Ref. No.: Ex/ME(M2)/PC/B/T/213/2024(S)

B.E. MECHANICAL ENGINEERING SECOND YEAR FIRST SEMESTER SUPPLEMENTARY EXAM 2024

Subject: FLUID MECHANICS - II **Time: 3 Hrs.** **Full Marks: 100**

Instructions: Answer any FIVE (5) questions. Write all pertinent assumptions. Assume any missing data.

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[1] (a) Consider a parallel flow of viscous fluid between two plates, where one plate is at rest and another is moving relative to the other and parallel to it at a velocity U_∞. Starting from the governing equations for the fluid flow, obtain the dimensionless velocity distribution across the plates for various values of dimensionless adverse, zero, and favourable pressure gradients. Sketch the corresponding velocity profiles and obtain the expression for the maximum velocity. Find also the expressions for shear stress and average velocity for the flow. Write all pertinent assumptions.
(b) Explain fully developed flow through s circular pipe with the help of neat sketch. [15+5 = 20]

[2] (a) For inviscid flow, consider a combination of a source and a sink of equal strength m, separated by a distance $2b$ along the x – axis. Write an expression for the stream function ψ and draw the streamline patterns.
(b) Combine the above flow pattern with rectilinear uniform flow U. Write an expression for the stream function ψ and draw the streamline patterns.
(c) For (b) obtain the location(s) of the stagnation point(s).
(d) Under what conditions, flow pattern in (a) becomes a doublet. Write an expression for the stream function ψ and draw the streamline patterns. [4+6+4+6 = 20]

[3] For turbulent, incompressible flow through a straight pipe of diameter $\boldsymbol{D}$, the head loss $\boldsymbol{h_f}$ in a length of $\boldsymbol{L}$ of the pipe depends on (i) the mean velocity of flow $\boldsymbol{V}$, (ii) fluid density $\boldsymbol{\rho}$, (iii) fluid viscosity $\boldsymbol{\mu}$, (iv) height of roughness elements $\boldsymbol{\varepsilon}$, (v) acceleration due to gravity $\boldsymbol{g}$, (vi) length $\boldsymbol{L}$ of the pipe. Using Buckingham-Π theorem find a functional relationship between these variables. [20]

[4] (a) Establish a relationship to get the effect of area variation on flow condition in terms of Mach number for compressible flow through duct. From it set the condition to achieve supersonic flow.
(b) A stream of nitrogen is flowing at a velocity of 500m/s at a pressure of 70kPa and static temperature of 233K. State whether the flow is supersonic or subsonic. Find the stagnation pressure and temperature using appropriate relations. For Nitrogen take adiabatic expansion index as 1.4 and $\boldsymbol{R}$ =297 J/Kg.K. [12+8 = 20]

[5] (a) Starting from Prandtl's boundary layer equations, derive von Karman momentum integral equation.
(b) For a turbulent boundary layer with 1/7th power law velocity profile, find the displacement and momentum thicknesses. [12+8 = 20]

[6] (a) How can you explain the singing of high tension power wires? Show your analysis by sketching the streamlines over the circular cross-section wire for different wind velocities characterized by different Reynolds number and thereby state the non-dimensional number characterizing this phenomenon.
(b) Consider laminar flow past a stationary cylinder. Draw the streamline patterns for $Re < 0.5$ and $Re = 50$ where Re is the Reynolds No. given by $Re = UD/\nu$ – where U is the free stream velocity, D is the cylinder diameter and ν is the kinematic viscosity of the fluid. Also draw a figure to show the pressure distribution around the cylinder for the 2 cases. For which of the 2 cases, there will be significant *form drag*. Explain why. [10+10 = 20]

[7] Write short notes on: (a) displacement thickness and momentum thickness; (b) normal shock; (c)Karman vortex street; (d) Mach cone. [5×4 = 20]