Ref. No.: Ex/IEE/ES/B/PE/T/216/2024

B. E. INSTRUMENTATION AND ELECTRONICS ENGINEERING

SECOND YEAR FIRST SEMESTER - 2024

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) Derive Newton`s Law of Viscosity with reference to shearing of a thin film of liquid. **[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) State Pascal`s Law for fluids? What assumptions are considered for a fluid flow when deriving Bernoulli`s equation? **[2 + 2]**

   (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) State the Hydrostatic Law. Does a manometer measure absolute pressure? **[2 + 2]**

   (b) Derive Navier`s Equation of Equilibrium in the i^{th} direction starting with the integral form of conservation of linear momentum. **[8]**

   (c) Describe the working principle of a piezometer using a neatly labelled diagram. **[4]**

   (d) State a situation (if any) when a piezometer is a better choice as a pressure measuring device than an U – Tube Manometer. Name two mechanical gauges which are used for measuring pressure. **[2 + 2]**

3. (a) What is Stokes hypothesis? **[2]**

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

   (c) A fluid flow is described using the following velocity field, $\vec{V} = (-3xz^2)\hat{\imath} + (-3y^2 + zx)\hat{\jmath} + (y^2z - 6zx)\hat{k}$, at coordinates (4,2,-1). Find out (i) If the flow is compressible or incompressible? (ii) If the flow is rotational or irrotational? **[5 + 5]**

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

[Turn over

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

(c) Explain the term 'Fully Developed Flow' for a Plane Poiseuille flow with the help of a neat and labelled diagram. **[7]**

5. (a) A horizontal taper pipe through which water is flowing has diameters 20 cm and 10 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 oil of specific gravity 0.8 is flowing through a venturimeter having inlet diameter 20 cm and throat diameter 10 cm. The oil-mercury differential manometer shows a reading of 25 cm. Calculate the discharge of oil through the venturimeter. Take $C_d = 0.98$. **[6]**

(c) A pipeline of 500 mm in diameter is 1.2 km long. Sometime later another parallel line of the same diameter is introduced in the second half of the length. Neglecting minor losses, find the change in discharge if $f = 0.04$ and head at inlet is 20 m over that at the outlet. **[10]**

6. (a) Find the discharge through a trapezoidal channel of width 10 m and side slope of 1 horizontal to 3 vertical. The depth of flow of water is 4.2 m and value of Chezy`s constant $C = 50$. The slope of the bed of the channel is given 1 in 4000. **[8]**

(b) An airplane travels at 800 km/hr at sea level where the temperature is 15°C. How fast would the airplane be flying at the same Mach number at an altitude where the temperature is -40°C? **[8]**

(c) What is a shockwave? Differentiate between normal and oblique shocks. **[3 + 1]**

7. (a) A high speed liquid sheet in ambient air is disintegrated into drops of liquid due to hydrodynamic instability. The drop diameter $\boldsymbol{d}$ depends upon the velocity $\boldsymbol{V}$ of liquid sheet, the thickness $\boldsymbol{h}$ of the liquid sheet, the surface tension coefficient $\boldsymbol{\sigma}$ of the liquid and density $\boldsymbol{\rho}$ of ambient air. Show with the help of Buckingham`s Pi theorem that the functional relationship amongst the above variables can be expressed as $\boldsymbol{d/h = F(\sigma/\rho V^2 h)}$, where $\boldsymbol{F()}$ is a function. **[10]**

(b) 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]**