Ref. No.: Ex/IEE/ES/B/PE/T/216/2025

B. E. INSTRUMENTATION AND ELECTRONICS ENGINEERING

SECOND YEAR FIRST SEMESTER - 2025

APPLIED FLUID MECHANICS

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

Answer Question No. 1 (compulsory) and Any 4 Questions from the rest.

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) (i) Explain the phenomenon of cavitation. (ii) What assumptions are considered for a fluid flow when deriving Bernoulli`s equation? **[3 + 2]**

   (c) Describe the variation of viscosity of a fluid with change in temperature. **[5]**

   (d) Classify fluids according to Newton`s Law of Viscosity with the help of a neat and labelled diagram. Also provide examples for the classifications. **[5]**

2. (a) (i) State the Hydrostatic Law. (ii) State Pascal`s Law. (iii) Does a manometer measure absolute pressure? **[2 + 2 + 2]**

   (b) Differentiate between absolute, gauge and vacuum pressure with the help of a neat and labelled diagram. **[7]**

   (c) Describe the working principle of a U-tube manometer using a neatly labelled diagram. **[5]**

   (d) State a situation (if any) when a piezometer is a better choice as a pressure measuring device than a manometer. **[2]**

3. (a) Differentiate between laminar and turbulent flow. **[2]**

   (b) A fluid flow is described using the following velocity field, $\vec{V} = (2x^2 + zt)\hat{\imath} + (2xy - zty^2)\hat{\jmath} + (3z - 4x^2y)\hat{k}$. Find the acceleration vector and velocity magnitude at position coordinates (2,-1,-1) and t = 3. **[8]**

   (c) A fluid flow is described using the following velocity field, $\vec{V} = (2xz^2 + 3y)\hat{\imath} + (-5y^2)\hat{\jmath} + (x^2z - zy)\hat{k}$, at coordinates (3,1,-2). 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. **[4]**

   (b) Derive the reduced expression of Continuity Equation for a conduit of variable cross-sectional area. [Properly mention any assumptions or correlations taken] **[10]**

(c) Explain the term 'Fully Developed Flow' for a Plane Poiseuille flow with the help of a neat and labelled diagram. **[6]**

5. (a) A horizontal taper pipe through which water is flowing has diameters 15 cm and 30 cm at the inlet and exit respectively. The velocity of water at the inlet is 4 m/s. Calculate the velocity heads at the inlet and the exit. **[4]**

(b) An orifice meter with orifice diameter 10 cm is inserted in a pipe of 20 cm diameter. The pressure gauges fitted upstream and downstream of the orifice meter gives readings of 19.62 N/cm^2 and 9.81 N/cm^2 respectively. Co-efficient of discharge for the orifice meter is given as 0.6. Find the discharge of water through pipe. **[6]**

(c) A single pipe 400 mm in diameter and 400 m long conveys water at the rate of $0.5m^3/s$. Find the change in discharge if another pipe of 200 m long and 200 mm in diameter is joined parallel with the existing pipe over half of its length. Friction factor for all the pipes is 0.02. **[10]**

6. (a) For a converging - diverging nozzle with a valve to control back flow describe the pressure variation along the nozzle as the valve is slowly opened, with the help of a neat diagram. **[10]**

(b) (i) What is Mach Number? (ii) Draw the different configurations of nozzles and diffusers for subsonic and supersonic flow. **[2+6]**

(c) What is a shockwave? Differentiate between normal and oblique shocks. **[2]**

7. (a) For rotodynamic fluid machines of a given shape and handling an incompressible fluid, the relevant variables involved are $\boldsymbol{D}$ (the rotor diameter), $\boldsymbol{Q}$ (the volume flowrate through the machine), $\boldsymbol{N}$ (the rotational speed of the machine), $\boldsymbol{gH}$ (the difference of head across the machine i.e the energy per unit mass), $\boldsymbol{\rho}$ (the density of fluid), $\boldsymbol{\mu}$ (the dynamic viscosity of the fluid) and $\boldsymbol{P}$ (the power transferred between fluid and rotor). Show with the help of Buckingham`s Pi theorem that the relationship between the variables can be expressed by a functional form of the pertinent dimensionless parameters as

$$f\left(Q/_{ND^3}, gH/_{N^2D^2}, \rho ND^2/_{\mu}, P/_{\rho N^3D^5}\right) = 0 \quad \textbf{[20]}$$