Reg. No. : [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

Question Paper Code : 11532

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2012.

Sixth Semester

Mechanical Engineering

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

(Regulation 2008)

(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 — $(10 \times 2 = 20$ marks)

1. Define flow compressing factor.

2. Give the sketch of subsonic and supersonic nozzle and diffuser.

3. Give two examples of Fanno flow and Rayleigh flow in thermal systems.

4. Air enters a duct of circular cross section of 15 cm diameter with a Mach number 0.5, pressure $300 KN/m^2$ and temperature 320°K. Average friction factor duct is 0.005. Assuming chocked adiabatic flow with friction. Determine length of duct.

5. What is the purpose of Prandtl — Meyer equation for the normal shock in a perfect gas?

6. Define propeller engine and jet engine.

7. Define speed ratio in propulsive system

8. Differentiate between normal shock and oblique shock.

9. Explain chemical rocket propulsion system.

10. Define propulsive efficiency.

PART B — (5 × 16 = 80 marks)

11. (a) (i) The pressure, temperature and Mach number at the entry of a flow passage are 2.45 bar, 26.5°C and 1.4 respectively. If the exit Mach number is 2.5 determine for adiabatic flow of a perfect gas $(\gamma = 1.3, R = 0.469\, kJ/Kg-K)$:

(1) Stagnation temperature.

(2) Temperature and velocity of gas at exit and

(3) The flow rate per square meter of the inlet cross-section. (10)

(ii) An aircraft is flying at an attitude of 8 km where the ambient temperature is 2500 k . Find Mach number and classify as subsonic or supersonic when the speed of the aircraft is

(1) 30 m/s

(2) 300 m/s, and

(3) 1000 m/s. (6)

Or

(b) Derive the following relationships between reference speeds from the adiabatic steady flow energy equation in kinetic form.

(i) $V_{max} = \sqrt{\frac{2a_0^2}{\gamma-1}}$

(ii) $a^* = \sqrt{\frac{2}{\gamma+1}a_0^2}$

(iii) $V_{max} = \sqrt{\frac{2a_0^2}{\gamma-1} + V^2}$

(iv) $a^* = \sqrt{\frac{2a^2 + V^2(\gamma-1)}{\gamma+1}}$. (16)

12. (a) Air enters a constant area pipe with velocity 150 m/s, temperature 60°C and pressure $0.5 MN/m^2$. If 180 kJ/kg of heat is added to the pipe find.

(i) The final pressure

(ii) Final Mach number

(iii) Change in stagnation change in stagnation pressure and

(iv) Change in entropy. (16)

Or

(b) 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, and

(v) verify the exit Mach number through exit velocity and temperature. (16)

13. (a) The state of a gas $(\gamma = 1.3, R = 0.469\ kJ/kg-K)$ upstream of a normal shock wave is given by the following data:

$M_x = 2.5, p_x = 2$ bar, $T_x = 275^0 K$.

Calculate the Mach number, pressure, temperature and velocity of the gas downstream of the shock; check the calculated values with those given in the gas tables. (16)

Or

(b) Air having a Mach number 3.0, approaches a symmetrical wedge having a wedge angle of 30°, The pressure and temperature of the air are 1 bar and 27°C. Find the Mach number and velocity of flow downstream of the shock wave, assuming that a weak oblique shock is formed. Also find the pressure, density, temperature and stagnation pressure downstream of the shock wave. (16)

14. (a) A turbojet engine operating with its exhaust nozzle unlocked propels an aircraft at a uniform speed of 900 km/h when it develops a thrust of 14 kN. The air intake to the engine is 50 kg/s and its air fuel ratio is 85. The calorific value of the fuel supplied to the engine is 44000 kJ/kg. The isentropic enthalpy change in the nozzle is $150 kJ/kg$. Find the thrust power, propulsive power, propulsive efficiency, thermal efficiency and overall efficiency of the engine. (16)

Or

(b) A turbojet aircraft flies at 850 km /h at an altitude of 10000 m above mean Sea level. The diameter of the inlet section and the jet exit are 0.75 m and 0.5 m respectively. The pressure and velocity of the gases at the exit are 0.3 bar and 500 m/s. The air fuel ratio for the engine is 40. Calculate: (i) air flow rate through the engine (ii) thrust (iii) specific thrust (iv) fuel specific impulse (v) thrust power (vi) TSFC. (16)

15. (a) (i) With a neat sketch explain the working of a hybrid rocket engine. (10)

(ii) Enumerate the differences between a mono propellant and a bi propellant? (6)

Or

(b) A projectile has the following data: Initial mass = 200 kg; mass of propellants = 70 kg; operating period = 3s; average specific impulse = 2400 Ns/kg. Find the mass ratio of the vehicle, propellant mass fraction, vehicle acceleration and total impulse. (16)
