B. E. MECHANICAL 2ND YR 1ST SEMESTER EXAMINATION 2019

FLUID MECHANICS - II

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

*All the parts of a **Module MUST** be answered **TOGETHER**.*
Assume any relevant data if necessary with suitable justifications. Notations should be properly described.
Symbols in this question paper carry their usual meanings.

Module: 1 (25 Marks)

1. Answer any **five.** **[5x5=20]**

   i) Describe the stress field for a generalized flow in Cartesian frame of reference.

   ii) With the help of neat sketch, distinguish between developing and developed flow.

   iii) Establish the relationship between Stream function and Velocity Potential function.

   iv) Explain stalled flow in the context of flow over a Cambered aerofoil.

   v) Distinguish between zone of silence and zone of action.

   vi) With at least one example for each, define the different types of unsteady flow.

   vii) Classify different types of turbulence.

Module: 2 (30 Marks)

Answer any **two**

2. Considering viscous incompressible flow, deduce the expression for the velocity profile for the leakage flow that occurs through the gap between a piston and a concentric cylinder. The diameter of the cylinder is large enough compared to the gap between it and the piston. Draw appropriate sketch of the problem and state necessary assumptions for deduction. **[15]**

3. Using method of superposition find the equation of stream function for a complex ideal flow consisting of uniform flow, doublet and circulation. Hence illustrate the location of the stagnation points for different situations. Explain Kutta-Joukowski's law and Magnus effect from this complex flow situation. **[15]**

4. Starting from the governing equation for 2D incompressible laminar boundary layer, find the expression relating wall shear stress with displacement and momentum thicknesses. **[15]**

5. Consider isentropic flow occurring from a reservoir through a converging nozzle. Find the condition for maximum mass flow rate. Obtain the value of the ratio of exit pressure at the nozzle with stagnation pressure at the reservoir at that condition. Show the typical variation of mass flow rate with this pressure ratio. **[15]**

Module: 3 (25 Marks)

6. Discuss different types of drag force and their importance in designing shape of automobiles. **[5]**

Or

Through a graphical analysis obtain maximum pressure drop across a Converging-Diverging nozzle. **[5]**

7.

(a) A vehicle having a flat top is moving at a steady velocity U_0 on an absolute horizontal road. In order to estimate the air friction on the top surface, obtain the necessary governing equation using order of magnitude analysis. Consider a 2D flow analysis. **[10]**

Or

Using the concept of compressible flow analysis prove that after a normal shock wave the flow will become subsonic. **[10]**

(b) The water supply through a pipe from a high head reservoir is controlled by a valve. Due to some reason the valve is suddenly closed causing stoppage of flow in a very rapid manner. It is observed that a crack is generated on the pipe. Analyze the situation using the concept of unsteady flow and suggest a possible reason for the generation of crack. **[10]**

Or

A small sphere of density ρ_s and diameter D settles at a terminal velocity V in a liquid of density ρ_f and dynamic viscosity μ. Gravity g is known to be a parameter. Using dimensional analysis, express the functional relationships between these variables in a dimensional form. **[10]**

Module: 4 (20 Marks)

Answer any **two**

8. An oil of viscosity 0.1 Ns/m^2 and specific gravity 0.90 flows through a horizontal pipe of 25 mm diameter. If the pressure drop per meter length of the pipe is 12 kPa, determine (a) the rate of flow; (b) the shear stress at the pipe wall; (c) the Reynolds number of the flow; and (d) the power required to maintain the flow. **[10]**

9. Two sources of strength $m/2$ are placed at $(\pm a, 0)$. Show that at any point on the circle, the x-component of velocity is parallel to the y-axis and the y-component of velocity is inversely proportional to y. **[10]**

10. The time averaged center-line velocity of a fully developed turbulent flow of water through a circular duct is observed to be 10 m/s. Assuming the velocity profile to vary in the radial direction following the 1/7th power law, find the average velocity and wall shear stress. **[10]**

11. Air flows isentropically through a duct. At point 1 the velocity is $240 m/s$, with $T_1 = 320K$ and $p_1 = 170kPa$. Compute (a) T_{01}, (b) p_{01}, (c) ρ_{01}, (d) Mach No., (e) V_{max}, and (f) V^*. At point 2 further downstream $V_2 = 290 m/s$ and $p_2 = 135kPa$. (g) What is the stagnation pressure p_{02}? **[10]**