VALLIAMMAI ENGINEERING COLLEGE

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DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

ME6604 - GAS DYNAMICS AND JET PROPULSION

UNIT -1 BASIC CONCEPT AND ISENTROPIC FLOWS

PART-A (2 Marks)

1. Distinguish between nozzle and diffuser. **BT-2**
2. When does maximum flow occur for a isentropic flow with variable are duct? **BT-1**
3. Differentiate between compressible and incompressible flow? **BT-2**
4. Name the four reference velocities that ate used in expressing the third velocities in non-dimensional form. **BT-1**
5. 'Zone of Silence' is absent in subsonic flow, Why? **BT-5**
6. What is the cross section of the nozzle required to increase the velocity of compressible fluid flow from (a) subsonic to supersonic, (b) subsonic to sonic. **BT-5**
7. What is subsonic, sonic and supersonic flow with respect to Mach number? **BT-5**
8. How the area and velocity vary in supersonic flow of nozzle and diffuser? **BT-6**
9. Define compressible flow and Mach number. **BT-1**
10. Predict stagnation state. **BT-2**
11. Express the stagnation enthalpy in terms of static enthalpy and velocity of flow. **BT-4**
12. List the condition for choking in CD nozzle. **BT-1**
13. Draw the disturbances wave propagation in compressible flow M = 1 and M>1. **BT-3**
14. When M^* is used instead of M? **BT-1**
15. Rewrite the advantage of using M^* (second kind of Mach number) instead of M (local Mach number) in some cases? **BT-6**
16. The wave front caused by firing a bullet gave a Mach angle of 35˚. Find the velocity of the bullet if the static temperature of atmosphere is 276K. **BT-3**
17. What is a Mach cone? **BT-5**
18. Define Mach number. **BT-1**
19. Describe compressible flow. **BT-2**
20. Discuss stagnation temperature and stagnation pressure. **BT-2**

PART –B

1) (a) Derive the following relations for one dimensional isentropic flow:

$$\frac{dA}{A}=\frac{dP}{\rho c^2}(1-M^2)$$ **BT-6**

(b) Derive the relation of effect of Mach number on Compressibility. **BT-6**

2) Derive the equation for mass flow rate in terms of area ratio? **BT-6**

$$\frac{m_{max}}{A*} X \frac{\sqrt{T_0}}{P_0} = \sqrt{\frac{\gamma}{R}} \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{2(\gamma-1)}}$$

3) (a) Derive the Bernoulli equation for isentropic compressible flow?

(b) Derive the equation of pressure co - efficient for compressible flow? **BT-6**

$$\frac{Po-P}{\frac{1}{2}\rho c^2} = 1+\frac{M^2}{4}+\frac{M^4}{40}+\cdots,$$

4) Carbon di oxide 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. **BT-3**

5) Air (γ=1.4, R=287 J/Kg.K) at an inlet Mach number of 0.2 enters a straight duct at400 K and expands isentropically if the exit Mach number is 0.8 determine the following.

   i. Stagnation temperature
   ii. Critical temperature
   iii. Static temperature at exit
   iv. Area ratio. **BT-3**

6) Draw and explain Mach cone, Mach angle and Mach waves? **BT-3**

7) A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure temperature and velocity of air at entry is 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, C_p =1.005 KJ/Kg-K. **BT-3**

8) A nozzle in a wind tunnel gives a test –section Mach number of 2.0. Air enters the nozzle from a large reservoir at 0.69 bars and 310 K .The cross – sectional area of the throat is 1000cm². Determine the following quantities for the tunnel for one dimensional isentropic flow

i) Pressures, temperature and velocities at the throat and test sections,
ii). Area of cross- sectional of the test section
ii) Mass flow rate
iv). Power rate required to drive the compressor **BT-3**

9) (a) Ambient air (P_o = 1 bar, T_o = 285K) is sucked by a blower through a convergent nozzle. The throat diameter is 12 cm. if the velocity at throat reaches the sonic value. Determine

i) Pressure and temperature at the throat
ii) Maximum mass flow rate **BT-3**

(b) A supersonic wind tunnel settling chamber expands air of Freon-21 through a nozzle from a pressure of 10 bars to 4 bars in the test section. Calculate the stagnation temperature to be maintained in the settling chamber to obtain a velocity at 500 m/s. in the test section for

i) Air (C_p = 1.025 KJ/Kg.K C_v = 0.735 KJ/Kg.K)
ii) Freon-21 (C_p = 0.785 KJ/Kg.K C_v = 0.675 KJ/Kg.K)

