G 1094 (Pages : 3) Reg. No.....

Name.....

B.TECH. DEGREE EXAMINATION, MAY 2016

Seventh Semester

Branch : Mechanical Engineering

GAS DYNAMICS AND JET PROPULSION (M)

(Old Scheme—Prior to 2010 Admissions)

[Supplementary/Mercy Chance]

Time : Three Hours Maximum : 100 Marks

Use of Approved Gas Tables and Charts are permitted.

Part A

Answer **all** *questions.*
Each question carries 4 *marks.*

1. Show the regimes of flow possible in a compressible flow with sketches.
2. Define the terms: Compressibility and nozzle efficiency.
3. Sketch the compression process in a subsonic and supersonic nozzle reflecting actual and isentropic expansion in h-s state space.
4. Explain in brief the flow characteristics of convergent nozzle.
5. What are the assumptions involved in Rayleigh flow ? Sketch fannoline for different mass densities.
6. Define the terms: critical length of the duct and thermal choking.
7. Why expansion shocks are not possible in a supersonic compressible flow?
8. Define the term : Shock strength and Mach Wave.
9. Define the terms: Solid and Liquid propellants. Give examples.
10. State the advantages and limitations of turbo jet engine ?

(10 × 4 = 40 marks)

Part B

Answer **all** *questions.*
Each question carries 12 *marks.*

11. Following quantities are given at the entry and exit of a passage: Entry: $P_1 = 2.07$ bar, $T_1 = 300$K, $M_1 = 1.4$ and Exit: $M_2 = 2.5$, assuming isentropic flow of an ideal gas ($\gamma = 1.4$, $R = 287$ J/KgK). Determine : (a) Velocity of sound at stagnation conditions ; (b) Maximum velocity ; (c) Mach number M_1^* and Ms_2^* ; (d) Temperature and pressure at exit and ; (e) Maximum flow rate.

(2 + 2 + 2 + 4 + 2 = 12 marks)

Or

Turn over

12. Starting from the adiabatic energy equation, derive the Bernoulli's equation for a compressible fluid. What is the equivalent of Bernoulli equation for isentropic compressible flow ?

13. Air (γ = 1.4 , R = 287.43J/kgK) enters a straight axisymmetric duct at 300K, 3.45 bar and 150 m/s and leaves it at 277K, 2.058 bar and 260 m/s. The area of cross section at the entry is 500 cm^2. Assuming adiabatic flow determine : (1) stagnation temperature ; (2) maximum velocity ; (3) mass flow rate ; and (4) area of cross section at exit.

(3 + 3 + 3 + 3 = 12 marks)

Or

14. (a) Air is discharged from a reservoir at P_0 = 6.91 bar and T_0 = 598 K through a nozzle to an exit pressure of 0.98 bar. If the flow rate is 3600 kg/hr, determine for isentropic flow ; (i) throat area, pressure and velocity ; (ii) exit area and exit Mach number ; (iii) Maximum velocity of fluid.

(3 + 3 + 2 = 8 marks)

(b) Explain the working principle of a convergent-divergent nozzle stating design and off-design conditions.

(4 marks)

15. 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 38C respectively and the coefficient of friction 0.005. If the Mach number at entry is 0.15, determine : (a) diameter and length of the duct ; (b) pressure and temperature at the exit ; (c) stagnation pressure loss and exit velocity of air.

(4 + 4 + 4 = 12 marks)

Or

16. The Mach number at the exit of a combustion chamber is 0.9. The ratio of stagnation temperatures at the exit and entry is 3.74. If the pressure and temperature of the gas at exit are 2.5 bar and 1000C respectively, determine : (a) Mach number, pressure and temperature of gas at entry ; (b) the heat supplied per kg of the gas and (c) the maximum heat that can be supplied.

(6 + 3 + 3 = 12 marks)

17. Starting from the energy equation, for flows through a normal shock, obtain the following relation :— $(C_x)(C_y) = a^{*2}$ and $(M_x^*)\,(M_y^*) = 1$.

Or

18. An aircraft flies at a Mach number of 1.2 at an altitude of 16,000 m (p = 0.103 bar, T = 216.65K). The compression in its engine is partly achieved by a Normal shock wave standing at the entry of its diffuser. Determine immediately downstream of the shock : (a) Mach number ; (b) temperature of air ; (c) Pressure of air ; and (d) stagnation pressure loss across the shock.

(3 + 3 + 3 + 3 = 12 marks)

19. Explain the working principle of: solid propellant rockets and ramjet engines .

(6 + 6 = 12 marks)

Or

20. (a) The forward flight velocity of rocket is 1350 m/s, the effective Jet velocity from a rocket is 2700 m/s and the propulsion consumption is 786 kg/s. Calculate : (i) Thrust ; (ii) Thrust power ; and (iii) propulsive efficiency.

(4 marks)

(b) A turbojet engine propels an aircraft at a speed of 900 kmph 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 fuel supplied to engine is 44,000 kJ.Kg Isentropic enthalpy change in the nozzle is 150 kJ/kg. Find : (a) thrust and thrust power ; (b) propulsive power and propulsive efficiency ; (c) Thermal efficiency and overall efficiency of engine.

(8 marks)

[5 × 12 = 60 marks]