Ref. No. : Ex/ME/5/T/113/2024(S)

BACHELOR OF ENGINEERING (MECH. ENGG.) 1ST YR 1ST SEM SUPPLEMENTARY EXAM 2024

FLUID MECHANICS – II

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

Symbols in the question paper carry their usual meanings. However, the symbols you will use during answering should be named with the used units

Assume any relevant data if necessary with suitable justifications.

For all the questions/problems, (a) state appropriate assumptions, and (b) draw appropriate schematics for representing the given problems

Answer any FIVE Questions.

All parts of a question must be answered TOGETHER.

1. (a) Derive Hagen-Poiseuille's velocity profile for steady pipe flow, clearly explaining all the assumptions.

   (b) Derive the expression for the pressure drop in a steady pipe flow as per Hagen-Poiseuille's equation. **[20]**

2. (a) Discuss the growth of the boundary layer over a flat plate, mentioning all flow regimes.

   (b) Explain the nominal, displacement, and momentum thicknesses with proper sketches. **[20]**

3. (a) Derive velocity profile for steady flow between two parallel plates, with the bottom plate stationary and the top plate moving at a constant velocity U_0. Explain all the assumptions behind this derivation.

   (b) Compute the displacement and momentum thicknesses in terms of the nominal thickness for a quadratic velocity profile. **[20]**

4. (a) Explain the differences between free vortex and forced vortex.

   (b) Show that the stream function orthogonally intersects the velocity potential function. **[20]**

5. (a) State von Karman's momentum integral equation for boundary layer flow over a flat plate and explain all assumptions and significance.

   (b) Using the von Karman momentum integral equation, find the expressions for wall shear stress, displacement, and momentum thicknesses for a linear velocity profile.

6. (a) Find the expression and magnitude for the speed of the traveling wave of the water hammer in a long steel pipe (assuming fluid compressibility of 2.05 GPa and pipe's Young modulus of 200 GPa).

   (b) Air flows isentropically through a duct. At point 1 the velocity is 240 m/s, with T_1 = 320 K and p_1 = 170 kPa. Compute (a) T_{01}, (b) p_{01}, (c) ρ_{01}, (d) Mach Number, and (e) V_{max}. **[20]**

7. (a) Explain source-sink pair flow and doublet flow.

   (b) Using the method of superposition, find equations of ψ and component velocities for an ideal flow consisting of uniform flow and doublet flow. **[20]**