UNIT-1 (BASIC CONCEPT AND ISENTROPIC FLOW)

TWO MARK QUESTION

1. Mach number
2. Crocco number
3. Stagnation velocity of sound
4. Diff b/w nozzle and diffuser
5. Impulse function
6. Types of nozzle and diffuser

13 MARK QUESTIONS

1. Various regions of flow
2. Effect of mach number on compressibility
3. (1) mach cone (2) mach angle (3) mach wave.

1. An air jet at 400 K has sonic velocity. Determine (i) velocity of sound at 400 K (ii) Velocity of sound at stagnation condition (iii) Maximum velocity of jet (iv) Stagnation enthalpy.

2. Air at P1 = 3 bar and T1 = 227 oC is flowing with a velocity of 200 m/s in a 0.3 m diameter duct. If Cp = 1050 J/kgK and γ = 1.38, determine the following: (i) Stagnation temperature and pressure (ii) Mass flow rate of air (iii) Mach number (iv) Stagnation pressure assuming the flow is incompressible.

3. Air is discharged from a reservoir at P0 = 6.91 bar and T0 = 325 oC through a nozzle to an exit pressure of 0.98 bar. If the flow rate is 3600 kg/hr, determine (i) Area, pressure and velocity at the throat (ii) Area and Mach number at exit and (iii) maximum possible velocity. Consider the flow is isentropic.

4. A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bar, 340 K and 180 m/s respectively. Determine (i) the exit pressure (ii) the exit velocity and (iii) the force exerted on the diffuser walls Assume isentropic flow, γ = 1.4, Cp = 1.00 kJ/kg K.

5. A supersonic nozzle expands air from P0 = 25 bar and T0 = 1050 K to an exit pressure of 4.35 bar; the exit area of the nozzle is 100 cm2. Determine (i) throat area (ii) pressure and temperature at the throat (iii) temperature at exit (iv) exit velocity as fraction of the maximum attainable velocity (v) mass flow rate

6. Air (γ = 1.4, R = 287.43 J/kgK) enters a straight axis symmetric duct at 300 K, 3.45 bar and 150 m/s and leaves it at 277 K, 2.085 bar and 260 m/s. The area of cross-section at entry is 500 cm2. Assuming adiabatic flow determine (i) Stagnation temperature (ii) Maximum velocity (iii) Mass flow rate and (iv) Area of crosssection at exit.

7. The pressure, temperature and Mach number at the entry of a flow passage are 2.45 bar, 26.5 oC and 1.4 respectively. If the exit Mach number is 2.5, determine for adiabatic flow of a perfect gas ($\gamma = 1.3$, R = 0.469 kJ/kgK). (i) Stagnation temperature (ii) Temperature and velocity of gas at exit (iii) the flow rate per square meter of the inlet cross-section.

8. Air at rest 90 oC is accelerated isentropically (take $\gamma = 1.4$). (i) What is the air speed in m/s when the Mach number becomes 0.8? (ii)What is the air speed when the flow becomes sonic? (iii) What is the Mach number when the air speed becomes 600 m/s?

UNIT-2 (FLOW THROUGH DUCTS)

TWO MARK QUESTIONS

1. Diff b/w fan no flow and Rayleigh flow.
2. Assumption made for fanno flow
3. Fannings coefficient of skin friction
4. Friction shocking
5. List out governing equation uses in Rayleigh flow.

16Marks

1. A circular duct passes 8.25 Kg/s of air at an exit Mach number of 0.5. The entry pressure and temperature
are 3.45 bar and 38°C respectively and the coefficient of friction 0.005.If the Mach number at entry is 0.15,
determine: (a) The diameter of the duct, (b) Length of the duct, (c) Pressure and temperature at the exit, (d)
Stagnation pressure loss, and (e) Verify the exit Mach number through exit velocity and temperature.

2. Air at an inlet temperature of 60 oC flows with a subsonic velocity through an insulated pipe having inside
diameter of 50 mm and a length of 5 m. The pressure at the exit of the pipe is 101kPa and the flow is
chocked at the end of the pipe. If the friction factor 4f = 0.005, determine the inlet Mach number, the mass
flow rate and the exit temperature.

