Reg. No. :

Question Paper Code : 31395

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2010.

Fifth Semester

Mechanical Engineering

ME 1303 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2004)

Time : Three hours | Maximum : 100 marks

Use of Gas Tables permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the velocity of sound at 293 K in Hydrogen?
2. Define stagnation state of a system.
3. When is the flow of a fluid said to be one dimensional?
4. What is choked flow through a nozzle?
5. Give the assumptions made on Rayleigh flow.
6. What is the limiting Mach number for isothermal flow?
7. How do the properties change across a shock wave?
8. When the shock wave will be called as oblique shock?
9. What type of compressor is used in turbojet? Why?
10. Give an example for hypergolic propellant.

PART B — (5 × 16 = 80 marks)

11. (a) (i) An aircraft is driven by propellers with a diameter of 4 m. At what engine speed will the tips of the propellers reach sonic velocity if the air temperature is 288 K? (6)

(ii) Derive the energy equation

$$\frac{a^2}{\gamma-1}+\frac{1}{2}c^2=\frac{1}{2}c_{max}^2=\frac{a_0^2}{\gamma-1}=h_0. \quad (10)$$

Or

(b) Explain the effect of Mach number on compressibility. Calculate the percentage deviation due to the assumption of incompressibility when Mach number is equal to 0.5 and specific heat ratio is 1.4.

12. (a) (i) Air flows through a nozzle which has inlet area of 10 cm^2. If the air has a velocity of 80 m/sec, a temperature of 301 K, and a pressure of 700 kPa at the inlet section and a pressure of 25 kPa at the exit, find the mass flow rate through the nozzle and, assuming one-dimensional isentropic flow, the velocity at the exit section of the nozzle. (10)

(ii) Derive the following relation for one dimensional isentropic flow : (6)

$$\frac{dA}{A} = \frac{dp}{\rho c^2}(1 - M^2).$$

Or

(b) A nozzle in a wind tunnel gives a test-section Mach number of 2.0. Air enters the nozzle from a large reservoir at 0.69 bar and 310 K. The cross-sectional area of the throat is 1000 cm^2. Determine the following quantities for the tunnel for one dimensional isentropic flow :

(i) Pressures, temperatures and velocities at the throat and test sections

(ii) Area of cross-section of the test section

(iii) Mass flow rate

(iv) Power required to drive the compressor.

13. (a) Air flows out of a pipe with a diameter of 0.3 m at a rate of 1000 m^3/min at a pressure and temperature of 150 kPa and 293 K respectively. If the pipe is 50 m long, and assuming that friction coefficient f = 0.005, find the Mach number at exit, the inlet pressure and the inlet temperature.

Or

(b) Air flows through a constant area duct whose walls are kept at a low temperature. The air enters the pipe at a Mach number of 0.52, a pressure of 200 kPa, and a temperature of 623 K. The rate of heat transfer from the air to the walls of pipe is estimated to be 400 kJ/kg of air. Find the Mach number, temperature and pressure at the exit of the pipe. Assume that the flow is steady, that the effects of wall friction are negligible, and that the air behaves as a perfect gas.

14. (a) A supersonic diffuser for air ($\gamma = 1.4$) has an area ratio of 0.416 with an inlet Mach number of 2.4 (design value). Determine the exit Mach number and the design value of the pressure ratio across the diffuser for isentropic flow. At an off-design value of the inlet Mach number 2.7 a normal shock occurs inside the diffuser. Determine the upstream Mach number and area ratio at the section where the shock occurs, diffuser efficiency and pressure ratio across the diffuser.

Or

(b) Derive the Rankine-Hugoniot relation for a normal shock wave.

15. (a) An aircraft flies at 960 kmph. One of its turbojet engines takes in 40 kg/sec of air and expands the gases to the ambient pressure. The air-fuel ratio is 50 and the lower calorific value of the fuel is 43 MJ/kg. For maximum thrust power determine

(i) Jet velocity

(ii) Thrust

(iii) Specific thrust

(iv) Thrust power

(v) Propulsive, thermal and overall efficiencies and

(vi) TSFC.

Or

(b) A rocket nozzle has an exit area ratio 3 : 1 with isentropic expansion. What will be the thrust per unit area of exit and specific impulse if the combustion chamber temperature is 2973 K and pressure is 20 bar? Assume atmospheric pressure is 1 bar and γ =1.3, R = 0.248 kJ/kg-K.