What is the test section Mach number for each case? **BT-5**

10). An air craft is flying at an altitude of 11000 meters, at 800 Km/hr. the air is reversibly compressed in an inlet diffuser the inlet temperature is 216.65 K and pressure is 0.226 bar. If the Mach number at the exit of the diffuser is 0.35. Calculate the following

1. Entry Mach number
2. Velocity, pressure and temperature of air at the diffuser exit. **BT-3**

UNIT II - FLOW THROUGH DUCTS

PART-A

1. Give assumptions made on Rayleigh flow. **BT-2**
2. Define critical condition in Fanno flow. **BT-1**
3. Differentiate between Fanno flow and Rayleigh flow. **BT-2**
4. State the assumptions made for Fanno flow? **BT-1**
5. Give two practical examples for Fanno flow and Rayleigh flow analysis. **BT-2**
6. Explain the difference between Fanno flow and isothermal flow. **BT-4**
7. Sketch the Rayleigh line on the T-s plane and explain the significance of it. **BT-3**
8. List some flow properties. **BT-1**
9. Give four examples of Fanno flow in thermal systems. **BT-2**
10. Label the limiting Mach number in isothermal flow? **BT-1**
11. Draw Fanno curve and represent subsonic and supersonic flows. **BT-3**

12. State the assumptions made to derive the equations for isothermal flow. **BT-2**
13. Explain at what conditions the assumption of Rayleigh flow is not valid in a heat exchanger? **BT-4**
14. What is the value of Mach number of air at the maximum point in Rayleigh heating process? **BT-5**
15. Explain chocking in Fanno flow? **BT-4**
16. Write down the expression for the pressure ratio of two sections in terms of Mach number in Rayleigh flow? **BT-6**
17. Define fanning's coefficient of skin friction? **BT-1**
18. Write down the ratio of velocities between any two sections in terms of their Mach number in a Fanno flow? **BT-6**
19. Define Rayleigh line and Fanno line? **BT-1**
20. What is the consumption made for Fanno flow? **BT-5**

PART-B

1. A circular duct passes 8.25Kg/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 :

   i) The diameter of the duct
   ii) Length of the duct
   iii) Pressure and temperature at the exit
   iv) Stagnation pressure loss and
   v) Verify the exit Mach number through exit velocity and temperature. **BT-3**

2. Air flows out of a pipe with a diameter of 0.3m at a rate of 1000 m^3/ min at a pressure and temperature of 150 kPa and 293 K respectively. If the pipe is 50 m long, and assuming that friction coefficient f = 0.005, find the Mach number at exit, the inlet pressure and the inlet temperature. **BT-3**

3. Air enters a long circular duct (d =12.5cm, f = 0.0045) at a Mach number 0.5, pressure 3.0 bar and temperature 312 K. If the flow is isothermal throughout the duct determine (a) the length of the duct required to change the Mach number to 0.7, (b) pressure and temperature of air at M = 0.7 (c) the length of the duct required to attain limiting Mach number, and (d) State of air at the limiting Mach number. Compared these values with those obtained in adiabatic flow. **BT-5**

4. A convergent – divergent nozzle is provided with a pipe of constant cross-section at its exit the exit diameter of the nozzle and that of the pipe is 40 cm. The mean coefficient of friction for the pipe is 0.0025. Stagnation pressure and temperature of air at the nozzle entry are

12 bar and 600 K. The flow is isentropic in the nozzle and adiabatic in the pipe. The Mach numbers at the entry and exit of the pipe are 1.8 and 1.0 respectively. Determine:

a) The length of the pipe
b) Diameter of the nozzle throat and
c) Pressure and temperature at the pipe exit. **BT-3**

5. Show that the upper and lower branches of a Fanno curve represent subsonic and supersonic flows respectively. Prove that at the maximum entropy point Mach number is unity and all processes approach this point. How would the state of a gas in a flow change from the supersonic to subsonic branch? **BT-3**

