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Question Paper Code : X 20849

B.E./B.Tech. DEGREE EXAMINATIONS, NOV./DEC. 2020

Sixth Semester

Mechanical Engineering

ME 6604 – GAS DYNAMICS AND JT PROPULSION

(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. Write the steady flow energy equation for isentropic flow of an air.
2. Distinguish static and stagnation quantities.
3. Define critical condition in Fanno flow.
4. Write down the expression for the pressure ratio of two sections in terms of Mach number in Rayleigh flow.
5. What is the nature of Mach number of flow after the Normal shock wave ?
6. How does the total temperature and total pressure change across the oblique shock wave ?
7. Why axial flow compressors are preferred over centrifugal compressors in jet engines ?
8. Depict the various forces acting on an aircraft propulsion system.
9. What is meant by thrust coefficient of a Rocket engine ?
10. How is solid propellant ignited ?

PART – B **(5×13=65 Marks)**

11. a) i) Given speeds and Mach numbers, assuming air is a perfect gas, determine the corresponding local temperature (take 1 mi/hr = 0.447 m/s) for the following : (1) A Boeing 747-400 at a cruise speed of 910 km/hr; M = 0.85. (2) Concorde at a cruise speed of 1,320 mi/hr; M = 2.0 (3) The fastest airplane, the Lockheed SR-71 Blackbird, flying at 2,200 mi/hr; M = 3.3 (4) The fastest car, the Thrust SSC, averaged 760.035 mi/hr; M = 0.97 **(7)**

ii) Helium flows at Mach 0.5 in a channel with cross-sectional area of 0.16 m^2. The stagnation pressure of the flow is 1 MPa and stagnation temperature is 1000 K. Calculate the mass flow rate through the channel, with $\gamma = 5/3$. **(6)**

(OR)

b) A supersonic diffuser, diffuses air in an isentropic flow from a Mach number of 3 to a Mach number of 1.5, the static conditions of air at inlet are 70 kPa and –7°C. If the mass flow rate of air is 125 kg/s determine (i) Stagnation conditions, (ii) Area at throat and exit, (iii) Static conditions of air at exit.

12. a) Air enters a constant area duct at Mach No. of 0.2, pressure of 1 atm, temperature of 273 K. Inside the duct, the heat added per unit mass is 1 MJ/kg. Estimate the Mach No. pressure, temperature, density, total temperature and total pressure of the air at the exit of the duct. Also summarise the effect of heat addition to subsonic frictionless flow in a constant area duct. **(8+5)**

(OR)

b) Air enters a constant area pipe of 150 mm diameter at Mach No. of 0.3 pressure of 1 atm, temperature of 273 K and flows through a length of 30 m. Inside the pipe, the friction coefficient f = 0.005. Estimate the Mach No., pressure, temperature and total pressure of the air at the exit of the duct. Also summarise the effect of friction to subsonic adiabatic flow in a constant area duct. **(8+5)**

13. a) An air plane having a diffuse designed for subsonic flight, has a normal shock attached to the edge of the diffuser, when the flight is flying at supersonic Mach Number. The diffuser exit mach no. is 0.3. The inlet and exit area of the diffuser are 0.29 m^2, 0.44 m^2. What must be the flight mach if isentropic diffuser is assumed behind the shock.

(OR)

b) Air approaches a symmetrical wedge (half wedge angle 15°) at mach no. 2. Determine for a strong pressure wave (a) wave angle (b) pressure ratio across shock (c) temperature ratio across shock (d) density ratio across shock (e) Down stream mach number.

14. a) i) Discuss the function and need of afterburner in jet engines. **(4)**

ii) Derive the thrust equation for turbo-prop engine. **(4)**

iii) Draw the following performance curve for turbo-prob, turbofan and turbojet engines. **(5)**

Propulsive efficiency Vs Flight Speed.

(OR)

b) Mach 2 aircraft engine employs a subsonic inlet diffuser of area ratio 3. A normal shock is formed just upstream of the diffuser inlet. The free stream conditions upstream of the diffuser are p = 10 bar, T = 300 K. Determine : (i) Mach number pressure and temperature at the diffuser exit, (ii) Diffuser efficiency including the shock. Assume isentropic flow in the diffuser downstream of the shock. **(13)**

15. a) i) Explain the working of solid propellant Rocket with neat sketch. **(5)**

ii) A rocket develops 9 kN thrust with 3.5 kg/s of propellant flow rate while flying at 400 m/s. If the heating value of the propellant is 7 kJ/kg, calculate the jet velocity, specific impulse and overall efficiency. **(8)**

(OR)

b) i) Derive the expression for the characteristic velocity in terms of combustion chamber temperature. **(5)**

ii) Describe the working of a multi-stage rocket. **(8)**

PART – C **(1×15=15 Marks)**

16. a) i) Derive the expression for change in area in isentropic flow and hence deduce the shape of subsonic and supersonic nozzle and diffusers. **(10)**

ii) Determine the maximum velocity of a rocket and altitude attained, if the Mass Ratio = 0.15, Burn out time = 75 s and effective jet velocity = 2500 m/s. **(5)**

(OR)

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.
