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

Question Paper Code : 20750

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

Fifth Semester

Mechanical Engineering

CME 386 – GAS DYNAMICS AND JET PROPULSION

(Common to Automobile Engineering and Mechanical and Automation Engineering)

(Regulations 2021)

(Approved Gas table may be permitted)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Name the different regions of compressible fluid flow.

2. Differentiate nozzle and diffuser.

3. What is the value of the Mach number of air at the maximum point in the Rayleigh heating process?

4. Compare Rayleigh flow and Fanno flow.

5. Why the shock waves cannot develop in subsonic flow?

6. Compare normal shock and oblique shock.

7. How is the turbofan engine different from the turboprop engine?

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

9. Classify rocket engines based on the source of energy employed.

10. Write the advantages of solid propellant rockets over liquid propellant rockets.

PART B — (5 × 13 = 65 marks)

11. (a) An air jet at 300 K has sonic velocity. Determine the following : (i) Velocity of sound at 300 K, (ii) Velocity of sound at stagnation conditions, (iii) Maximum velocity of the jet, (iv) Stagnation enthalpy and (v) Crocco number. Take Y = 1.4 R = 287 J/kg K.

Or

(b) The velocity, pressure and temperature of a duct are 320 m/s, 1 bar and 295 K, Calculate the following : (i) Stagnation pressure, (ii) Stagnation temperature, (iii) Velocity of sound in dynamic condition, (iv) Velocity of sound in stagnation condition and (v) Stagnation pressure assuming constant density. Take Y = 1.4. R = 287 J/kg K.

12. (a) The pressure, temperature and velocity of a gas in a combustion chamber entry are 0.35 bar, 300 K and 55 m/s. The increase in stagnation enthalpy of the gas between entry and exit is 1170 kJ/kg. Calculate the following: (i) Exit Mach number, (ii) Exit pressure, (iii) Exit temperature and (iv) Exit velocity. Take Y= 1.4. Cp = 1.005 kJ/kg K.

Or

(b) Air enters a pipe of 25 mm diameter, at a Mach number of 2.4 stagnation temperature of 300 K and static pressure of 0.5 bar. If the coefficient of friction is 0.003, determine the following for a section at which the Mach number reaches 1.2. (i) Static pressure and temperature, (ii) Stagnation pressure and temperature, (iii) Velocity of air, (iv) Distance of this section from the inlet, and (v) Mass flow rate.

13. (a) The stagnation pressure and temperature of the air at the entry of a nozzle are 5 bar and 450 K respectively. The exit Mach number is 2.1 where a normal shock occurs. Calculate the following quantities before and after the shock. (i) Static temperatures, (ii) Stagnation temperatures, (iii) Static pressures, (iv) Stagnation pressures, (v) Stagnation pressure loss, and (vi) Increase in entropy.

Or

(b) An oblique shock wave occurs at the leading edge of a symmetrical wedge. Air has a Mach number of 2.1 and a deflection angle (δ) of 15°. Determine the following for strong and weak waves (i) Wave angle, (ii) Pressure ratio, (iii) Density ratio, (iv) Temperature ratio, and (v) Down stream Mach number.

14. (a) An aircraft flies at a speed of 520 kmph at an altitude of 6000 m. The diameter of the propeller of an aircraft is 2.4 m and the flight to jet speed ratio is 074 . Find the following (i) The rate of air flow through the propeller, (ii) Thrust produced, (iii) Specific thrust, (iv) Specify impulse, and (v) Thrust power.

Or

(b) A turbojet propels an aircraft at a speed of 900 km/h while taking 3000 kg of air per minute. The isentropic enthalpy drop in the nozzle is 200 kJ/kg and the nozzle efficiency is 90%. The air-fuel ratios 85 and the combustion efficiency is 95%. The calorific value of the fuel is 42,000 kJ.kg. Calculate (i) Propulsive power (ii) Thermal efficiency, and (iii) Propulsive efficiency.

15. (a) Explain the construction and operation of a solid propellant rocket engine. Also, name any four solid propellants.

Or

(b) Describe with a schematic diagram the principle of working of liquid propellant rocket. Also, write the desirable characteristics of liquid propellants.

PART C — ($1 \times 15 = 15$ marks)

16. (a) A rocket engine has the following data: Effective jet velocity = 1200 m/s. Flight to jet-speed = 0.82, Oxidizer flow rate = 3.4 kg/s. Fuel flow rate = 1.2 kg/s. Heat of reaction per kg of the exhaust gases = 2250 KJ/kg. Calculate the following : (i) Thrust, (ii) Specific impulse, (iii) Propulsive efficiency. (iv) Thermal efficiency, and (v) Overall efficiency.

Or

(b) A rocket nozzle has a throat area of 18 cm^2 and a combustor pressure of 25 bar. If the specific impulse is 127.42 sec and the rate of flow of propellant is 44.145 N/s. determine the thrust coefficient, propellant weight flow coefficient, specific propellant consumption and characteristics velocity.