www.onlineAnna.com

A 401

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2005.

Fifth Semester

Mechanical Engineering

ME 333 — GAS DYNAMICS AND SPACE PROPULSION

Time : Three hours Maximum : 100 marks

Answer ALL questions.

Use of Gas Tables Permitted.

PART A — (10 × 2 = 20 marks)

1. Define : Stagnation enthalpy.

2. Distinguish between Mach wave and normal shock.

3. Give any two assumptions regarding Fanno flow.

4. State the two governing equations used in plotting Rayleigh line.

5. Define the term : Strength of a shock wave.

6. Sketch an oblique shock and show the angles associated with flow through it.

7. Give the equation of thrust for a turbojet engine.

8. How is turbofan engine different from turbo prop engine?

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.

www.onlineAnna.com

www.onlineAnna.com

PART B — (5 × 16 = 80 marks)

11. (i) Deduce expressions for $\frac{P^*}{P_0}$ and $\frac{T^*}{T_0}$ for a compressible fluid flow under isentropic conditions. (6)

(ii) A conical air diffuser has an intake area of 0.11 m^2 and an exit area of 0.44 m^2. Air enters the diffuser with a static pressure of 0.18 MPa, static temperature of 37°C and velocity of 267 m/s. Calculate (1) the mass flow rate of air through the diffuser, (2) the Mach number, static temperature and static pressure of the air leaving diffuser and (3) the net thrust acting upon the diffuser due to diffusion. (10)

12. (a) (i) Sketch the Fanno line as h–s and h–ρ diagrams and explain how these lines are constructed? (6)

(ii) The friction factor for a 50 mm diameter steel pipe is 0.005. At the inlet to the pipe the velocity is 70 m/s, temperature is 80°C and the pressure is 10 bar. Find the temperature, pressure and Mach number at exit if the pipe is 25 m long. Also determine the maximum possible length. (10)

Or

(b) (i) Distinguish between Rayleigh flow and Fanno flow. (4)

(ii) Air enters a combustion chamber with a certain Mach number. sufficient heat is added to obtain a stagnation temperature ratio of 3 and a final Mach number of 0.8. Determine the Mach number at entry and the percentage loss in static pressure. Take r = 1.4 and C_p = 1.005 kJ/kg K for air. (12)

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 cm^2 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 cm^2 and exit area is 25 cm^2. Estimate the exit Mach number, exit pressure and loss in stagnation pressure for flow through nozzle. (10)

Or

(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)

www.onlineAnna.com

www.onlineAnna.com

(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) Determine the optimum flight to jet speed ratio that gives desirable performance for a turbojet engine. (6)

(ii) The flight speed of a turbojet is 800 km/hour at 10000 m altitude. The density of air at that altitude is 0.17 kg/m^3. The drag for the plane is 6.8 kN. The propulsive efficiency of the jet is 60%. Calculate the SFC, Air–fuel ratio and jet velocity. Assume the calorific value of fuel as 45000 kJ/kg and the overall efficiency of turbojet plant as 18%. (10)

Or

(b) (i) Compare solid and liquid propellant systems. (8)

(ii) With neat sketches explain the constructional features and working of (1) Ramjet engine and (2) turbofan engine. (8)

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 systems. 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)

www.onlineAnna.com