G 731 (Pages : 3) Reg. No.....

Name.....

B.TECH. DEGREE EXAMINATION, MAY 2014

Seventh Semester

Branch : Mechanical Engineering

ME 010 703—GAS DYNAMICS AND JET PROPULSION (ME)

(Improvement/Supplementary)

[2010 Admissions]

Time : Three Hours Maximum : 100 Marks

Use of Gas tables permitted.

Part A

Answer **all** *questions.*
Each question carries 3 marks.

1. Explain Mach Cone and Mach angle.
2. How turbo propulsion engine different from turbo fan engine ?
3. What is Fanno line ? What are the assumptions taken during Fanno flow ?
4. State three applications of isentropic flow.
5. Why are expansion shocks impossible ?

(5 × 3 = 15 marks)

Part B

Answer **all** *questions.*
Each question carries 5 marks.

6. Give two practical examples of each :
   (a) Steep compression waves.
   (b) Infinitesimal pressure wave.
7. Derive the given relation for one dimensional isentropic flow.

$$\frac{p^*}{p} = \left[\frac{2}{r+1} + \frac{r-1}{r+1} \cdot M^2\right]^{r/r-1}.$$

8. Derive the expression for the ratio of static pressure and temperature across the shock in terms of Mach number upstream and down stream of shock.

Turn over

9. What is Rayleigh flow ? Give two practical examples. Under what conditions the assumption of Rayleigh flow is not valid in a heat exchanger ?

10. Enumerate five methods of modern rocket propulsion.

(5 × 5 = 25 marks)

Part C

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

11. Starting from continuity and momentum equation derive the expression for the velocity of sound in a perfect gas, in terms of characteristic gas constant and static temperature.

(12 marks)

Or

12. (a) Show that the Mach number of the flow in a gas which has been traversed by an isentropic finite amplitude pressure wave (pressure ratio r_p) is given by

$$M = \frac{2}{r-1}\left[1 - r_p^{\left(\frac{r-1}{2r}\right)}\right].$$

(8 marks)

(b) Show that for inducing sonic velocity in a gas (r = 1.4), the pressure ratio required for a compression wave is 4.77.

(4 marks)

13. A conical diffuser has entry and exit diameter of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bar, 340 K and 180 m/s. Determine (a) the exit pressure ; (b) the exit velocity ; and (c) the force exerted on the diffuser walls. Assume isentropic flow and r = 1.4.

(12 marks)

Or

14. Explain the behaviour of flow in a convergent, divergent nozzle when it is operated at (i) design pressure ratio ; (ii) pressure ratio higher than the design value ; and (iii) pressure ratio lower than the design value.

(12 marks)

15. The conditions of gas in a combustor at entry are P_1 = 0.343 bar, T_1 = 310 K and velocity v_1 = 60 m/s. Determine the Mach number, Pressure, temperature and velocity at the exit, if the increase in stagnation enthalpy of the gas between entry and exit is 1172.5 kJ/kg.

(12 marks)

Or

16. Prove that the Mach numbers at the maximum enthalpy and maximum entropy points on the Rayleigh line are $1/\sqrt{r}$ and 1.0 respectively. Show the h = constant and s = constant lines at these points on the Rayleigh line on the h–s and p–v planes.

(12 marks)

17. (a) Derive Rankine–Hugoniot relation for a normal shock.

(b) A gas (r = 1.4, R = 0.287 kJ/kg K) at a Mach number of 1.8, P = 0.8 bar and T = 373 K passes through a normal shock. Determine the density after the shock.

(12 marks)

Or

18. A jet of air at 275 K and 0.69 bar has an initial Mach number of 2.0. If it passes through a normal shock wave. Determine :

(a) Mach number.

(b) Pressure.

(c) Temperature.

(d) Density.

(e) Speed of sound ; and

(f) Jet velocity down stream of the shock.

(12 marks)

19. Describe the working of a Scram jet Engine. What is its advantages over the Ramjet ?

(12 marks)

Or

20. Air enters a combustion chamber at $M_1 = 2.5$ $P_1 = 2$ bar, $T_1 = 288$ K. A normal shock occurs at the end of the combustion chamber ; the static pressure before the shock is 4.0 bar. Determine (a) Mach number ; (b) Static pressure ; and (c) Static temperature at the exit of the combustion chamber. What are these values in the absence of shock.

(12 marks)

[5 × 12 = 60 marks]