3. A long pipe of 0.0254 m diameter has a mean coefficient of friction of 0.003. Air enters the pipe at a Mach

number of 2.5, stagnation temperature 310 K and the static pressure 0.507 bar. Determine for a section at
which the Mach number reaches 1.2: (i) static pressure and temperature, (ii) Stagnation pressure and
temperature, (iii) Velocity of air, (iv) Distance of this section from the inlet and (v) mass flow rate of air.

4. Air is supplied to a combustion chamber in a gas turbine plant at 350K, 0.55 bar and 75 m/s. The air-fuel
ratio is 29 and the calorific value of the fuel is 42 MJ/kg. Assuming γ = 1.4 and R = 287 J/kgK for the gas,
Determine (i) The initial and final mach numbers (ii) Final pressure, temperature and velocity of the gas,
(iii)The maximum stagnation temperature attainable

6. The stagnation temperature of air in a combustion chamber is increased to 3.5 times its initial value. If the air at entry is at 5 bar, 105 oC and a Mach number of 0,25 determine (i) the Mach number, pressure and temperature at the exit, (ii) stagnation pressure loss and (iii) the heat supplied per kg of air. 7. The Mach number at inlet and exit for a Rayleigh flow are 3 and 1.5 respectively. At inlet static pressure is 50 kPa and stagnation temperature is 295 K. Consider the fluid is air. Find (i) static pressure, static temperature and velocity at exit, (ii) Stagnation pressure at inlet and exit, (iii) heat transferred, (iv) maximum possible heat transfer (v) change in entropy between two sections, (vi) Is it a cooling or heating process? 8. Air flows with a negligible friction in a constant area duct. At section one, the flow properties are T1 = 60.4 oC, p1 = 135 kPa absolute and velocity 732 m/s. Heat is added to the flow between section one and section two, where the mach number is 1.2. Determine the flow properties at section two, the heat transfer per unit mass and the entropy change

UNIT-3 (NORMAL AND OBLIQUE SHOCKS)

TWO MARK QUESTIONS

1. Normal and oblique shocks.
2. Diff b/w normal and oblique shock
3. Strength of shock wave
4. Application of moving shock wave
5. Normal shock in H-S diagram with Rayleigh and fanno line

13 MARK QUESTIONS

1. Prandtl Meyar relationship derivation

1. Air flows adiabatically in a pipe. A normal shock wave is formed. The pressure and temperature of air before the shock are 150 kN/m2 and 25 oC respectively. The pressure just after the normal shock is 350 kN/m2. Calculate, (i) Mach No. before shock. (ii) Mach no., 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

2. A convergent divergent nozzle operates at off design condition while conducting air from a high pressure tank to a large container. A normal shock occurs in the divergent part of the nozzle at a section where the cross section area is 18.75 cm2. The stagnation pressure and stagnation temperature at the inlet of the nozzle are 0.21 Mpa and 36 oC respectively. The throat area is 12.5 cm2 and the exit area is 25 cm2. Estimate the exit Mach number, exit pressure. Loss in stagnation pressure and entropy increase during the flow between the tanks.

3. The ratio of the exit to entry area in a subsonic diffuser is 4.0. The mach number of a jet of air approaching the diffuser at P0 = 1.013 bar, T = 290 K is 2.2. There is a standing normal shock wave just outside the diffuser entry. The flow in the diffuser is isentropic. Determine at the exit of the diffuser, (i) Mach number (ii) Temperature and pressure (iii) Stagnation pressure loss between the initial and final states of the flow

4. A compression shock occurs in a divergent flow passage. On the upstream side of the shock the velocity of air is 400 m/sec and is at 2 bar and 35 oC. Determine (i) Mach number on the downstream side of the shock wave. (ii) The air velocity on the downstream side. (iii) Change in entropy per unit mass of air as a result of shock γ=1.4.

