Master of Mechanical Engineering Examination, 2018
Second Semester
Subject: Advanced Fluid Mechanics – II
Answer any four questions
Assume any data if not given with proper Justification

Time: Three hours **Full marks: 100**

1(a) Using the complex transformation function W for uniform flow and doublet, find the expression for potential function φ and stream-function Ψ for flow past a circular cylinder.

(b) With a neat diagram, evaluate the complex function that transforms a circle of radius 'a' to a flat plate of length '4a'. (25)

2 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. (25)

3. (a) State and explain Schwarz-Christoffel (S-C) theorem in reference to a flow passage straight wall boundaries.

(b) Using Schwarz-Christoffel theorem, find the transformation function 'W' for horizontal flow past a vertical flat plate without separation. (25)

4. 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 outside the buffer layer follows the logarithmic law. (25

5. Derive the Orr-Sommerfeld equation for the analysis of Instability. (25)

6. Find Rayleigh's equation and from this show that uniform flow is unconditionally stable while a shear layer i.e. parallel flow jump is unconditionally unstable. (25)

7. What do you understand by Centrifugal Instability and instability of inviscid fluid. (25)

8. With a suitable example explain the Kelvin-Helmholtz instability. (25)

9. Consider a Poiseuille flow which has basic flow velocity and pressure as given below:

$$\vec{U} = V\left[1 - \left(r^2/a^2\right)\right]\hat{i} \quad \text{for, } 0 \le r \le a, 0 \le \theta \le 2\pi, -\alpha \prec x \prec \alpha$$

$$P = P_0 - 4\rho\nu V\frac{x}{a^2}, \text{ for, } 0 \le r \le a, 0 \le \theta \le 2\pi, -\alpha \prec x \prec \alpha$$

Where, the symbols have their usual meaning. Determine, what are the conditions of such a flow to be stable or, unstable. (25)