Department of Applied Mechanics

AML711 Advanced Fluid Mechanics

I Sem. 2008-09. Dated: 26.11.08

Time: 1-3 PM. MAJOR TEST Max. Marks: 80

NOTE: Answer ALL Questions.

(1) (a) Define "Mach cone" and explain its significance in Compressible Fluid Flows. (4)

(b). A converging Nozzle of throat area is supplied from a reservoir containing compressed air. The conditions in the reservoir are $P_0, \rho_0, T_0, C_0, S_0$ etc. Assuming the flow to be steady, one dimensional, isentropic, inviscid and air to be a perfect gas ($K=1$) derive the expression for the exit pressure P^* at which choking takes place. Calculate the expression for the mass flow through the nozzle at this condition. (6).

(2) The Velocity profile and skin friction coefficient in the turbulent B.L over a flat plate is given by,

$u/u_\infty = (y/\delta)^{1/7}$ $0 \le y/\delta \le 1$, $u/u_\infty = 1$ for $y \ge \delta$, $C_f = \frac{\tau_w}{\frac{1}{2}\rho u_\infty^2} = \frac{0.045}{(u_\infty \delta/\nu)^{1/4}}$

Starting from Momentum Integral Equation, derive the expression for $\delta(x)$ and C_D. Assume that B.L is turbulent from the leading edge only. Using this result, calculate the ~~expressions for $\delta(x)$~~ skin friction drag on a ship 100 m long, having a wetted area of $400\,m^2$ moving through water [($\rho_{water} = 10^3\ kg/m^3$) and ($\mu_{water} = 1\ cP$)] at a Velocity of 5 m/s. Estimate the power required to overcome this drag. What is the Value of B.L. displacement thickness at the trailing edge of the ship? (10).

(3) Consider the flow of water ($\rho = 10^3\ kg/m^3$, $\mu = 1\ cP$) through a circular pipe of 100 mm diameter having an average roughness height of $k_s = 0.05$ mm. Calculate the maximum Value of average Velocity (u_{av} in m/s) so that pipe can be ~~by~~ considered as hydraulically smooth. (Assume $f = 0.32/Re^{1/4}$). (9).

(4) (a) Explain the Variation of C_D for a flow over a sphere as Reynolds No is Varied. Identify the Various flow regimes.

(b). Briefly describe any three methods by which Separation can be delayed on a body. (5+5).

(5) Define Prandtl's mixing length and explain its physical significance. Describe the Variation of mixing length in

(a) Wall turbulent flows

(b) Free Turbulent flows. (8).

(6) What is Orr-Sommerfield Equation and explain how it can be used for predicting transition in a boundary layer. Explain the factors that affect the Shape of the Neutral Stability curve. (8).

(7) Briefly Explain the following.

(a) Reynolds Analogy for heat transfer in B.L flow over a flat plate.

(b). Stokes stream function for axisymmetric, inviscid, incompressible, irrotational flows.

(c). Reynolds Stress Tensor and the concept of eddy Viscosity. (15).

(8) The propeller of an airplane having a diameter of 2m is moving through still air at a Velocity of 100 m/s. The theoretical efficiency of the propeller is 60%. Use integral flow analysis to derive expression for thrust developed by the propellor and calculate its value. Assume air is incompressible and its density is 1.1 kg/m3. What is the power required to drive the propellor in KW? (10).