DEPARTMENT OF AEROSPACE ENGINEERING
IIT KHARAGPUR

End Semester Examination (Autumn 2003-04)

INTRODUCTION TO AERODYNAMICS (21001)

II year B.Tech.(Hons).Aero. Time :3Hrs.
Max. Marks : 60.

ATTEMPT ANY FIVE QUESTIONS.

Q.1) (a) Define Total Temperature and Total Pressure. (3)

(b) Define Characteristic Mach Number M^* and explain its significance after deriving a relation between M and M^*. (5)

(c) Find the stagnation temperature and stagnation pressure for carbon-di-oxide flowing at 150 m/s if the pressure and temperature of the undisturbed stream are 500 kPa and 30^0 C respectively. (For CO_2, $\lambda = 1.28$ and R= 188 J/KgK. (4)

Q.2) (a) Show that critical mass flow per unit area for a nozzle is given by

$$\frac{\dot{m}}{A^*} = \Gamma \frac{p_o}{\sqrt{RT_o}} \quad \text{where} \quad \Gamma = f(\gamma) \qquad (5)$$

(b) Oxygen ($\lambda = 1.4$ and R= 260 J/KgK) is contained in a tank at 150 kPa and 20 deg.C. If it is expanded isentropically to attain Mach No. unity what is the sonic speed and temperature at that station. (5)

(c) Define Compressibility. (2)

Q.3) (a) Show that to attain supersonic speed a convergent-divergent nozzle is required. (4)

(b) Explain with neat sketch how the flow through a nozzle changes as the Pressure ratio is varied. (5)

(c) Derive the relation:-

$$\frac{T_o}{T} = 1 + \frac{\gamma - 1}{2} M^2 \qquad (3)$$

Q.4) (a) Derive the following relation between velocities across a normal shock:-

$$u_1 . u_2 = (a^*)^2 \qquad (5)$$

(b) Derive the following relation across a normal shock:

$$\frac{p_1}{p_2} = \frac{1 + \gamma M_2^2}{1 + \gamma M_1^2} \qquad (4)$$

Where 1 & 2 refers to stations ahead and behind the shock.

(c) Explain why total temperature remains constant across a normal shock. (3)

Turn Over

Q.5) (a) Derive Navier-Stokes equations. (6)

(b) Flow is taking place between two infinite parallel plates with upper plate moving with uniform velocity V_∞ . Obtain a relation for velocity distribution between the plates. Explain the distribution with a neat sketch. (6)

Q.6) (a) Derive Bernoulli's Equation. (5)

(b) A low speed wind tunnel has a contraction ratio of 12:1 for the nozzle (contraction cone). If the flow in the test section **at standard sea level condition** has a velocity of 60 m/s, calculate the height difference of a U-tube manometer with one side connected to nozzle inlet and the other to the test section. Mercury ($\rho = 1.36 \times 10^4$ kg/cu.m) is the manometer fluid. (4)

(c) Derive the potential equation for 2-D inviscid, incompressible flow. (3)

Q.7) Write SHORT NOTES on:- (4 x 3)

(a) Skin friction drag and form drag

(b) Laminar and turbulent flow

(c) Kutta-Jowkowski's Theorem

(d) Stream Function

Q.8) (a) Derive a relation for area ratio A/A^* in terms of Mach No. for a C-D Nozzle. (5)

(b) A nozzle in a wind tunnel gives a test section Mach No. of 2.0. Air enters the nozzle from a large reservoir at 0.69 bar and 310 K. The cross-sectional area of the throat is 1000 cm^2. Determine:- (7)

(1) Pressure, Temperature and Velocity at the throat.

(2) Exit area and mass flow.