6. The Mach number at the exit of a combustion chamber is 0.9. The ratio of stagnation temperature at exit and entry is 3.74. If the pressure and temperature of the gas at exit is 2.5 bar and 1000°C respectively, determine (a) Mach number, pressure and temperature of the gas at entry (b) the heat supplied per kg of the gas and (c) the maximum heat that can be supplied. Take $\gamma = 1.3$, C_p= 1.218 KJ/Kg K. **BT-3**

7. The conditions of a gas in a combustor at entry are: P_1=0.343bar ,T_1 = 310K ,C_1= 60m/s. Determine the Mach number, pressure, temperature and velocity at the exit if the increase in stagnation enthalpy of the gas between entry and exit is 1172.5KJ/Kg.[C_p=1.005KJ/Kg K, γ =1.4]. **BT-3**

8. A combustion chamber in a gas turbine plant receives air at 350 K, 0.55 bars and 75 m/s. The air – fuel ratio is 29 and the calorific value of the fuel is 41.87 MJ/Kg .Taking γ=1.4 and R = 0.287 KJ/kg K for the gas determine.

a) The initial and final Mach numbers,
b) Final pressure, temperature and velocity of the gas
c) Percent stagnation pressure loss in the combustion chamber and
d) The maximum stagnation temperature attainable. **BT-3**

9. The stagnation temperature of air in a combustion chamber is increased to 3.5 times its initial value. If the air at entry is 5 bars, 105°C and a Mach number of 0.25. Determine 1. The Mach no. Pressure and temperature at the exit, 2. Stagnation pressure loss and 3. The heat supplied per Kg of air. **BT-3**

10. Air enters a constant area duct at M_1 = 3, P_1 = 1 atm, and T_1 = 300 K. Inside the duct the heat added per unit mass is q = 3 x 10^5 J/Kg. Calculate the flow properties M_2, P_2, T_2, ρ_2, T_{02} and P_{02} at the exit. **BT-3**

UNIT III NORMAL AND OBLIQUE SHOCKS

PART-A

1. Why the efficiency of a machine, experiencing shock wave is considerably low? **BT-5**
2. A normal shock occurs at a point in air flow where the pressure is 530 kPa and the temperature is -30 ˚C. If the pressure ratio across this shock wave is 2.6. Find the Mach number and static temperature at the downstream of the shock waves. **BT-3**
3. Prepare the beneficial and adverse effects of shock waves? **BT-6**
4. Define oblique shock? **BT-1**
5. What is the use of Pitot tube in supersonic flow? **BT-5**
6. State the reasons the shock waves cannot be developed in subsonic flow? **BT-2**
7. Mention the useful applications of shock wave. **BT-2**
8. Prepare the list the situations where shocks are undesirable? **BT-6**
9. Explain how the pilot tube and could be used to measure the Mach number in supersonic flow. **BT-4**
10. Complete the Prandtl-Meyer relation for normal shock. **BT-3**
11. Write the changes across normal shock for Mach number and static pressure. **BT-5**
12. Give two useful applications of the shock waves. **BT-2**
13. Define strength of shock wave. **BT-1**
14. How is the shock formed? **BT-6**
15. Where is the shock advantageous? **BT-1**
16. Define strong and weak wave? **BT-1**
17. Explain why the shock cannot occur in subsonic flows. **BT-5**
18. Give the difference between Normal shock and Oblique shock? **BT-2**
19. Define supersonic wind tunnels? **BT-1**
20. Calculate the strength of shock wave when normal shock appears at M = 2. **BT-3**

PART-B

1).The state of a gas (γ=1.3, R = 0.469 KJ/Kg K) upstream of a normal shock is given by the following data: M_x =2.5, P_x= 2 bar, T_x =275 K. Calculate the Mach number, pressure, temperature and velocity of the gas downstream of the shock; check the calculated values with those give in the gas tables. **BT-3**

2) 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 P_0 =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.

