Reg. No. : | | | | | | | | | | | |

R 3460

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2007.

Fifth Semester

Mechanical Engineering

ME 1303 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2004)

Time : Three hours Maximum : 100 marks

Gas tables can be permitted

Answer ALL the questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define compressible flow and Mach number.

2. Define stagnation temperature and stagnation pressure.

3. What is subsonic, sonic and super sonic flow with respect to Mach number?

4. How the area and velocity vary in super sonic flow of nozzle and diffuser?

5. Give two practical examples for Fanno flow and Rayleigh flow analysis.

6. What are the assumptions made in the analysis of Rayleigh process?

7. How is the shock formed?

8. What do you understand by strong and weak wave? Which one is preferred?

9. What is a bypass engine and define bypass ratio?

10. Distinguish between monopropellant and bipropellant.

PART B — (5 × 16 = 80 marks)

11. (a) (i) What is the effect of Mach number on the compressibility? Prove for

$$\gamma = 1.4 \quad \frac{p_0 - p}{\frac{1}{2}\rho c^2} = 1 + \frac{1}{4}M^2 + \frac{1}{40}M^4 + \cdots$$

(ii) Derive the following relations :

$$\frac{T_0}{T} = 1 + \frac{\gamma - 1}{2} M^2$$

$$\frac{T^*}{T} = \frac{2}{\gamma + 1} + \frac{\gamma - 1}{\gamma + 1} M^2 .$$

Or

(b) Air (c_p = 1 .05 kJ/kg K, γ = 1.38) at $p_1 = 3 \times 10^5$ N/m^2 and T_1 = 500 K flows with a velocity of 200 m/s in a 30 cm diameter duct. Calculate

(i) Mass flow rate

(ii) Stagnation temperature

(iii) Mach number

(iv) Stagnation pressure values assuming the flow is compressible.

12. (a) A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bar, 340 K and 180 m/s respectively. Determine :

(i) the exit pressure

(ii) the exit velocity and

(iii) the force exerted on the diffuser walls.

Assume isentropic flow, γ = 1.4, c_p = 1.00 kJ/kg K.

Or

(b) Air flowing in a duct has a velocity of 300 m/s, pressure 1.0 bar and temperature 290 K. Taking γ = 1.4 and R = 287 J/kg K. Determine

(i) Stagnation pressure and temperature

(ii) Velocity of sound in the dynamic and stagnation conditions

(iii) Stagnation pressure assuming constant density.

13. (a) A circular duct passes 8.25 kg/s of air at an exit Mach number of 0.5. The entry pressure and temperature are 3.45 bar and 38°C respectively and the coefficient of friction 0.005. If the Mach number at entry is 0.15, determine.

(i) the diameter of the duct

(ii) length of the duct

(iii) pressure and temperature at the exit

(iv) stagnation pressure loss.

Or

(b) A combustion chamber in a gas turbine plant receives air at 350 K, 0.55 bar and 75 m/s. The air-fuel ratio is 29 and the calorific value of the fuel is 41.87 MJ/kg. Taking $\gamma = 1.4$ and R = 0.287 kJ/kg K for the gas determine :

(i) the initial and final Mach numbers,

(ii) final pressure, temperature and velocity of the gas,

(iii) percent stagnation pressure loss in the combustion chamber, and

(iv) the maximum stagnation temperature attainable.

14. (a) The ratio of the exit to entry area in a subsonic diffuser is 4.0. The Mach number of a jet of air approaching the diffuser at p_o = 1.013 bar, T = 290 K is 2.2. There is a standing normal shock wave just outside the diffuser entry. The flow in the diffuser is isentropic. Determine at the exit of the diffuser.

(i) Mach number

(ii) Temperature, and

(iii) Pressure.

Or

(b) A jet of air at a Mach number of 2.5 is deflected inwards at the corner of a curved wall. The wave angle at the corner is 60°. Determine the deflection angle on the wall, pressure and temperature ratios and final Mach number.

15. (a) Explain with a neat sketch the principle of operation of a ramjet engine and state its advantages and disadvantages.

Or

(b) Explain with a neat sketch the working of a turbo-pump feed system used in a liquid propellant rocket.
