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

Q 2404

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2007.

Fifth Semester

Mechanical Engineering

ME 333 — GAS DYNAMICS AND SPACE PROPULSION

Time : Three hours Maximum : 100 marks

(Use of Standard Gas Tables Permitted)

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What are the sonic speeds in air at 21°C under isothermal and isentropic condition?

2. What is meant by recovery factor in relation to adiabatic wall temperature?

3. Plot p_0/p and A/A^* for M ranging from 0.1 to 10 and write your comments.

4. What is the value of M^* for air if $M = 2$?

5. What do you understand by sonic boom and boom carpet?

6. Write the Prandtl-Meyer relation and identify its significance.

7. How is the jet speed of ideal ramjet engine is related to its flight speed?

8. Why turbofan engine is more efficient than turbojet engine?

9. If the speed ratio is 2, calculate the efficiency of turbojet engine and rocket engine.

10. Mention the significance of pyrogalic propellants?

PART B — ($5 \times 16 = 80$ marks)

11. (a) (i) Deduce the expression for compressibility correction $(p_0 - p)/(0.5\rho V^2)$ and discuss about the compressibility effects. (4 + 2)

(ii) Air assumed to be perfect gas with k = 1.4 flows through a frictionless channel. The speed of the air increases in the direction of the flow. At station 1 the static temperature is 305 K, the static pressure is 206785 N/m^2 and the mean speed is 150 m/s. At station 2 the mean speed is such that the local Mach no is unity. Calculate the values of the static temperature, the mean speed, the density and the static pressure of the air at station 2. (10)

Or

(b) Derive the expression for the area velocity relationship in an isentropic flow form the first principles and deduce the shape of subsonic, supersonic, subsonic and supersonic (or supersonic and subsonic) nozzle and diffusers. (16)

12. (a) It is required to deliver 1010 m^3/min of air at 295 K and 157 kPa at the exit of constant area duct. The inside diameter of the duct is 0.3 m and its length is 51.7 m. If the flow is adiabatic and the average friction factor is 0.005, determine

(i) the exit Mach number

(ii) inlet pressure of the air

(iii) inlet temperature of the air and

(iv) the total change of entropy. (4 + 4 + 4 + 4)

Or

(b) Air at a temperature of 280 K, 100 kPa and Mach number 3 flows through a frictionless pipe. Heat is transferred to the air to decelerate the flow to M = 1.5. What are the resultant temperature, pressure and density. Also calculate the maximum specific heat interaction. Plot the process on the h-s diagram and explain. (4 + 4 + 4 + 4)

13. (a) Consider Mach 2.5 airflow at a pressure of 1 atm, which is desired to be slowed to sub-sonic speed with minimum loss in total pressure. Use the following options

(i) A simple Normal Shock

(ii) A oblique shock with flow deflection of 20°, followed by a normal shock and

(iii) An oblique shock with flow deflection of 10°, followed a second oblique shock with further flow deflection of 10°, then followed by a normal shock. Calculate the loss in total pressure in each case and present your work out with comments. (3 + 4 + 9)

Or

(b) (i) Compare normal shock wave with oblique shock waves.

(ii) A reservoir containing air at 40×10^5 N/m^2 is connected to ambient air at atmospheric pressure through a CD Nozzle, designed for M = 2.0, with axial flow at the nozzle exit plane. Under these conditions, nozzle is under expanded or over-expanded condition. Find the flow properties (pressure and Mach Number) and direction of flow after expansion/compression waves. Sketch the flow pattern. (4 + 12)

14. (a) (i) Explain the working of turbojet engine and deduce the expression for its propulsive efficiency. (12)

(ii) What are the effects of after burner on the engine performance? (4)

Or

(b) (i) With a simple sketch, explain the role of different zones in a gas turbine combustion chamber. (8)

(ii) Explain the salient features of turbo-prop engine with a sketch. (8)

15. (a) (i) Explain the properties of major liquid and solid fuels and oxidizer (two each). (10)

(ii) What is effective jet velocity and how is it related to the actual jet velocity and specific impulse? (6)

Or

(b) (i) Describe the advantages and limitations of multi-staging of rocket. (6)

(ii) Deduce the expression for the characteristic velocity and explain its significance. (4 + 2)

(iii) What is escape velocity and how is it affected by the mass of the object? (4)
