B.E./B.TECH. Degree Examination, December 2020

Semester - VI

ME16604 - Gas Dynamics and Jet Propulsion

(Regulation 2016)

Time: Three hours Maximum : 80 Marks

Use of Gas tables is permitted

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. A plane travels with a velocity of 1000 kmph at an altitude where the pressure and temperature are 40kPa and –35°C. The value of Mach number
   (a) M= 1, (b)M < 1, (c) M > 1
2. What is limiting Mach number for maximum enthalpy point in Rayleigh flow?
   (a)M > 1/γ (b) M< 1/γ , (c) M = 1/γ (d) None of these
3. Which one of the following is the correct sequence of the position of the given components in a Turboprop?
   (a) Propeller, compressor, turbine, burner (b) Compressor, Propeller, burner, turbine
   (c) Propeller, compressor, burner, turbine (d) Compressor, Propeller, turbine, burner
4. Which of the following statement is correct relating to rocket engines ?
   (a) The combustion chamber in a rocket engine is directly analogous to the reservoir of super sonic wind tunnel
   (b) The stagnation conditions exist at the combustion chamber
   (c) The exit velocities of exhaust gases are much higher than those in jet engine
   (d) all of the above
5. Higher the velocity of supersonic flow, smaller the angle of mach cone, "comment on the validity of this statement".
6. State the assumptions used in Fanno flow.
7. The diameter of an aircraft propeller is 4.0 meters. The speed ratio is 0.8 at a flight speed of 450 kmph. If the ambient conditions of air at the flight altitude are T=256K and P=0.54 bar, determine the propulsive efficiency and Thrust.
8. Distinguish between monopropellant and bipropellant.

PART B - (4 X16 = 64 marks)

9. (a) (i) An aircraft is flying at an altitude of 14,000 m at a Mach number of 0.82. The cross sectional area of the inlet diffuser before the LP compressor stage is 0.5m^2. Determine (i). The mass of air entering the compressor, (ii). The speed of aircraft, (iii). The stagnation pressure, temperature of air at the diffuser entry. Take (γ = 1.4, R= 287 J/ KgK) **(8)**

(ii) Derive the expression for obtaining a relation between the non-dimensional impulse function and the Mach number. **(8)**

(OR)

(b) (i) Air is discharged from a reservoir at 6.91 bar, 325°C through a nozzle to an exit pressure of 0.98 bar. If the flow rate is 3,600 kg/hr determine for isentropic flow (i). throat area, pressure and velocity, (ii) Exit Mach number and Temperature **(8)**

(ii) An air jet at 400K has sonic velocity. Determine (i). Velocity of sound at 400K, (ii). Velocity of sound at stagnation conditions, (iii). Maximum velocity of jet, (iv). Stagnation enthalpy and (v). Crocco number. **(8)**

10. (a) Air is flowing in an insulated duct. The inlet Mach number is 0.25, the friction factor 4f = 0.01. The diameter of duct is 15 cm. **(16)**

(i) What length of the pipe would give a 10 % loss in stagnation pressure. What is the Mach number at this section (ii) What is the loss in % from inlet to a section at which the Mach number is 0.8 ? (iii) What is the maximum length to reach choking condition

(OR)

(b) A gas at a pressure of 69 kPa and temperature 278 K enters a combustion chamber at a velocity of 60 m/sec. The heat supplied in the combustion chamber is 1.4056 MJ/kg. Determine the Mach number, pressure, temperature and velocity of the gas at the exit, Maximum heat transfer and Maximum attainable temperature, percentage change in stagnation pressure loss. What are the pressure and temperatures at critical properties, Assume c_p = 1.004 kJ/kg and ratio of specific heats on 1.4 for the gas. **(16)**

11. (a) (i) A turbojet aircraft flies at 875 kmph at an attitude of 10000 m above mean level. Compute air flow rate through the engine, thrust, specific thrust, specific impulse, thrust power and TSFC from the following data,: diameter of the air inlet section = 0.75m, diameter of the jet pipe at exit = 0.5 m, velocity of the gases at the exit of the jet pipe = 500m/s, pressure at the exit of the jet pipe = 0.30 bar, air fuel ratio = 40 **(8)**

(ii) Distinguish the working of turbojet, turbofan turboprop engine. **(8)**

(OR)

(b) (i) A convergent air nozzle has exit to throat area ratio of 3.0. A normal shock appears at the divergent section where the existing area ratio is 2.2. Evaluate the Mach number before and after the shock. If the inlet stagnation properties are 5 bar and 450K, Evaluate the properties of air at the exit. **(8)**

(ii) A Supersonic stream of air at M = 3.0, deflected inwards by 15 degrees. This generates weak shock waves. Compute the following quantities for this wave. (i)Wave angle, (ii) Downstream Mach number, (iii)Temperature ratio, static and stagnation pressure values. **(8)**

12. (a) (i) A rocket nozzle has a throat area of $18cm^2$ and combustion chamber pressure of 25 bar, if the specific impulse is 127.42 sec, and weight flow rate 44.145 N/s, determine thrust coefficient, propellant weight flow coefficient, SPC and characteristic velocity. **(8)**

(ii) A rocket flies at 10080 kmph with an effective exhaust jet velocity of 1400m/s and propellant flow rate of 5.0 kg/s, if the heat of reaction of the propellant is 6500 kJ/kg of the propellant mixture determine propulsion efficiency and propulsion power, engine output, thermal efficiency and overall efficiency. **(8)**

(OR)

(b) (i) The data for a rocket engine is given below combustion chamber pressure =38 bar, combustion chamber temperature=3500 K, oxidizer flow rate = 41.67 kg/s, mixture ratio 5.0, if the expansion in the rocket nozzle takes place to the ambient pressure of $583.58 N/m^2$, evaluate nozzle throat area, thrust, thrust coefficient, characteristic velocity, exit gas velocity and maximum possible velocity. Take $\gamma = 1.3$, R = 287 J/kg k **(8)**

(ii) The effective jet velocity from a rocket is 2700 m/s. The forward flight velocity is 1350 m/s and the propellant consumption is 78.6 kg/s. Compute the thrust, thrust power and propulsive efficiency. **(8)**