

**B.E DEGREE EXAMINATIONS: APRIL/MAY 2014**

(Regulation 2009)

Fifth Semester

**MECHANICAL ENGINEERING**

MEC112: Gas Dynamics And Jet Propulsion

(Use of approved GAS tables is permitted)

**Time: Three Hours**

**Maximum Marks: 100**

**Answer all the Questions:-**

**PART A (10 x 1 = 10 Marks)**

1. When a compressible gas is brought to stagnation state, then its stagnation temperature equals to
 

a) Static temperature	b) Velocity temperature
c) Sum of static and velocity temperatures	d) difference between static and velocity temperature
2. A fluid flow with Mach number less than 0.3 can be considered as
 

a) Compressible fluid	b) ideal fluid
c) incompressible fluid	d) Newtonian fluid
3. A C-D duct with subsonic flow at throat is known as
 

a) Nozzle	b) Diffuser
c) Orifice meter	d) Venturi meter
4. All isentropic process should necessarily be
 

a) Reversible and adiabatic	b) Irreversible and adiabatic
c) Reversible and isothermal	d) None of the above
5. The value of  $\gamma$  for a polyatomic ideal gas is
 

a) 1.3	b) 1.4
c) 1.23	d) 1.66
6. When  $L > L_{max}$  in supersonic fanno flow, it leads to
 

a) Change in inlet pressure	b) Change in velocity
c) Low mass flux	d) Shock wave
7. In the limiting condition for a fanno flow
 

a) $v \gg a$	b) $a \ll v$
c) $a \gg v$	d) $a = v$
8. Stagnation enthalpy of gas during deceleration of isothermal flow
 

a) Keeps on increasing up to M of 1	b) Keeps on decreasing
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- |                     |                                 |
|---------------------|---------------------------------|
| c) Remains constant | d) Decreases up to a M of 0.845 |
|---------------------|---------------------------------|
9. The shock phenomena is a/an
 

a) Reversible process	b) Irreversible process
c) Adiabatic process	d) constant pressure process
  10. RAM effect takes place when the air is passed through
 

a) Diffuser	b) Nozzle
c) Turbine	d) Combustion chamber

**PART B (10 x 2 = 20 Marks)**

11. What is the basic difference between compressible and incompressible fluid flow?
12. Explain the stagnation state with practical example
13. A plane travels at a speed of 2400 KM/h in atmosphere of 5°C. Find the mach number.
14. Show the effect of area ratio on mach with neat sketch for isentropic flow.
15. How does the flow behave when the heat transfer exceeds the maximum in Rayleigh flow?
16. What is friction choking?
17. What are the significant properties changes across a normal shock?
18. What is Prandtl-Meyer relation? What is its significance?
19. What is the difference between air breathing and non-air breathing propulsive systems?
20. Define the term "propulsive efficiency"

**PART C (5 x 14 = 70 Marks)**

21. a) (i) A stream of air at a given temperature passes from a duct of uniform cross sectional area of 0.001 m<sup>2</sup> through a converging diverging diffuser having same exit area correctly designed so as to increase the air pressure. The air enters the diffuser at 105 kPa pressure and 75°C temperature with a velocity of 600 m/s. Assuming isentropic diffusion. Determine the area at throat and pressure of air at exit. (7)
  - (ii) Prove that  $T^*/T = 2/\gamma + 1 + \gamma - 1/\gamma + 1 M^2$  (7)
- (OR)**
- b) (i) An aircraft is flying at an altitude of 12,000 meters (T=216.65K, P=0.193 bar) at a Mach number of 0.82. The cross sectional area of the inlet diffuser before the low pressure compressor stage is 0.5 m<sup>2</sup>. Determine a) the mass of air entering the compressor per second b) the speed of the aircraft and c) the stagnation pressure and temperature of air at the diffuser entry. (7)

(ii) Derive an equation for the mass flow rate in terms of Mach number. (7)

22. a) A supersonic nozzle expands air from  $P_0 = 25$  bar and  $T_0 = 1050$  K to an exit pressure of 4.35 bar; the exit area of the nozzle is  $100 \text{ cm}^2$ . Determine a) throat area b) pressure and temperature at the throat c) temperature at exit d) exit velocity as fraction of the maximum attainable velocity and e) mass flow rate.

(OR)

b) Derive the fleigner's equation for an isentropic flow.

23. a) The data at the inlet to a ramjet engine combustion chamber employing a hydrocarbon fuel are as follows: Velocity of air fuel mixture = 73 m/s, static temperature = 333 K, static pressure = 0.55 bar. The heat of reaction of the fuel air mixture is 1400 kJ/kg. Assuming that the working fluid has the same thermodynamic properties as air before and after combustion, calculate (i) the loss in stagnation pressure due to heat addition (ii) the maximum heat of reaction for which flow with the specified initial conditions can be maintained.

(OR)

b) (i) The average friction factor of a 25 mm diameter 12 meter long pipe is 0.004. (7) The conditions of air at entry are 2 bar and 300 K. Determine the mass flow rate, pressure, temperature and the mach number at exit, if the mach number at inlet is 0.25.

(ii) In refinery a hydrocarbon gas at  $30^\circ\text{C}$  flows through a 100 m long buried pipe (7) line of 30 mm diameter. At the entrance the average velocity is 15 m/s and static pressure is 2 bar. Find the exit conditions from the pipe line. Take  $f = 0.0034$ , molecular weight of gas 16 and  $\gamma$  for gas 1.4.

24. a) A convergent nozzle has an exit to throat area ratio of 3.0. The stagnation properties of air at inlet are  $700 \text{ kN/m}^2$  and  $90^\circ\text{C}$ . Throat area is  $10 \text{ cm}^2$ . Due to its operation at off design condition a plane normal shock is seen to stand at a section where  $M = 2$ . Determine the Mach number, static pressure and static temperature at the exit of the nozzle. Assume isentropic flow before and after the shock.

(OR)

b) An aircraft engine employs a subsonic inlet diffuser of area ratio 4. Free stream air at a total pressure and temperature of  $1 \times 10^5 \text{ N/m}^2$  and 570 K approaches the

diffuser with a Mach number 2.2. A shock wave stands just outside the diffuser inlet. Determine the Mach number, pressure and temperature of the air at the exit of the diffuser. Also find the loss in stagnation pressure of air.

25. a) A turbojet engine takes in 20 kg/s of air and expands the gas to atmospheric pressure. It uses a fuel of lower calorific value 48 MJ/kg and the air fuel ratio for the engine is 80. The flight speed of the aircraft is 250 m/s. For maximum thrust power, determine thrust, TSFC, propulsive efficiency, thermal efficiency and overall efficiency.

(OR)

b) (i) Explain the working principle of turbo jet engine with neat sketch. (7)

(ii) Explain the working principle of pulse jet engine with neat sketch. (7)

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