5. A pitot tube kept in a supersonic wind tunnel forms a bow shock ahead of it. The static pressure upstream of the shock is 16 kPa and the pressure at the mouth is 70 kPa. Estimate the Mach number of tunnel. If the stagnation temperature is 300 oC, calculate the static temperature and total pressure upstream and downstream of the tube

6. A gas (γ = 1.3) at p1 = 345 mbar, T = 350 K and M1 =1.5 is to be isentropically expanded to 138 mbar. Determine (i) the deflection angle (ii) final Mach number (iii) the temperature of the gas.

7.Air approaches a symmetrical wedge (angle of deflection δ = 15 oC) at a Mach number of 2. Consider strong waves conditions. Determine the wave angle, pressure ratio, density ratio, temperature ratio and downstream Mach number.

UNIT-4 (JET PROPULSION)

TWO MARK QUESTIONS

1. Specific impulse
2. Propulsive efficiency
3. propulsive or thrust power
4. Ram effect
5. Overall and thermal efficiency

13 MARK QUESTIONS

1. Ram jet engine
2. Pulse jet engine
3. Turbo jet engine
4. Turbo propulsive engine
5. Turbo fan

1. A turbojet aircraft flies at 875 kmph at an altitude of 10,000m above mean sea level. Calculate (i) air flow rate through the engine (ii) thrust (iii)specific thrust (iv)specific impulse (v) thrust power and (vi) TSFC from the following data: Diameter of the air at inlet section = .75 m, diameter of jet pipe at exit = 0.5 m, velocity of the gases at the exit of the jet pipe = 500 m/s, pressure at the exit of the jet pipe = 0.30 bar, airfuel ratio = 40

2. The diameter of the propeller of an aircraft is 2.5m. It flies at a speed of 500Kmph at an altitude of 8000m. For a flight to jet speed ratio of 0.75 determine (a) the flow rate of air through the propeller, (b) thrust produced (c) specific thrust, (d) specific impulse and (e) the thrust power.

3. A turbojet propels an aircraft at a speed of 900 km/hr, while taking 3000 kg of air per minute. 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 42000kJ/kg. Calculate: (i) The propulsive power, (ii) Thrust power, (iii) Thermal efficiency and (iv) Propulsive efficiency

4. The flight speed of a turbojet is 800 km/hr at 10,000 m altitude. The density of air at that altitude is 0.17 kg/m3. The drag for the plane is 6.8 kN. The propulsive efficiency of the jet is 60 %. Calculate the SFC, Airfuel ratio and jet velocity. Assume the calorific value of fuel as 45000 kJ/kg and the overall efficiency of turbojet plant as 18 %

UNIT -5 (SPACE PROPULSION)

TWO MARK QUESTIONS

1. Mono propellants
2. Bi propellants
3. Properties of propellants
4. Thrust coefficient of rocket engine

13 MARK QUESTIONS

1. Liquid propellant rocket engine
2. Solid propellant rocket engine
3. Hybrid propellant rocket engine
4. Nuclear propellant rocket engine
5. Liquid propellant feed system

1. A rocket has the following data: Propellant flow rate = 5 kg/s, Nozzle exit diameter = 10 cm, Nozzle exit pressure = 1.02 bar, Ambient pressure = 1.013 bar, thrust chamber pressure = 20 bar, thrust = 7 kN. Determine the effective jet velocity, actual jet velocity, specific impulse and the specific propellant consumption. Recalculate the values of thrust and specific impulse for an altitude where the ambient pressure is 10 m bar.

2. The effective jet velocity from a rocket is 2700 m/s. The forward flight velocity is 1350 m/s and the propellant consumption is 78.6 kg/s. Calculate: Thrust, Thrust power and propulsive efficiency.

[1]3. A rocket engine has the following data. Combustion chamber pressure is 38 bar, combustion chamber temperature is 3500 K, oxidizer flow rate is 41.67 kg/s, mixture ratio is 5, and the properties of exhaust gases are Cp/Cv = 1.3 and R = 0.287 kJ/kgK. The expansion takes place to the ambient pressure of 0.0582 bar. Calculate the nozzle throat area, thrust, thrust coefficient, exit velocity of the exhaust and maximum possible exhaust velocity

[1] **INAYAKKALVI:https://inayakkalvi.github.io**