



# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal-500043, Hyderabad

B.Tech V SEMESTER END EXAMINATIONS (REGULAR/ SUPPLEMENTARY) - FEBRUARY 2024

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

- (a) Discuss the vehicle propulsion technologies that will lower the launch operation costs in space transportation. [BL: Understand| CO: 1|Marks: 7]

(b) An artificial satellite revolves in a circular orbit at height 600 km above the earth's surface. What is the orbital velocity and period of revolution of the satellite? (Radius of the earth = 8400 km,  $g = 9.8 \text{ m/s}^2$ ) [BL: Apply| CO: 1|Marks: 7]

## MODULE – II

- (a) What is the operating principle of operation of a rocket engine? Distinguish between air breathing engine and rocket engine. [BL: Understand| CO: 2|Marks: 7]

(b) A rocket engine with chamber pressure of 4.5 MPa and nozzle throat diameter of 110 mm produces thrust of 17 kN by consuming propellant flow rate of 7.5 kg/s with calorific value of 25 MJ/kg. If the flight velocity happens to be 850 m/s, determine the specific impulse, effective exhaust velocity, specific propellant consumption and thrust power, and thrust coefficient. [BL: Apply| CO: 2|Marks: 7]

## MODULE – III

- (a) Illustrate the properties of solid rocket propellant. What are the advantages of solid propellant rocket engine? [BL: Understand| CO: 3|Marks: 7]

(b) In a rocket engine, a solid propellant with  $n = 0.68$ , is used, which has a thrust coefficient  $CF$  of 0.95, and a characteristic velocity  $C^*$  of 1850 m/s. When the unburnt propellant temperature is  $10^\circ\text{C}$  and the chamber pressure is 4.5 MPa, find the regression rate. [BL: Apply| CO: 3|Marks: 7]
- (a) Analyze the parameters that are required for the selection criteria of solid propellants. [BL: Understand| CO: 4|Marks: 7]

(b) A single-stage chemical rocket with  $I_{sp} = 250$  is designed to escape with the following mass:  $m_l$  = payload mass = 200 kg;  $m_s$  = structural mass = 800 kg;  $m_0$  = total mass = 30,000 kg. Determine the mass ratio, velocity increment, payload, and structural fraction for this rocket engine assuming there are no drag and gravity effects. [BL: Apply| CO: 4|Marks: 7]

## MODULE – IV

5. (a) With a neat sketch, explain the working principle of liquid rocket propellant and the types of liquid rocket propellant. [BL: Understand| CO: 5|Marks: 7]
- (b) Explain various injectors used in liquid rocket engine with neat sketches. List out its applications, advantages and disadvantages. [BL: Understand| CO: 5|Marks: 7].
6. (a) Why is cooling of nozzle throat critical for thermal failure? Enumerate the desirable physical properties of a liquid propellant rocket engine. [BL: Understand| CO: 5|Marks: 7]
- (b) Sketch and explain turbo-pump feed system of liquid propellant rockets. Mention the construction details and flow line of propellants. [BL: Understand| CO: 5|Marks: 7]

## MODULE – V

7. (a) Outline the basic principle of electrostatic thruster with a neat sketch. Why is swirling electron field used in a Hall thruster? [BL: Understand| CO: 6|Marks: 7]
- (b) What is solar sail? Explain briefly solar cells and solar generators with neat sketches. [BL: Understand| CO: 6|Marks: 7]
8. (a) Demonstrate the working of nuclear rocket engine, its application and challenges involved, with a neat sketch. [BL: Understand| CO: 6|Marks: 7]
- (b) A 1.75 kW electrochemical rocket with helium as propellant is to be designed and developed using tungsten filament resistive heating element for obtaining the thrust coefficient of 1.8. Assuming the mass flow rate of propellant to be 0.12 g/s, determine the exit velocity, characteristic velocity, temperature of propellant gas, thrust, and specific impulse for electrochemical rockets with thruster efficiency of 0.85. [BL: Apply| CO: 6|Marks: 7]

