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B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2012.

Sixth Semester

Mechanical Engineering

080120037 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2008)

Time : Three hours Maximum : 100 marks

Use of Gas Tables is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define Mach number.

2. Express the stagnation enthalpy in terms of static enthalpy and velocity of flow.

3. Differentiate nozzle and diffuser.

4. Draw the variation of Mach number along the length of a convergent divergent duct when it act as a

   (a) Nozzle

   (b) Diffuser.

5. What are the assumptions made for Rayleigh flow?

6. Explain the difference between Fanno flow and isothermal flow.

7. What is oblique shock?

8. Define strength of shock.

9. What is thrust augmentation?

10. Define propulsive efficiency.

PART B — ($5 \times 16 = 80$ marks)

11. (a) An air jet ($\gamma = 1.4$, R 287 J / kg K) at 400 K has sonic velocity. Determine

(i) Velocity of sound at 400 K,

(ii) Velocity of sound at the stagnation conditions,

(iii) Maximum velocity of the jet,

(iv) Stagnation enthalpy.

(v) Crocco number. (16)

Or

(b) (i) Air ($\gamma = 1.4$, R = 287 J /kg K) enters a straight axis symmetric duct at 300 K, 3.45 bar and 150 m/s and leaves it at 277 K, 2.058 bar and 260 m/s. The area of cross section at entry is 500 cm^2. Assuming adiabatic flow determine

(1) Stagnation temperature,

(2) Maximum velocity,

(3) Mass flow rate,

(4) Area of cross section at exit (12)

(ii) Show that $T_0/T = (1 + (\gamma - \frac{1}{2}) M^2)$ (4)

12. (a) A conical air diffuser has an inlet area 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

(i) The mass flow rate of air through the diffuser,

(ii) The Mach number, static temperature and static pressure of the air leaving diffuser and

(iii) The net thrust acting upon the diffuser due to diffusion. (16)

Or

(b) An air nozzle is to be designed for an exit Mach number of 3.5. The stagnation conditions for the isentropic flow are 800 kpa and 240°C. Estimate pressure, temperature, velocity and area at throat and exit for a mass flow rate of 3.5 kg/s. (16)

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 3.5 bar and 38°C respectively and coefficient of friction is 0.005. If the Mach number at entry is 0.15, determine

(i) Diameter of the duct,

(ii) Length of the duct,

(iii) Pressure and temperature at the exit,

(iv) Stagnation pressure loss. (16)

Or

(b) Air is flowing in an insulated duct with a Mach number of $M_1 = 0.25$. At a section downstream entropy is greater by an amount 0.124 k J / kg K as a result of friction. What is the Mach number at this section? The static properties at inlet are 700 kpa and 60°C. Find velocity, temperature and pressure at exit. Find properties at the critical section. (16)

14. (a) A convergent divergent nozzle is designed to expand air from a reservoir in which the pressure is 800 kpa and temperature is 40°C to give a Mach number at exit of 2.5. The throat area is 25 cm^2. Find

(i) Mass flow rate,

(ii) Exit area,

(iii) When a normal shock appears at a section where the area is 40 cm^2, determine the pressure and temperature at exit. (16)

Or

(b) An oblique shock wave at an angle of 33°C occurs at the leading edge of a symmetrical wedge. Air has a Mach number of 2.1 upstream temperature of 300 K and upstream pressure of 11 bar. Determine the following

(i) Downstream pressure,

(ii) Down stream temperature,

(iii) Wedge angle,

(iv) Downstream Mach number. (16)

15. (a) (i) With neat sketch, explain the working of RAMJET engine. And list out the advantages and disadvantages of the RAMJET engine. (12)

(ii) Explain the working of Turbo propeller Engine. (4)

Or

(b) A turbojet engine takes in 50 kg/s of air and propels an aircraft with uniform flight speed of 880 km/hr. Isentropic enthalpy change for nozzle is 188 kJ/kg and velocity coefficient is 0.96. The fuel air ratio is 1.2%. Combustion efficiency is 95%. Calorific value of fuel is 44,000 kJ/kg. Find out :

(i) Thermal efficiency of the engine,

(ii) Fuel flow in kg/hr.

(iii) Propulsive efficiency, and

(iv) Overall efficiency. (16)
