Hall Ticket No | | | | | | | | | | | Question Paper Code:AAEC14

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
(Dundigal-500043, Hyderabad)

B.Tech V SEMESTER END EXAMINATIONS (REGULAR) - DECEMBER 2022
Regulation:UG20

AEROSPACE PROPULSION

Time: 3 Hours **(AERONAUTICAL ENGINEERING)** **Max Marks: 70**

Answer ALL questions in Module I and II
Answer ONE out of two questions in Modules III, IV and V
All Questions Carry Equal Marks
All parts of the question must be answered in one place only

MODULE – I

1. (a) How the spacecraft can transfer from the orbits? Discuss the concept of rocket dispersion considerations with neat sketch. [BL: Understand| CO: 1|Marks: 7]

   (b) A satellite is launched from a circular equatorial parking orbit at an altitude of 160 km into a coplanar circular synchronous orbit by using a Hohmann transfer ellipse. Assume a homogeneous spherical earth with a radius of 6374 km. Determine the velocity increments for entering the transfer ellipse and for achieving the synchronous orbit at 42,200 km altitude. [BL: Apply| CO: 1|Marks: 7]

MODULE – II

2. (a) Determine Tsiolkovsky rocket equation. List the assumptions used in the analysis of an ideal rocket unit. [BL: Understand| CO: 2|Marks: 7]

   (b) A rocket operates at sea level (P = 0.1013 MPa) with a chamber pressure of P_1 = 2.068 MPa, a chamber temperature of T_1= 2222 K, and a propellant consumption of $\dot{m}$= 1 kg/sec. (Let γ = 1.30, R = 345.7 J/kg. K). Calculate the ideal thrust and the ideal specific impulse. [BL: Apply| CO: 2|Marks: 7]

MODULE – III

3. (a) Outline about the propellant grain and grain configurations. List down the different solid propellants used with its desirable properties. [BL: Understand| CO: 3|Marks: 7]

   (b) A solid-propellant rocket has the following data:
   Combustion chamber temperature = 2600 K, Combustion chamber pressure = 18 MPa, Propellant density = 1600 kg/m^3, Grain diameter = 10 mm, Exhaust gas constant R = 400 J/kg. K, Gas-specific heat ratio γ = 1:2, Vielle's law constants a = 4:0, n = 0:6, Burn time = 12 s, Exit pressure = 100 kPa. Calculate
   i) The nozzle throat diameter
   ii) Characteristic velocity
   iii) Optimal thrust coefficient
   iv) Thrust force
   v) The mass flow rate and total burnt mass of the propellant
   vi) The specific impulse
   vii) The total impulse [BL: Apply| CO: 3|Marks: 7]

4. (a) Describe in detail about the combustion instabilities in solid propellant rockets and the corrective measure to minimize the effect. [BL: Understand| CO: 4|Marks: 7]

   (b) During testing of a new propellant in a strand burner, the regression rate at a chamber pressure of 7 and 17 MPa are found to be 25 and 45 mm/s, respectively. If the regression rate happens to follow Saint–Robert's law, determine the chamber pressure when it regresses at 35 mm/s. [BL: Apply| CO: 4|Marks: 7]

MODULE – IV

5. (a) Discuss the different propellant feed systems used in liquid propellant rocket engines. [BL: Understand| CO: 5|Marks: 7]

   (b) A rocket powered by a liquid-propellant rocket motor has the following data: Thrust force of 450 kN at sea level

   Propellant consumption rate = 150 kg/s

   Gas exit static pressure = 70.0 kPa

   Exhaust area = 0:5 m^2

   If the exhaust speed is kept constant, calculate the effective exhaust speeds and thrust force in the following cases:

   i) Sea-level operation (Pa = 101 kPa)

   ii) At an altitude of 3 km (Pa = 70.0 kPa)

   iii) In space operation (Pa = 0.0 kPa) [BL: Apply| CO: 5|Marks: 7]

6. (a) With the help of neat sketches, outline the injection systems used in liquid propellant rocket engines. [BL: Understand| CO: 5|Marks: 7]

   (b) A rocket motor has a combustion chamber with temperature 3500 K and pressure 22 atmospheres. The throat area is 0:1 m^2. The exit pressure is equal to atmospheric pressure at altitude of 20 km. Specific heat ratio γ = 1:23 and specific heat at constant pressure Cp = 2520 J/kg/K. Calculate:

   i) Exit velocity

   ii) Mass flow through the motor

   iii) Thrust force

   iv) Specific impulse [BL: Apply| CO: 5|Marks: 7]

MODULE – V

7. (a) What are the methods for ion generation? Classify electric rockets and derive the basic equations. [BL: Understand| CO: 6|Marks: 7]

   (b) Determine the flight characteristics of an electrical propulsion rocket for raising a low satellite orbit. Data given: I_s = 2000 sec, F = 0.20 N, Duration = 4 weeks = 2.42 x 10^6 sec ; Payload mass = 100 kg, α = 100 W/kg, η_t = 0.5 [BL: Apply| CO: 6|Marks: 7]

8. (a) Compare the performance of electric, ion and nuclear propulsion systems with chemical rocket propulsion systems. [BL: Understand| CO: 6|Marks: 7]

   (b) Outline the basic features of solar powered rockets. Make comparison of chemical, electrical, nuclear propulsion systems used in rockets. [BL: Apply| CO: 6|Marks: 7]