

M.E / M. TECH DEGREE EXAMINATIONS: NOV/ DEC 2024

(Regulation 2024)

First Semester

DEFENCE TECHNOLOGY

24DTE001: Rockets and Missiles Fundamentals

COURSE OUTCOMES**CO1:** Understand basics of missile physics as well as the engineering aspects of missile integration.**CO2:** Understand physics behind guided missiles and aero dynamics of missiles.**CO3:** Characterization of sub-systems used in missiles.**Time: Three Hours****Maximum Marks: 100****PART A (4*20 = 80 Marks)**

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|----|------|---|----|-----|-------------------|
| 1. | a) | Define thrust of a rocket motor. Derive the expression for thrust of the rocket motor. | 10 | CO1 | [K ₃] |
| | b) | A rocket motor ejects mass at a rate of 30 kg/s with an exhaust velocity of 3,100 m/s. The pressure at the nozzle exit is 5 kPa and the exit area is 0.7 m ² . What is the thrust of the engine in vacuum? | 5 | CO1 | [K ₃] |
| | c) | Answer the following questions in one word or one line: | 5 | CO1 | [K ₃] |
| | i) | Name India's first long range ballistic missile. | | | |
| | ii) | When a missile is flying in a trimmed condition, what is the net pitching moment about CG. | | | |
| | iii) | A scramjet engine carries its own oxidizer (True or False) | | | |
| | iv) | Newton's laws of motion are applicable in Inertial frame of reference (True or False) | | | |
| | v) | How much is the initial velocity added to a rocket due to the rotation of Earth, if launched on equator towards East? | | | |
| 2. | a) | With a neat sketch, enumerate the major sub-systems of an air-to-air missile. | 5 | CO3 | [K ₃] |
| | b) | The normal force coefficient and axial force coefficient (based on body base area) acting on a missile flying at sea level at M=2 are 0.5 and 0.4 respectively. The diameter of missile is 1.0 m. Calculate the normal force and axial force acting on the missile. | 5 | CO3 | [K ₃] |
| | c) | Define reliability. Discuss the reliability of a system in series and parallel. The probability of failure of two components are ; F1 = 0.1 and F2 = 0.2, then Find the reliability R1 and R2 and system reliability. | 5 | CO3 | [K ₃] |
| | d) | Discuss CEP for a missile. 100 missiles were fired on a designated target. 20 missiles impacted within a radius of 20 m from the target. 50 missiles impacted within a radius of 30 m. All 100 missiles impacted within a radius | 5 | CO3 | [K ₃] |

- of 60 m from target. What is the CEP of the missile?
3. a) With a neat sketch, write 3-DOF equations of motion clearly explaining each term. 5 CO2 [K₄]
- b) What are jigs and fixtures? Discuss their advantages in missile integration. 5 CO2 [K₄]
- c) What is cable harness? What are the advantages of cable harness in electrical integration of missile? 5 CO2 [K₄]
- d) An air to air missile of mass 100 kg is required to produce lateral acceleration of 30 g at M=2.0 and altitude=10 km. What is the maximum C_N required to be produced by the missile? The density of air at 10 km altitude is 0.4 kg/m³. The speed of sound at 10 km is 300 m/s. Reference area, S_R = 0.025 m² 5 CO2 [K₄]
4. a) What is Coriolis force? Discuss the effect of Coriolis force on the movement of an object in Northern and Southern hemisphere. 5 CO1 [K₃]
- b) A spacecraft's dry mass is 75,000 kg and the effective exhaust gas velocity of its main engine is 3,100 m/s. How much propellant must be carried if the propulsion system is to produce a total ΔV of 700 m/s? 5 CO1 [K₃]
- c) Why rockets are generally launched from the equator? Explain 5 CO2 [K₃]
- d) Discuss the effect of nose bluntness of a ballistic missile during reentry phase. 5 CO2 [K₃]

Answer any ONE Question

PART B (1*20 = 20 Marks)

5. a) Describe multistage rockets. What are their advantages? 10 CO1 [K₄]
- b) Following data is given for a rocket motor: Initial mass = 80 T; payload mass = 2T; Propellant mass = 60T; Structural mass = 18 T. Calculate the incremental velocity, ΔV, considering two stage multi-staging. (Note: Divide the propellant mass and structural mass equally among different stages) 5 CO1 [K₄]
- c) With a neat sketch, discuss the three phases of a ballistic missile. 5 CO2 [K₄]

OR

6. a) With a neat sketch, discuss earth-centered inertial frame of reference and earth-centered earth-fixed frame of reference. 10 CO2 [K₄]
- b) Derive the relation for rotation matrix, when a vector is rotated counterclockwise by an angle, . 5 CO3 [K₄]
- c) Calculate the acceleration due to gravity at Karman line. 5 CO3 [K₄]
