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

Question Paper Code : B 4750

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2010.

Fifth Semester

Mechanical Engineering

ME 333 — GAS DYNAMICS AND SPACE PROPULSION

(Regulation 2001)

Time : Three hours Maximum : 100 marks

Use of gas tables permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define closed and open system.

2. What is the difference between intensive and extensive property?

3. What is meant by Fanno flow?

4. Is it possible to get subsonic to supersonic flow in a constant area duct? Give reasons.

5. Define : "Strength of a shock wave".

6. Explain how the pitot tube could be used to measure the Mach number in supersonic flow.

7. Sketch the thrust and propulsive efficiency variation against the speed ratio for a turbo jet engine.

8. Briefly explain thrust augmentation and any two methods of achieving it.

9. Name any two solid propellant fuels and oxidizers.

10. What are the advantages of solid propellant rockets over liquid propellant rockets? List any two.

203

PART B — (5 × 16 = 80 marks)

11. (a) What is meant by velocity of sound? Derive the expression for the velocity of sound. (16)

Or

(b) (i) Ambient air at altitude of 6000 m above sea level enters the engine of an aircraft flying at 500 km/hour. If the flow rate through the engine is 25 kg/sec, determine the diameter of the inlet to the engine. (8)

(ii) The pressure, velocity and temperature of isentropic flow of air at the entry of a Nozzle are 2 bar, 150 m/sec and 330 K and the exit pressure is 1.5 bar.

(1) Determine the shape of the Nozzle

(2) Determine the Mach Number at the entry and exit of the Nozzle

(3) Mass flow rate through the nozzle.

Take ratio of specific heats (γ) for air as 1.4 and $C_p = 1.0$ kJ/kg K. (8)

12. (a) Air enters a constant area duct at $M_1 = 3$, $p_1 = 1$ atm, and $T_1 = 300$ K. Inside the duct the heat added per unit mass is $q = 3 \times 10^5$ J/Kg. Calculate the flow properties M_2, p_2, T_2, ρ_2, T_{02} and p_{02} at the exit. (16)

Or

(b) Air at an inlet temperature of 60°C flows with subsonic velocity through an insulated pipe having inside diameter of 50 mm and a length of 5 m. The pressure at the exit of the pipe is 101 kPa and the flow is choked at the end of the pipe. If the friction factor $4f = 0.005$, determine the inlet Mach number, the mass flow rate and the exit temperature. (16)

13. (a) (i) Derive the Rankine-Hergonoit relations. (6)

(ii) When a converging divergine nozzle is operated at off-design condition a normal shock occurs at a section where the cross sectional area is 18.75 cm² in the diverging portion. At inlet to the nozzle the stagnation state is given as 0.21 MPa and 36°C. The throat area is 12.5 cm² and exit area is 25 cm². Estimate the exit Mach number, exit pressure and loss in stagnation pressure for flow through nozzle. (10)

Or

204

(b) (i) For flow through a normal shock deduce the relation

$$M_y^2 = \frac{M_x^2 + \frac{2}{r-1}}{\frac{2r}{r-1} M_x^2 - 1}.$$ (8)

(ii) A bow shock occurs infront of a pitot tube when it is used in a supersonic flow field. It measures 16 kPa and 70 kPa for static pressure upstream of the shock and the pressure at the mouth of the tube respectively. Estimate the Mach Number of the supersonic flow. If the stagnation temperature is 300°C. Calculate the static temperature and total (stagnation) pressure upstream and downstream of the pitot tube. (8)

14. (a) (i) What is ram jet? (4)

(ii) The specific impulse of a rocket is 125 sec and the flow rate of propellant is 44 kg/sec. The nozzle throat area is 18 cm^2 and the pressure is the combustor is 25 bar. Determine thrust co-efficient, propellant flow co-efficient, specific propellant consumption and characteristic velocity.

Or

(b) Briefly explain the following :

(i) Turbotan engines

(ii) Aircraft combustors. (2 × 8 = 16)

15. (a) (i) Derive expressions for thrust and specific impulse and propulsive efficiency of a rocket motor. (6)

(ii) Calculate the thrust specific impulse, propulsive efficiency, thermal and overall efficiencies of a rocket engine from the following data :

Effective jet velocity = 1250 m/s, flight to jet speed ratio = 0.8, oxidizer flow rate = 3.5 kg/s, fuel flow rate = 1 kg/s. Heat of reaction of exhaust gases = 2500 kJ/kg. (10)

Or

(b) (i) Discuss in detail the various propellants used in solid fuel rockets and liquid fuel system. Also sketch the propellant feed-system for a liquid propellant rocket motor. (8)

(ii) Explain the performance characteristics for solid propellant and liquid propellant rockets. (8)

205