Seat No.: _____ Enrolment No. _____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII • EXAMINATION – WINTER • 2014

Subject Code: 170106 Date: 29-11-2014

Subject Name: Viscous and Boundary Layer Theory

Time: 10:30 am - 01:00 pm Total Marks: 70

Instructions:

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

Q.1	**(a)**	Derive the equation of flow through pipe with neat sketch.	**07**
	(b)	Derive the governing equation of Couette flow.	**07**
Q.2	**(a)**	A plate of length 500mm and width 250mm has been placed in a stream of oil which flows with a velocity of 6m/s. Oil has specific gravity of 0.9 and kinematic viscosity of 1stoke, calculate boundary layer thickness at the middle of plate, shear stress at the middle of plate and friction drag on one side of the plate.	**07**
	(b)	Explain Prandtl's mixing length theory.	**07**
		OR	
	(b)	What is critical Reynolds number? Derive Orr-Sommerfeld equation.	**07**
Q.3	**(a)**	Write a short note on fully developed turbulent flow in a pipe for moderate Reynolds number.	**07**
	(b)	What is turbulence? Compare velocity profiles in a pipe for laminar ant turbulent flows with neat sketch.	**07**
		OR	
Q.3	**(a)**	Derive continuity and momentum equation for the hydrodynamic boundary layer grows over the flat plate.	**07**
	(b)	Define boundary layer thickness, displacement thickness, momentum thickness and energy thickness, and derive expression for the energy thickness for laminar flow over a flat plate.	**07**
Q.4	**(a)**	Write a short note on boundary layer separation and the methods to control it.	**07**
	(b)	Derive momentum equation for turbulent flow in terms of Reynolds stresses.	**07**
		OR	
Q.4	**(a)**	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**
Q.4	**(b)**	Define Reynolds number, Prandtl number and Nusselt number. Derive the expression for average Nusselt number for the combined laminar and turbulent flow over the flat plate.	**07**
Q.5	**(a)**	Derive the expressions for thermal boundary layer thickness, local and convective heat transfer coefficients, and Nusselt no. from the integral approach.	**07**

(b) Air at 20°C and at atmospheric pressure flows at a velocity of 4.5m/s past a flat plate with a sharp leading edge. The entire plate surface is maintained at a temperature of 60°C. Transition occurs at critical Reynolds number. Find the distance from the leading edge at which the flow in the boundary layer changes from laminar to turbulent. At that location calculate, thickness of hydrodynamic layer and thermal boundary layer, local and average convective heat transfer coefficients, heat transfer rate from both sides for, unit width of the plate, mass entrainment in the boundary layer, and the skin friction coefficient. At mean film temperature thermo physical properties of air are density 1.123Kg/m^3, kinematic viscosity $17\times10^{-6}m^2/s$, Pr=0.699 and conductivity 0.02755W/m°C. **07**

OR

Q.5 **(a)** Explain mean motion and fluctuations for turbulent flow. **07**

(b) Derive energy equation for the thermal boundary layer over the flat surface. **07**

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