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B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2013.

Sixth Semester

Mechanical Engineering

ME 2351/ME 64/10122 ME 602 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2008/2010)

(Common to PTME 2351 – Gas Dynamics and Jet Propulsion for B.E. (Part-Time) Fifth Semester – Mechanical Engineering – Regulation 2009)

Time : Three hours Maximum : 100 marks

Use of Gas Tables is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Find the sonic velocity through air at 0°C.

2. Distinguish between Mach wave and normal shock.

3. Show the Rayleigh line in h- s diagram and give the different Mach number regions for heating and cooling.

4. What are the assumptions made for fanno flow?

5. Define compression and rarefaction shocks.

6. What are the assumptions used for oblique shock flow?

7. Why ramjet engine does not require a compressor and a turbine?

8. Find optimum propulsive efficiency when the jet velocity is 500 m/s and flight velocity is 900 m/s.

9. What are the requirements of good liquid propellants?

10. What are the advantages of a hybrid rocket?

PART B — (5 × 16 = 80 marks)

11. (a) Air($C_p = 1.05\,kJ/kgK$, $\gamma = 1.38$) at $p_1 = 3\times10^5 N/m^2$ and $T_1 = 500\,K$ flows with a velocity of 200 m/s in a 30 cm diameter duct available. Calculate (i) Mass flow rate, (ii) Stagnation temperature. (iii) Mach number, (iv) Stagnation pressure values, assuming the flow is compressible and incompressible respectively. (16)

Or

(b) The pressure, temperature and velocity of air at the entry of a diffuser are 0.7 bar, 345 K and 190 m/s respectively. The entry diameter of a diffuser is 15 cm and exit diameter is 35 cm. Determine the following, (i) Exit pressure, (ii) Exit velocity and (iii) Force exerted on the diffuser walls. Assuming isentropic flow and take $\gamma = 1.4, c_p = 1005 J/kgK$. (16)

12. (a) Air at $P_1 = 3$ bar, $T_1 = 288\,K$ and $M_1 = 1.5$ is brought to sonic velocity in a frictionless constant area duct through which heat transfer takes place. Calculate (i) Final pressure, final temperature and the heat added during the process, (ii) What will be the mach number, pressure and temperature of air if this heat is extracted from the air? (16)

Or

(b) A convergent - divergent nozzle is provided with a pipe of constant cross section at its exit. The exit diameter of the nozzle and that of the pipe is 50 cm. The mean coefficient of friction for the pipe is 0.002. The stagnation pressure and temperature of air at the nozzle entry are 10 bar and 620 K. The mach numbers at the entry and exit of the pipe are 1.6 and 1.0 respectively. Determine (i) The length of the pipe. (ii) Diameter of the nozzle throat and (iii) Pressure and temperature at the pipe exit. (16)

13. (a) Derive the expression for change in entropy across the shock and state the necessary conditions for a normal shock to occur in compressible flow. (16)

Or

(b) An oblique shock wave at an angle of 33° 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) Downstream temperature, (iii) Wedge angle and (iv) Downstream mach number. (16)

14. (a) A turbojet plane has two jets of 250 mm diameter and the net power at the turbine is 3000 kW. The fuel consumption per kWhr is 0.42 kg with a fuel of calorific value 49 MJ/kg, when flying at a speed of 300 m/s in atmospheric having a density of 0.168 kg/m^3. The air fuel ratio is 53. Calculate: (i) Absolute velocity of jet, (ii) Resistance (or) Drag of the plane, (iii) Overall efficiency of the plane and (iv) Thermal Efficiency. (16)

Or

(b) A turbojet engine operates at an altitude of 11 km and a mach number of 0.82. The data for an engine is given below: Stagnation temperature at the turbine inlet = 1220 K, Stagnation temperature rise through the compressor = 170K, Calorific value of the fuel = 42 MJ/kg, Compressor efficiency = 0.75, Combustion chamber efficiency = 0.97, Turbine efficiency = 0.83, Exhaust nozzle efficiency = 0.96 and Specific impulse = 20 seconds. Determine: (i) Air fuel ratio, (ii) Compressor pressure ratio. (iii) Turbine pressure ratio, (iv) Exhaust nozzle pressure ratio and (v) Mach number of exhaust gas. (16)

15. (a) (i) Draw a neat sketch explaining the general working of the Hybrid propellant Rocket. (10)

(ii) Comparison between solid and liquid propellant propulsion. (6)

Or

(b) A rocket operating at an altitude of 19 km with the following data: Propellant flow rate = 1 kg/s, Thrust chamber pressure $= 28 \times 10^5\ N/m^2$. Thrust chamber temperature = 2500 K and Nozzle area ratio = 10.12. Calculate: (i) Thrust, (ii) Effective jet velocity and (iii) Specific impulse, Take $\gamma = 1.3$ and R = 355 J/kgK. (16)
