Code.No: R05422107 | R05 | SET-3

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
IV B.TECH II SEM–REGULAR/SUPPLEMENTARY EXAMINATIONS MAY - 2010
BOUNDARY LAYER THEORY
(AERONAUTICAL ENGINEERING)

Time: 3hours **Max.Marks:80**

Answer any FIVE questions
All questions carry equal marks
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1. Derive the energy equation for a fluid in motion in the form of a differential equation. [16]

2. Find the displacement thickness, momentum thickness and energy thickness for the velocity distribution in the boundary layer given by [u / U] = [(2y / δ) – (y / δ)^2], where u is the velocity at a distance y from the plate and u = U at y = δ, where δ is the boundary layer thickness. [16]

3. Write short notes on:
   (a) General stress system in a fluid,
   (b) General strain system,
   (c) Stokes hypothesis. [16]

4. Starting from the Navier – Stokes equations, derive the expression for heat transfer rate at the wall of a moving plate for the flow between two plates, one stationary and the other moving with a constant velocity (Couette flow). [16]

5.a) Making use of the Vector and Cartesian forms of the Navier – Stokes equations, develop Prandtl's BL equations for laminar flow over an object. State clearly all the assumptions involved.

b) Show the formation of boundary layer on a circular cylinder. Illustrate it with sketches in full details. [8+8]

6. Explain the necessity for the Pohlhausen solution Vis-a-Vis Blasius solution of laminar BL equations. Hence describe the Pohlhausen method with its work out. [8+8]

7. Consider the Momentum equation given below for incompressible turbulent boundary layer in two dimensions:

$$\rho\left(U\frac{\partial U}{\partial x}+V\frac{\partial U}{\partial y}\right)=-\frac{\partial p}{\partial x}+\frac{\partial}{\partial y}\left[\mu\frac{\partial U}{\partial y}-\overline{\rho uv}\right]\text{ with}$$

$$-\overline{\rho u v}=\rho\varepsilon_m\frac{\partial U}{\partial y}\, or\;\; \rho K^2 y^2\left|\frac{\partial U}{\partial y}\right|\frac{\partial U}{\partial y}.$$

Describe in detail the inner layer, called laminar sub-layer. Hence determine its thickness making use of the established processes. ε_m is turbulent viscosity. [16]

8.a) Illustrate turbulent boundary layer profiles for various pressure gradients with a single plot of $\frac{\bar{u}}{U_e}$ and $\frac{y}{\delta}$. Explain the variations of these curves for strongly favorable and strongly adverse pressure gradients.

b) Explain the terms:

(i) Generation of stress and

(ii) Dissipation as referred to in the Reynolds stress equation. [8+8]

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