M.E. Mechanical Engineering First Year Second Semester Examination 2017
Subject: Advanced Fluid Mechanics – II

Time: Three hours **Full Marks: 100**

Answer any **Four** questions. All Questions Carry Equal Marks.

All symbols have their usual meaning.

1. (a) Consider the complex transformation $\mathbf{w} = \frac{\mu}{z}$, where μ is the strength of the doublet placed at the origin, **w** and **z** are complex variables. Following graphical method, how do you obtain equi-potential lines (Φ) and streamlines (Ψ) in the **z**-plane from uniform flow in the **w**-plane?

   (b) The transformation for flow at a wall angle is represented by $\mathbf{w} = \mathbf{Az}^{\mathbf{n}}$. Plot the flow patterns for $\mathbf{n} = 3$ and 2/3.

   (c) Considering successive transformation relating the **w**- and **z**-patterns of flow, obtain the horizontal flow patterns normal to a vertical plate of height '**2a**', where '**a**' is the radius of the circle. (8+7+10)

2. (a) What is doublet flow? Obtain the equation for stream-function for a doublet flow.

   (b) Show that the combination of a uniform flow and doublet represents a flow past a stationary circular cylinder. With a neat sketch, show the pressure distribution around the cylinder. (10+15)

3. Following suitable transformation function, obtain the pattern of flow the following:

   (a) Vertical flow normal to a horizontal surface.

   (b) Horizontal flow normal to a vertical plate. (15+10)

4. (a) What is Schwarz-Christoffel transformation? Obtain the transformation function '**w**' for horizontal flow past a vertical flat plate without separation.

   (b) The transformation of the **z**-plane pattern of an infinite strip of height '**l**' to the **t**-plane pattern for flow from each end to a slit at the origin is given by $z = \frac{l}{\pi} In(t)$. Establish the relationship between '**w**-' and '**z**-'pattern of flow. (10+15)

5. Consider a two-dimensional, incompressible turbulent boundary layer flow over a flat surface. Starting from the two-dimensional boundary layer equations and using Prandtl's mixing length hypothesis, show that the velocity distribution very close to the wall (law of the wall) can be expressed by $\mathbf{u}^+ = \mathbf{y}^+$, where viscous force dominates over the turbulent shear stresses. (25)

6. a. Explain the basic idea of stability analysis with a suitable example. (5)

   b. What is Kelvin-Helmhotz instability? Explain with a neat diagram considering to jet of fluid moving in opposite direction with same velocity. Assume the fluids of equal density. (20)

7. Derive the Orr-Sommerfeld equation for the analysis of Instability and get Rayleigh equation from it. (25)

8. Show that uniform flow is unconditionally stable while a shear layer i.e. parallel flow jump is unconditionally unstable. (25)

9. Explain Centrifugal Instability and instability of inviscid fluid. (25)

Paper Setters: Date: