Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

B. E. - SEMESTER – VII • EXAMINATION – WINTER 2012

Subject code: 170106 Date: 28/12/2012

Subject Name: Viscous flow and Boundary Layer Theory

Time: 10.30 am - 01.00 pm Total Marks: 70

Instructions:

1. **Attempt any five questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Define boundary layer thickness, momentum thickness and energy thickness, and derive expression for the energy thickness for laminar flow over a flat plat. **07**

(b) Write a short note on boundary layer control methods. **07**

Q.2 **(a)** Derive the von-Karman momentum integral equation for the flow past a flat plate in the form $\tau_0 = \rho U_\infty^2 \frac{\partial \theta}{\partial x}$ **07**

Where, θ is momentum thickness

(b) Derive Orr-Sommerfeld Equation. **07**

OR

(b) What is critical Reynolds number? State OSE, discuss the solution of it and show how critical Reynolds number is obtained from that. And derive Rayleigh equation from the OSE. **07**

Q.3 **(a)** Explain Prandtl's mixing length hypothesis and derive expression for mixing length. **07**

(b) Write a short note on Relaminarization. **07**

OR

Q.3 **(a)** Write down the characteristics of the turbulent flow. **07**

(b) Explain the evolution of the turbulent flow from laminar flow. **07**

Q.4 **(a)** Derive the expression to determine boundary layer thickness in turbulent boundary layer. **07**

(b) Air is flowing over a flat plate 5m long and 2.5m wide with a velocity of 4m/s at 15°C. If ρ=1.208kg/m^3 and υ=1.47×10^{-5}m^2/s. calculate **07**

1) Length of plate over which the boundary layer is laminar, and thickness of the boundary layer at that point
2) Shear stress at the location where boundary layer ceases to be laminar.
3) Total drag force on the both sides on that portion of plate where boundary layer is laminar.

OR

Q.4 **(a)** Derive energy equation for thermal boundary layer in the form of **07**

$$u\frac{\partial t}{\partial x}+v\frac{\partial t}{\partial y}=\frac{k}{\rho c_p}\frac{\partial^2 t}{\partial y^2}+\frac{\mu}{\rho c_p}\left(\frac{\partial u}{\partial y}\right)^2.$$

(b) A flat plate 1m wide and 1.5 m long is maintained at 90°C in free stream of air having 10°C. Determine the velocity with which air must flow over a flat **07**

plate such that the rate of energy transfer from plate is 3.75kW. properties of air are $\rho=1.09kg/m^3$, $c_p=1.007Ns/m^2$, $\mu=20\times10^{-6}kg/m$ and Pr=0.7

Q.5 **(a)** Derive momentum equation for turbulent flow in terms of Reynolds stresses. **07**

(b) Explain the flow development in laminar duct flow entering in a tube with uniform velocity of U_∞, show velocity profiles at different length from entry. Relate entry length with height of duct. **07**

OR

Q.5 **(a)** Air at a temperature 30°C flows past a flat plate at a velocity of 1.8m/s. the flat surface has a sharp leading edge and its total length equals 750mm. calculate **07**

1) Average skin friction or drag co-efficient
2) The average shear stress, and
3) Ratio of average shear stress to the shear stress at the trailing edge.

(properties of air at 30°C are, $\rho=1.165kg/m^3$ and $\upsilon=16\times10^{-6}m^2/s$)

(b) Find the ratio of friction drag on the front half and rear half of the flat plate kept at zero incidence angle in a stream of uniform velocity, if the boundary layer is turbulent over whole plate. **07**

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