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Question Paper Code : 72165

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Sixth Semester

Mechanical Engineering

ME 6604 — GAS DYNAMICS AND JET PROPULSION

(Regulations 2013)

Time : Three hours Maximum : 100 marks

State clearly any assumption made with justification.

Use of approved gas table data book is allowed.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the effect of Mach number on compressibility?

2. "Higher the velocity of supersonic flow, smaller the angle of Mach cone". Comment on the validity of this statement.

3. What do you mean by friction chocking?

4. List the governing equations that useful to describe the Rayleigh flow.

5. Distinguish between 'Shock angle' and 'deviation angle'.

6. What is the response of change of fluid stagnation states across a normal shock?

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 the need of liquid propellant feeding system for rockets?

10. A spacecraft's engine ejects mass at a rate of 30 kg/s with an exhaust velocity of 3,100 m/s. The pressure at the nozzle exit is 5 kPa and the exit area is 0.7 m^2. What is the thrust of the engine in a vacuum?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Discuss the change of Mach number in CD nozzle under various back pressure. (8)

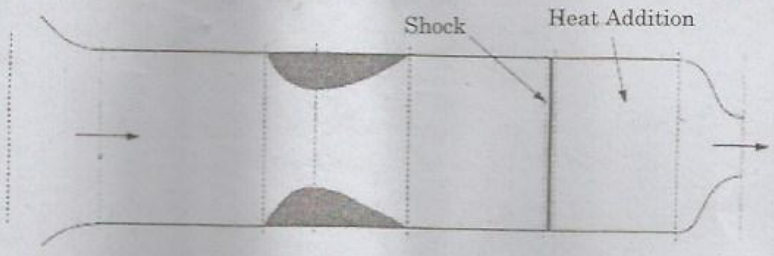
(ii) An airplane is traveling while you are observing from the ground. How will you know whether it is subsonic or supersonic? Explain. (5)

(iii) How fluid stagnation states will change if the fluid flow in diffuser follows an adiabatic process? (3)

Or

(b) Air flows through a convergent-divergent (CD) nozzle. At some section in the nozzle, pressure = 2 bar, velocity = 170 m/s and temperature = 200°C and cross sectional area = 1000 mm². Assuming isentropic flow conditions, determine : (i) stagnation temperature and stagnation pressure (ii) sonic velocity and Mach number at this section (iii) velocity, Mach number and flow area at outlet section where pressure is 1.1 bar (iv) pressure, temperature, velocity and flow area at throat section.

12. (a) Consider the following system.



Section between 2-3 and 5-6 considered as Fanno flow process

(i) Mark the following statements as true or false with proper reason. (4)

(1) $P_{01}A_1^* = P_{07}A_7^*$ and (2) $P_{06}A_6^* = P_{09}A_9^*$.

(ii) Sketch the process path for the above system on a T-s diagram. Indicate both the static and stagnation states. (7)

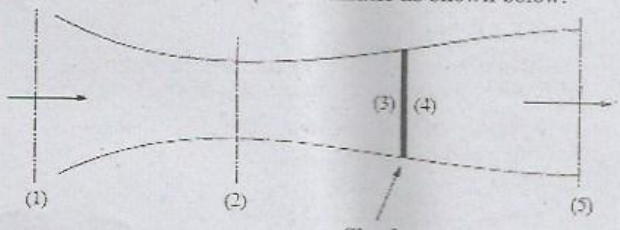
(iii) Sketch the pressure distribution along the stream wise location from station [1] to station [9]. (5)

Or

(b) (i) Prove that the Mach numbers at the maximum enthalpy and maximum entropy points on the Rayleigh line are $1/\sqrt{\gamma}$ and 1.0 respectively. (12)

(ii) Show the h = constant and s = constant lines at these points on the Rayleigh line on the h-s and p-v planes. (4)

13. (a) Air enters a CD nozzle which has an exit-to-throat area ratio of 1.8. A normal shock occurs at a location where the cross sectional area is 1.2 times that of the throat. The schematic as shown below:



(i) Locate the static and stagnation states of 1,2,3,4 and 5 on a T-s diagram. (6)

(ii) What is the operating pressure ratio P_5/P_{01}? (10)

Or

(b) The stagnation pressure and temperature of air at the entry of a nozzle are 5 bar and 500K respectively. The exit Mach number is 2 where a normal shock occurs. Calculate the following quantities before and after the shock: static and stagnation temperatures and pressures, air velocities and Mach numbers. What are the values of stagnation pressure loss and increase in entropy across the shock?

14. (a) (i) Discuss the function and need of afterburner in jet engines. (7)

(ii) Derive the thrust equation for turbo-prop engine. (6)

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

Propulsive efficiency Vs Flight Speed. (3)

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.

15. (a) A rocket nozzle has a throat area of 18 cm^2 and combustion chamber pressure of 25 bar. If the specific impulse is 127.42 s and weight flow rate 44.145 N/s determine: (i) The thrust coefficient (ii) Propellant weight flow rate (iii) Specific propellant consumption (iv) Characteristics velocity.

Or

(b) Describe with the aid of illustrative diagrams of any two arrangements of solid propellant grains employed for restricted and unrestricted burning. Indicate the directions of burning and flow of gases.
