) Give the expression for hydrostatic stress and deviatoric stress for a three (3) – dimensional cartesian viscous flow and properly name the variables. [5]