Applied Mechanics Department

AML360: Engineering Fluid Flows

10

II Sem, 2006-07.

Dated: May, 4, 2007. MAJOR TEST

Max. Marks: 80.

Time: 1-3 pm.

NOTE:- Answer ALL Questions

(1) Explain the Variation of Coefficient of Drag (C_D) with Reynolds Number (Re) for the flow over a spherical body. Identify the different regimes and relate the Variation of C_D with flow field changes in each regime. (8)

(2) Define Prandtl's Mixing length hypothesis and state the physical significance of mixing length. Explain, how the ~~Vari~~ Variation of mixing length is modelled in the following cases.

(a) Fully Turbulent wall layer

(b) Fully Turbulent core flow in a duct.

(c) Free Turbulent Flows. (10)

(3) The Velocity profile and skin friction coefficient in the turbulent Boundary layer over a flat plate are given by,

$u/U_\infty = (y/\delta)^{1/7}$ $0 \le y/\delta \le 1$, $u/U_\infty = 1$ for $y > \delta$.

$C_f = \tau_w / \frac{1}{2}\rho U_\infty^2 = 0.020 / Re_\delta^{1/6}$; $Re_\delta = (U_\infty \delta/\nu)$

Starting from Momentum Integral Equation, derive the expression for $\delta(x)$ and C_D. Assume that B.L is turbulent from the leading edge. Using this result, Calculate the skin friction drag on a ship 200 m long and having a wetted area of 8000 m^2, moving through the sea at a Velocity of 10 m/s. Estimate the power required to overcome the skin friction drag. What is the maximum allowable roughness height so that the surface can be considered as hydraulically smooth. Assume $\rho_w = 10^3$ Kg/m^3, μ_w = 1cP. (12)

(4) In a turbulent flow of water through a pipe, the Velocity profile is given by, $u/u_{max} = (1 - r/R)^{1/7}$. If u_{max} = 5 m/s, $\rho = 10^3$ Kg/m^3 D = 50mm, μ = 1cP, Calculate $Re = (\rho U_{bulk} D/\mu)$. What is the thickness of the laminar Sublayer and the Value of friction factor?

(10).

(5) Briefly explain the following.

(a) Turbulent Prandtl Number and its significance.

(b) Reduction of Drag on a body by Boundary layer Control.

(c) Oseen's Approximation for C_D over a sphere at low Reynolds Numbers. (12)

(6) Consider the turbulent circular jet issuing into an otherwise stagnant body of same fluid. Using proper turbulence model, derive the expressions for the functional dependence of d (diameter of the jet) and U_{max} (max Velocity of the jet) on the axial distance 'x'. (9)

(7) A Velocity field is given by,

$$\bar{U} = \left[\cos\theta \left(1 - \tfrac{1}{2r^2}\right)\right] \underline{r} - \left[\sin\theta \left(1 + \tfrac{1}{2r^2}\right) + \tfrac{1}{2}\Gamma r\right] \underline{\theta}$$

(a) Derive the expression for stream function 'ψ' if it exists.

(b) Calculate circulation around a circle of unit radius around origin ($r = 1$).

(c) Locate the stagnation points. (10)

(8) Consider laminar and Turbulent Boundary layer over a flat plate. Compare the following properties.

(a) Velocity profile in the B.L

(b) growth rate of B.L

(c) Drag force on the plate. (9)