Ref. No. : Ex/ME/5/T/113/2023(S)

BACHELOR OF ENGINEERING (MECH. ENGG.) 1ST YR 1ST SEM SUPPLEMENTARY EXAM 2023

FLUID MECHANICS – II

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

STRICTLY FOLLOW THE INSTRUCTIONS GIVEN BELOW.

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, (1) state appropriate assumptions, (2) choose a proper coordinate frame, and (3) draw appropriate schematics for representing the situation***

*Answer any **FIVE** Questions.*

***All the parts of a question** must be **answered TOGETHER**.*

1. Derive Hagen-Poiseuille's velocity profile and pressure drop for steady pipe flow, clearly explaining all the assumptions. **[20]**

2. (a) Derive velocity profiles for steady flow between two parallel plates when the bottom plate is kept stationary and the top plate is moving at a constant velocity Uo.

   (b) The lubricating oil of specific gravity 0.82 and dynamic viscosity 12.066×10^{-2} Pa.s is pumped at a rate of 0.01 m^3/s through a 0.15 m diameter and 200 m long pipe. Calculate the Reynolds number, pressure drop, average shear stress at the wall, and power required to maintain the flow. **[10+10]**

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

   (b) Using the order of magnitude analysis, derive the boundary layer equations over a flat plate. **[10+10]**

4. Derive von Karman momentum integral equation for boundary layer flow over a flat plate. **[20]**

5. (a) With the neat sketches, explain the nominal, displacement, and momentum thicknesses.

   (b) Using the von Karman momentum integral equation, find the expressions for wall shear stress, displacement, and momentum thicknesses for a **linear velocity profile**. **[10+10]**

6. (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 source flow. **[10+10]**

7. (a) Find the speed of propagation of weak pressure wave through a compressible fluid under the adiabatic condition.

   (b) Explain all types of expansion processes in a convergent-divergent nozzle flow. Write the difference between normal shock and oblique shock. **[10+10]**

8. (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 $240m/s$, with $T_1 = 320K$ and $p_1 = 170kPa$. Compute (*a*) T_{01}, (*b*) p_{01}, (*c*) ρ_{01}, (*d*) Mach Number, (*e*) V_{max}.

   (c) A normal shock wave takes place during the flow of air at a Mach number of 1.8. The static pressure and temperature of the air upstream of the shock wave are 100kPa (abs) and 150°C. Determine the Mach number, pressure, and temperature downstream of the shock. **[10+5+5]**