1. Mach number 2. Temperature 3. Pressure
4. What is the stagnation pressure loss between the initial and final states? **BT-3**

3) a) The velocity of a normal shock wave moving into stagnant air (P =1.0 bar, T=17°C) is 500 m/s. If the area of cross - section of the duct is constant. Determine (a) pressure (b) temperature (c) velocity of air (d) stagnation temperature and (e) the Mach number imparted upstream of the wave front. **BT-3**

b) The following data refers to a supersonic wind tunnel:
Nozzle throat area =200 cm^2 Test section cross- section =337.5 cm^2
Working fluid; air (γ=1.4, Cp =0.287 KJ/Kg K)
Calculate the test section Mach number and the diffuser throat area if a normal shock is located in the test section. **BT-3**

4) A supersonic diffuser for air (γ=1.4) has an area ratio of 0.416 with an inlet Mach number of 2.4 (design value). Determine the exit Mach number and the design value of the pressure ratio across the diffuser for isentropic flow. At an off - design value of the inlet Mach number (2.7) a normal shock occurs inside the diffuser. Determine the upstream Mach number and area ratio at the section where the shock occurs, diffuser efficiency and the pressure ratio across the diffuser. Depict graphically the static pressure distribution at off design. **BT-3**

5) Starting from the energy equation for flow through a Normal Shock obtain the following relations (or) Prandtl – Meyer relation

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

$M_x^* \times M_y^* = 1$ **BT-6**

6) A gas (γ =1.3) at p1 =345 Mbar, T_1= 350 K and M_1=1.5 is to be isentropically expanded to 138 Mbar. Evaluate (a) the deflection angle, (b) final Mach number and (c) the temperature of the gas. **BT-5**

7) a) A jet of air at Mach number of 2.5 is deflected inwards at the corner of a curved wall. The wave angle at the corner is 60°. Determine the deflection angle of the wall, pressure and temperature ratios and final Mach number. **BT-3**

b) Derive the Rankine –Huguenot relation for an oblique shock. Compare graphically the variation of density ratio with the initial Mach number in isentropic flow and flow with oblique shock. **BT-6**

8). Air flows adiabatically in a pipe. A normal shock wave is formed. The pressure and temperature of air before the shock are 150 KN/m^2 and 25°C respectively. The pressure just after the shocks are is 350 KN/m^2. Calculate: 1. Mach No. before shock, 2. Mach No., Static temperature and velocity of air after the shock wave, 3. Increase in density of air, 4. Loss of stagnation pressure of air and Change in entropy. **BT-3**

9. A supersonic nozzle is provided with a constant diameter circular duct at exit. The duct diameter is same as the nozzle exit diameter. Nozzle exit cross-section is three times that of its throat. The entry conditions of the gas (γ=1.4, R=0.287 kJ/kg K) are P_0 =10 bar, T_0 = 600 K .Calculate the static pressure, Mach number and the velocity of the gas in the duct:
   (1) When the nozzle operates at its design condition,
   (2) When a normal shock occurs at its exit **BT-3**

10). 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 cm^2. The stagnation pressure and stagnation temperature at the inlet of the nozzle are 0.21 MPa and 36 °C respectively. The throat area is 12.5 cm^2 and the exit area is 25 $cm^{2.}$ Estimate the exit Mach number, exit pressure, loss in stagnation pressure, and entropy increase during the flow between the tanks. **BT-3**

<u>UNIT IV - JET PROPULSION</u>

PART-A

1. Rewrite thrust power and propulsive efficiency of aircraft engine. **BT-6**
2. Why a ram jet engine does not require a compressor and turbine? **BT-4**
3. Name three commonly used aircraft engines. **BT-1**
4. List out the different types of jet engines. **BT-1**
5. Give the components of turbo jet. **BT-2**
6. A turbo jet engine having a flight velocity of 800 Km/hr at an ambient pressure of 60 KPa the properties of gas entering the nozzle are 300 KPa and 200°C. The mass flow rate of air is 20 kg/s. Assuming for air C_p/C_v = 1.4 and R = 0.287 LJ/Kg K, find the thrust power of the engine. **BT-3**
7. What are the benefits of thrust augmentation in a turbojet engine? **BT-5**
8. Sketch the thrust and propulsive efficiency variation against the speed ratio for a turbo jet engine. **BT-3**
9. What is after burning in turbojet engines? **BT-5**
10. List out the main parts of a Ram jet engine? **BT-1**
11. Define propulsive efficiency as applied to jet propulsion. **BT-1**
12. What is weight flow co-efficient? **BT-5**
13. Find the ratio of jet speed to flight speed for optimum propulsive efficiency. **BT-3**
14. Rewrite any two differences between ram jet and pulse jet. **BT-6**
15. What is scram jet? **BT-5**
16. Write an expression for thrust of a jet propulsion. **BT-3**
17. Discuss “ram effect”. **BT-2**
18. Define IWR? **BT-1**

