00383

# B.Tech. AEROSPACE

## Term-End Examination

## December, 2012

## BASE-003 : HIGH SPEED AERODYNAMICS

*Time : 3 hours* *Maximum Marks : 70*

*Note : Attempt **any seven** questions. All questions carry **equal** marks. Use of scientific calculator, normal shock table and steam table is **permitted**.*

1. (a) What is the Relationship between internal energy and enthalpy ? 4

   (b) Carbon-dioxide expands isentropically through a nozzle from a pressure at 3.0 bar to 1.0 bar if the initial temperature is 483 K, determine

   (i) the final temperature 3

   (ii) the change in the internal energy 3

2. (a) Define strong shock wave and weak shock wave in a compressible flow. 3

   (b) Develop the famous Prandtl relation for normal shock waves. 7

3. (a) Sketch supersonic flow field across a thin wedge and explain difference between a shock wave and a Mach wave. 5

(b) Prove for an oblique shock wave that 5

$$M^2n, 2 = \frac{1 + \left[\frac{(r-1)}{2}\right] M^2n, 1}{r\, M^2n, 1 - \frac{(r-1)}{2}},$$ where

Mn, 1 and Mn, 2 are the normal components of the supersonic Mach Number's across the oblique shock waves.

4. Airflows isentropically through a nozzle of throat area 7 $cm^2$ and exit area 24 $cm^2$. If $P_0 = 650$ kPa and $T_0 = 200°C$, compute the mass flow, exit pressure and exit Mach number for 10

(a) Subsonic Flow

(b) Supersonic Flow

5. Explain when a fluid is termed as incompressible and what conditions make it compressible ? Hence demonstrate the effect of Mach number on the flow past an air foil with Mach number 10

6. The equations of 2-D fluid motion in isentropic flow are given in indicial notation as below 10

Continuity $\frac{\partial \rho}{\partial t} + \rho u_J \frac{\partial u}{\partial x_J} = 0$

Momentum $\rho \frac{\partial u_i}{\partial t} + \rho u_J \frac{\partial u_i}{\partial x_J} = \frac{-\partial \rho}{\partial x_i}$

Isentropic relation $\frac{p}{p_0} = \left(\frac{\rho}{\rho_0}\right)^{\gamma}$

If the perturbation velocity components are given as $\mu_1 = U + \mu$ and $\mu_2 = v$ then develop the equations in terms of perturbation velocity components and suggest how to apply Boundary condition for a planar wing.

7. The Mach number and pressure at the entry of a subsonic diffuser are 0.9 and 4.163 bar respectively. Determine the area ratio required and the pressure rise if the Mach number at the exit of the diffuser is 0.20. Assume isentropic diffusion of air. 10

8. Show with sketches and plots that a normal shock wave can be transformed into an oblique shock 10

9. (a) Prove the Relation $M_1^* M_2^* = 1$ 5

(b) Hence show that $M_2^2 = \dfrac{1 + \dfrac{r-1}{2} M_1^2}{r M_1^2 - \dfrac{r-1}{2}}$ 5

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