Register Number:…….

B.E., DEGREE EXAMINATIONS JUNE 2013

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 Questions

Part A (10 x 1 = 10 Marks)

1. In compressible flow the density of the fluid
   a. remains constant b. varies from one point to another
   c. zero d. none of the above
2. Characteristic Mach number is the ratio between
   a. fluid velocity and velocity of sound b. fluid velocity and critical velocity of sound
   c. critical velocity of sound to fluid velocity d. fluid velocity to stagnation velocity of sound
3. The maximum mass flow occur for an isentropic flow with variable area when
   a. Mach number reaches supersonic conditions
   b. Mach number reaches sub sonic condition
   c. Mach number reaches sonic condition
   d. Mach number reaches hypersonic condition
4. Impulse function is the
   a. difference between impulse force and pressure force
   b. product of pressure force and impulse force
   c. ratio between pressure force and impulse force
   d. sum of the pressure force and impulse force
5. Which of the following statements is true for Rayleigh flow
   a. variable area duct b. perfect gas
   c. both ‘a’ and ‘b’ d. none of the above
6. In subsonic flow region, the effect of friction
   a. increases the enthalpy and pressure of the gas
   b. decreases the enthalpy and pressure of the gas
   c. keeps the enthalpy and pressure as constant
   d. none of the above

7. Shock waves cannot develop in subsonic flow because

a. velocity of fluid is greater than velocity of sound

b. velocity of fluid is equal to velocity of sound

c. velocity of fluid is less than velocity of sound

d. none of the above

8. The strength of a shock wave for Mach number 2 is

a. 4.5 b. 2.5 c. 3.5 d. 6.5

9. Ram effect is produced in ram jet engine due to

a. conversion of pressure energy into kinetic energy

b. conversion of heat energy into kinetic energy

c. conversion of kinetic energy into pressure energy

d. both (b) and (c)

10. Propeller is used in turbofan engine to increase the

a. efficiency of the engine b. increase the velocity of air entering the engine

c. increase the fuel economy d. none of the above

PART B (10 x 2 = 20 Marks)

11. Define zone of action and zone of silence
12. A plane travels at a speed of 2400 km/h in an atmosphere of 5°C. Find the Mach angle.
13. Differentiate Adiabatic and Isentropic process.
14. Draw the shape of the nozzle for the expansion of air from 2 MPa to 800 KPa
15. Give the assumptions made in isothermal flow
16. Define fanning's coefficient of skin friction
17. Give two practical examples of Rayleigh flow
18. Define strength of a shock wave
19. What are applications of moving shock wave?
20. What is thrust augumentation?

PART C (5 x 14 = 70 Marks)

21. a) Derive an expression for the acoustic velocity of a compressible fluid flow in terms of its temperature.

(OR)

b) (i) Carbon dioxide expands isentropically through a nozzle from a pressure of 3.2 bar to 1 bar. If the initial temperature is 475 K, determine the final temperature, the enthalpy drop and the change in internal energy. (7)

(ii) Air flows in a duct with a velocity of 215 m/s. the temperature of air measured at a point along the duct is 30°C, and the air pressure is 5 bar. Determine (i) stagnation pressure (ii) Mach number at that point (7)

22. a) A supersonic, diffuser diffuse 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.

(OR)

b) A certain quantity of air at a pressure of 3.344 bar and temperature 627°C is flowing through a convergent-divergent nozzle. The exit pressure is 1.05 bar. Determine the temperature, velocity and density of air at exit. Also determine the pressure, temperature, density and velocity of air at exit if the divergent portion is to act as diffuser. Assume isentropic flow at both cases.

23. a) Air having a Mach number 3 with total temperature 295°C and static pressure 0.5 bar flows through a constant area duct adiabatically to another section where the Mach number is 1.5. Determine the amount of heat transferred and the change in stagnation pressure.

(OR)

b) Air at 120 KN/m^2 and 40°C flows through a 200 mm diameter pipe adiabatically. If the upstream Mach number is 2.5, determine the maximum length of pipe and the properties of air at exit. Also estimate the length of the pipe if the exit Mach number is 1.8. Take f= 0.01.

24. a) Starting from the energy equation for flow through a normal shock, obtain the following Prandtl – Meyer relation

$C_x \times C_y = a^{*2}$

$M_x \times M_y = 1$

(OR)

b) Air flows adiabatically in a pipe. A normal shock is formed. The pressure and temperature of air before the shock are 150 KN/m^2 and 25°C respectively. The pressure just after shock is 350 KN/m^2. Calculate (i) Mach number before the shock (ii) Mach number, static temperature and velocity of air after the shock wave (iii) Increase in density of air (iv) Loss of stagnation pressure of air (v) Change in entropy.

25. a) A turbojet propels an aircraft at a speed of 900 km/h while taking 3000 kg of air/min. The isentropic enthalpy drop in the nozzle is 200 kJ/kg and the nozzle efficiency is 90%. The air – fuel ratio is 85 and the combustion efficiency is 95%. The calorific value of the fuel is 42,000 kJ/kg. Calculate (i) Propulsive power (ii) thermal efficiency (iii) propulsive efficiency

(OR)

b) The specific impulse of a rocket is 125 s and the flow rate of propellant is 44 kg/s. The nozzle throat area is 18 cm^2 and the pressure in the combustor is 25 bar. Determine the thrust coefficient, propellant flow coefficient, specific propellant consumption and characteristic velocity.

****