19. Differentiate between pressure thrust and momentum thrust? **BT-2**
20. Define specific impulse. **BT-1**

PART-B

1. Explain the principle of operation of a turbojet engine and state its advantages and disadvantages. **BT-5**

2. (i) Explain the working principle of turbofan engine and turbojet engine with a neat sketch. **BT-5**

   (ii) A turbojet engine, on the test bed, receives air at 1 bar and 300 K and it is compressed through a compression ratio of 8, with an isentropic efficiency of 85%. Fuel with heating value of 40 MJ/kg is used to raise the temperature to 1100 K before entering the turbine with isentropic efficiency of 95%. The mechanical transmission efficiency is 95%. The expansion in the nozzle is complete. Determine the jet velocity, specific impulse and specific fuel consumption. **BT-3**

3. i) Explain the working principle of Ramjet engine with a neat sketch. **BT-4**

   (ii) A turbojet engine, flying at an altitude, receives air at 0.6 bar and 255K and it is compressed through a compression ratio of 8, with an isentropic efficiency of 80%. Fuel with heating value of 40 MJ/Kg is used to raise the temperature to 1200 K before entering the turbine with isentropic efficiency of 95%. The mechanical transmission efficiency is 97%. A convergent nozzle with an exit area of 0.5 m^2 is used to produce a gas jet. Determine the jet velocity, thrust, and specific fuel consumption. **BT-3**

4. An aircraft flies at 90 Km/hr. One of its turbojet engines takes in 40 kg/s of air and expands the gases to the ambient pressure .The air – fuel ratio is 50 and the lower calorific value of the fuel is 43 MJ/Kg. For maximum thrust power, determine: (a)jet velocity (b) thrust (c) specific thrust (d) thrust power (e) propulsive, thermal and overall efficiencies and (f) TSFC **BT-3**

5. A turbo jet engine propels an aircraft at a Mach number of 0.8 in level flight at an altitude of 10 km. The data for the engine is given below:

   Stagnation temperature at the turbine inlet =1200 K
   Stagnation temperature rise through the compressor = 175 K
   Calorific value of the fuel = 43 MJ/Kg
   Compressor efficiency = 0.75
   Combustion chamber efficiency = 0.975
   Turbine efficiency = 0.81
   Mechanical efficiency of the power transmission between turbine and compressor =0.98
   Exhaust nozzle efficiency = 0.97
   Specific impulse = 25 seconds

   Assuming the same properties for air and combustion gases calculate:

i) Fuel –air ratio,
ii) Compressor pressure ratio,
iii) Turbine pressure ratio,
iv) Exhaust nozzles pressure ratio ,and
v) Mach number of exhaust jet. **BT-3**

6. A turbojet aircraft flies at 875 Km/hr. at an attitude of 10,000 m 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 = 0.75 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 air to fuel ratio = 40. **BT-3**

7. (i) Derive the thrust equation for rocket engine. **BT-6**

   (ii)The diameter of the propeller of an aircraft is 2.5 m; it flies at a speed of 500 Km/hr at an altitude of 8000 m. For a flight to jet speed ratio of 0.75, determine: The flow rate of air through the propeller, Thrust produced, specific thrust, specific impulse and thrust power. **BT-3**

8. An aircraft propeller flies at a speed of 440 Km/hr. The diameter of the propeller is 4.1 m and the speed ratio is 0.8. The ambient conditions of air at the flight altitude are T = 255K and P = 0.55 bar. Find the following: (i) Thrust (ii) Thrust Power (iii) Propulsive efficiency.

