G 1065 (Pages : 3) Reg. No.....

Name.....

B.TECH. DEGREE EXAMINATION, MAY 2015

Seventh Semester

Branch : Mechanical Engineering

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

(New Scheme—2010 Admission onwards)

[Improvement/Supplementary]

Time : Three Hours Maximum : 100 Marks

Part A

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

1. How will you classify the compressible flow based on Mach number range ?
2. Differentiate between Fanno and Rayleigh flow.
3. Deduce an expression for sonic velocity in terms of the properties of air.
4. Define thrust, power and propulsive efficiency of aircraft system.
5. With neat sketch explain the working of scramjet engine.

(5 × 3 = 15 marks)

Part B

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

6. With usual notations and suitable supporting diagram, derive continuity equation for 1-D compressible steady flow conditions.
7. Differentiate between nozzle and diffuser.
8. Explain what is meant by stagnation properties of fluid and supersonic flow.
9. What is the effect of Mach number on compressibility ? Justify with equations.
10. Compare the constructional features and operating performance of turboprop and turbojet engines.

(5 × 5 = 25 marks)

Part C

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

11. (a) During a flight, a fighter aircraft attains its cruise speed of 600 m/s at 10 km altitude after taking off at 150 m/s from sea level. Assuming the speed to have increased linearly with altitude during the climb, compute the variation in Mach number with altitude.

Turn over

(b) Deduce an expression for sonic velocity in terms of the properties of air.

(7 + 5 = 12 marks)

Or

12. (a) Air flows through a duct. The pressure and temperature at station 1 are $p_1 = 0.7$ atmosphere and $T_1 = 30°C$, respectively. At a second station, the pressure is 0.5 atmospheres. Calculate the temperature and density at the second station. Assume the flow to be isentropic.

(b) Write short notes on effect of Mach number on compressibility.

(6 + 6 = 12 marks)

13. (a) A gas ($\gamma = 1.4$, R = 0.287 kJ/kgK) at a Mach number of 1.8, $p = 0.8$ bar and T = 373 K passes through a normal shock. Determine its density after the shock. Compare this value in an isentropic compression through the same pressure ratio.

(b) Derive an expression for mass flow rate through varying cross sectional passage for isentropic flow in terms of pressure ratio.

(6 + 6 = 12 marks)

Or

14. (a) A De Laval nozzle has to be designed for an exit Mach number of 1.5 with an exit diameter of 200 mm. Find the required ratio of throat area to exit area. The reservoir conditions are given as $p_0 = 1$ atmg ; $T_0 = 20$ °C. Find also the maximum mass flow rate through the nozzle. What will be the exit pressure and temperature ?

(b) Explain for a convergent nozzle the variation of pressure and Mach number when the back pressure is gradually lowered from stagnation pressure.

(7 + 5 = 12 marks)

15. (a) A straight pipe of 0.05 m diameter is attached to a large air reservoir at pressure 13.8×10^5 N/m^2 and temperature 310 K. The exit of the pipe is open to atmosphere. Assuming adiabatic flow with an average friction coefficient of 0.005, calculate the pipe length necessary to obtain a mass flow rate of 2.25 kg/s.

(b) What are the effects of heat addition and removal from a gas during Rayleigh flow ?

(6 + 6 = 12 marks)

Or

16. (a) Prove that in a Rayleigh line at maximum entropy point Mach number is unity.

(b) Air at pressure of 3.5×10^5 N/m^2 and a temperature of 300K is to be transported at the rate of 0.090 kg/s over a distance of 600 m through a pipe. The final pressure is to be atleast 1.40×10^5 N/m^2. Assuming isothermal flow and $f = 0.004$, determine the minimum pipe diameter.

(5 + 7 = 12 marks)

17. (a) Prove that for a normal shock $\frac{Py}{Px} = \left(1 + KM_x^2\right)\left(1 + KM_y^2\right)$ where K is the ratio of specific heats for air.

(b) A normal shock moves in a constant area tube as shown in Fig (1). In region 1, $V_1 = 100$ m/s, $T_1 = 30°C$, and $p_1 = 0.7$ atm. The shock speed C_s with respect to a fixed coordinate system is 600m/s. Find the fluid properties in region 2.

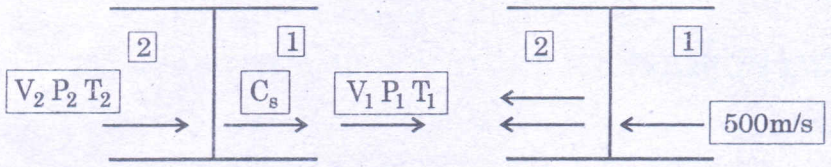

Fig (1)

Fig (2)

(5 + 7 = 12 marks)

Or

18. (a) Consider a pipe in which air at 300 K and 1.5×10^6 N/m^2 flows uniformly with a speed of 150 m/s. The end of the pipe is suddenly closed by a valve, and a shock wave is propagated back into the pipe. Compute the speed of the wave and the pressure and temperature of the air which has been brought to rest.

(b) Starting from energy equation derive Prandtl-Meyer function.

(7 + 5 = 12 marks)

19. A turbojet engine flying at a speed of 990 km/hr consumes air at a rate of 55.5 kg/s Calculate :

(i) Exit velocity of jet when enthalpy change for the nozzle is 200 kJ/kg and velocity coefficient is 0.97.

(ii) Fuel flow rate in kg/s when air fuel ratio is 75 : 1.

(iii) Thrust-specific fuel consumption.

(iv) Thermal efficiency of the plant when combustion efficiency is 93% and calorific value of fuel is 45000 kJ/kg.

(v) Propulsive power.

(vi) Propulsive efficiency.

(vii) Overall efficiency.

(12 marks)

Or

20. (a) With T-S diagram explain, the working of turbo-jet system.

(b) Give the differences with merits and demerits of turbo-prop and turbo-jet engines.

(6 + 6 = 12 marks)

[5 × 12 = 60 marks]