(b) Air is moving in a constant area duct at the temperature of –50°C and 52.5 kPa. The velocity at this section is 167 m/s. Assume Rayleigh flow process and Find

(i) Stagnation properties at inlet

(ii) Properties at section where static temperature is maximum and

(iii) Properties at section where chocking condition is exist.

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

Question Paper Code : 53316

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2019.

Sixth Semester

Mechanical Engineering

ME 6604 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2013)

(Common to PTME 6604 – Gas Dynamics and Jet Propulsion for B.E. Part-Time – Fifth Semester – Mechanical Engineering – Regulation 2013)

Time : Three hours Maximum : 100 marks

State clearly any assumption made with justification.

Use of Gas Table is allowed

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is stagnation velocity of sound and for which process (isentropic / adiabatic) this velocity is constant?

2. Differentiate nozzle and diffuser.

3. What is Rayleigh line and Fanno line?

4. In Rayleigh subsonic flow during heating and cooling process what is the response of change in fluid static and total pressure?

5. State the reason for development of shock wave in nozzle.

6. What is Hugoniot curve?

7. What is effective jet velocity and effective jet Mach number?

8. Give the reason why propeller engines are not in common use in present day aircraft engines.

9. How do you compare solid and liquid propellant rockets?

10. What is escape velocity and how it is calculated?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Make a sketch of the pressure pulse pattern when a point source of disturbance moves at sonic velocity in air. Also explain the propagation of disturbance. (8)

(ii) Estimate the sonic velocity and the maximum possible flow velocity for air corresponding to stagnation temperature of 750 K. What would be the sonic velocity when the flow takes place at half the maximum velocity? (5)

Or

(b) (i) When the following events that found in a CD nozzle during its operation? Discuss with proper sketches. (8)

(1) Venturi effect

(2) First Critical

(3) Third Critical.

(ii) Using stagnation enthalpy equation, obtain the below form. (5)

$$\frac{a^2}{\gamma-1}+\frac{1}{2}C^2=\frac{1}{2}C_{max}^2=\frac{a_0^2}{\gamma-1}=h_0 .$$

12. (a) Using Rayleigh flow governing equations develop the ratio of end to initial state of

(i) Static temperature (T_2/T_1) and stagnation temperature $(T_{02}^{\cdot}/T_{01})$

(ii) Static pressure (p_2/p_1) and stagnation pressure (p_{02}/p_{01}). Obtain all the relations in terms of Mach number.

Or

(b) Air at Mach number 0.5, pressure 3 bar and temperature 47°C enters a 15 cm circular duct. If the coefficient of friction factor is 0.005, for choked condition, determine length of duct, change in entropy, change in impulse function and loss in total pressure.

13. (a) Air at static conditions of 50 kPa and 300 K is to be expanded isentropically from a Mach number 1.5 to achieve a pressure of 20 kPa. Find out the flow deflection angle required. Also get the final Mach number and temperature of the gas.

Or

(b) The stagnation pressure and temperature of air at the entry of a nozzle are 5 bar and 500 K respectively. The exit Mach number is 2.0 where a normal shock occurs. Calculate the following quantities before and after the shock: Static and stagnation pressures and temperatures, air velocities and Mach numbers. What are the values of stagnation pressure loss and increase in entropy across the shock?

14. (a) Discuss the function of basic components involved in aircraft gas turbine engine. Also draw the T-s diagram of Brayton cycle.

Or

(b) A turbojet engine propels an air plane in level flight at 10 km altitude with a Mach number of 0.8. The total pressure of air at entrance to the compressor is 0.95 times free stream to total pressure. Calculate (i) the ram recovery ratio of the air entering the compressor and (ii) isentropic efficiency of the diffusion system.

15. (a) A rocket engine has the following performance details :

Velocity of jet = 1400 m/s; Flight to jet speed ratio = 0.8; Oxidizer flow rate = 4 kg/s; Fuel flow rate = 1 kg/s; Heat of reaction per kg of exhaust gas = 2500 kJ/kg

Calculate the thrust, specific impulse, propulsive efficiency, thermal and overall efficiency of the rocket engine.

Or

(b) (i) Write short notes on : (5 + 5)

(1) Multi-stage rocket

(2) Hybrid propellant rocket.

(ii) If a rocket engine produces a thrust of 1,000 kN at sea level with a propellant flow rate of 400 kg/s, calculate the specific impulse. (3)

PART C — (1 × 15 = 15 marks)

16. (a) The speed of supersonic aircraft flying at an altitude of 1100 m corresponds to a Mach number (M) of 2.5. Estimate the time elapsed between the instant the aircraft was directly over head of an observer and the instant the observer feels the disturbance due to aircraft. Consider the following three cases and presume that the temperature at the given height is 280 K.

(i) when the observer is stationary

(ii) when the observer is moving in the direction of the aircraft at M = 0.5 and

(iii) when the observer is moving in the opposite direction with M = 0.5

Or