   BT-3

9. A turbo propels an aircraft at a speed of 900 km/hour, while taking 3000 Kg of air per minute. The isentropic enthalpy drop in the nozzle is 200 KJ/Kg and nozzle efficiency is 90%. The air-fuel ratio is 85 and the combustion efficiency is 95%. The calorific value of the fuel is 42000 kJ/Kg. Calculate,

   (i) The propulsive power (ii) Thrust power (iii) Thermal efficiency and (iv) Propulsive efficiency. **BT-3**

10. A turbojet engine is traveling at 850Km/h at standard sea level conditions (101.32 KPa and 15^oC) .The compressor ratio is 4:1.The turbine inlet temperature is 1000^oC.Calculate

    (i) Specific Thrust
    (ii) Thrust S A C
    (iii) Propulsive efficiency

    Assume $\gamma = 1.4$, $C_p = 1.005$ kJ/kg. K. **BT-3**

UNIT- V, SPACE PROPULSION

PART-A

1. Why rocket is called as non-breathing engine? Can rocket work at vacuum? **BT-4**
2. Explain the applications of inhibitors in solid propellants? **BT-4**
3. Rewrite the mono-propellants? Give examples. **BT-6**
4. What are the types of rocket engines based on source of energy employed? **BT-5**
5. Prepare any four specific application of rocket. **BT-6**
6. A rocket flies at 10080 km/hr. with an effective exhaust jet velocity of 1400 m/s and the propellant flow rate of 5kg/s. Find the propulsion efficiency and propulsion power of the rocket. **BT-3**
7. List down the types of rocket engines? **BT-1**
8. What is meant by hypergolic propellant? **BT-5**
9. What is bypass engine and define bypass ratio? **BT-5**
10. Briefly explain thrust augmentation and any two methods of achieving it. **BT-4**
11. Give any two advantages and disadvantages of rockets compared to air breathing engines. **BT-2**
12. Define escape velocity. **BT-1**
13. Distinguish between monopropellant and bipropellant. **BT-2**
14. Define rocket propulsion? **BT-1**
15. Name any two solid propellant fuels and oxidizers. **BT-1**
16. Differentiate the advantageous of solid propellant rockets over liquid propellant rockets? List any two. **BT-2**
17. Define terminal velocity. **BT-1**
18. State thrust augmentation? **BT-1**
19. What is restricted burning in rockets? **BT-5**
20. List out the types of liquid propellant rocket engines? **BT-1**

PART-B

1. (i) Explain the working of Multi-stage rocket with their merits and demerits. **BT-5**

   (ii) Describe the importance of characteristic velocity. A weather satellite is to be launched at an altitude of 500 km above the earth's surface. Determine the required orbital velocity and derive the equation used. **BT-5**

2. Evaluate the maximum velocity of a rocket and the altitude attained from the following data:

   Mass ratio = 0.15
   Burnout time = 75s
   Effective jet velocity = 2500 m/s

What are the values of the velocity and altitude losses due to gravity? Ignore drag and assume vertical trajectory. **BT-5**

3. What are the advantages and disadvantages of liquid propellants compared to solid propellants? **BT-3**

4. Explain with a neat sketch the working of a gas pressure feed system used in liquid propellant rocket engines. **BT-3**

5. Describe the important properties of liquid and solid propellants desired for rocket propulsion. **BT-2**

6. A Rocket has the following data:

Propellant flow rate:	= 203 Kg/s
Thrust Chamber Pressure:	= 47 bar
Thrust Chamber temperature:	= 3020 K
Nozzle exit diameter:	= 650 mm
Ambient pressure:	= 1.013 bar
Thrust produced:	= 420 KN

Calculate effective jet velocity, actual velocity, specific impulse and specific propellant consumption. Recalculate the values of thrust and specific impulse for an altitude of 20000 m. **BT-3**

7. A rocket nozzle has an exit area ratio 3:1 with isentropic expansion. What will be the thrust per unit area of exit and specific impulse if the combustion chamber temperature is 2973 K and pressure is 20 bar. Assume atm pressure is 1 bar and R=0.287kJ/kg K and γ =1.3.

BT-5

8. Draw the sketch of a pulse jet engine. Write down its main advantages and disadvantages. **BT-3**

9. Discuss in detail the various propellants used in solid fuel rockets and the liquid fuel system. Also sketch the propellant feed-system for a liquid propellant rocket motor. **BT-2**

10. Calculate the orbital and escape velocities of a rocket at mean sea level and an altitude of 300 km from the following data: **BT-3**

Radius of earth at mean sea level	= 6341.6 Km
Acceleration due to gravity at mean sea level	= 9.809 m/s²