

**III B.Tech II Semester Supplementary Examinations,
November/December 2005
ROCKETS AND MISSILES
(Aeronautical Engineering)**

Time: 3 hours**Max Marks: 80**

**Answer any FIVE Questions
All Questions carry equal marks**

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1. Sketch a layout of a liquid propellant rocket and show the fuel pump, igniters and feed lines on it, what is the effect of the injector on the performance of the rocket engine. [16]
2. Explain the following with respect to solid rocket motor:
 - (a) Erosive burning
 - (b) Thrust termination
 - (c) Chuffing
 - (d) Hazard properties of solid propellants [16]
3. What are the effects of atmosphere on the performance of the rocket? Describe the structural and aerodynamic effects of wind on the rocket. [16]
4. (a) Analyze the longitudinal dynamics of a missile by using two degrees of freedom model and state how the various aerodynamic derivatives affect the dynamics of a missile.
(b) Why cruciform missiles are roll stabilized. [12+4]
5. Prove that the cut off velocity for a rocket with vertical flight in friction less air is given by

$$V_p = -\bar{V}_j \left[\frac{(m_p/M_0)g}{a_0+g} + \ln \left(1 - \frac{m_p}{m_0} \right) \right]$$

$$\dot{m}_p = \text{constant mass rate of propellant consumption}$$
 Where initial velocity is zero.
Find the expression for the vertical coasting distance of the missile. [16]
6. Derive an expression for the ideal burn out velocity for a rocket. Draw a figure showing all the forces acting on a rocket in vertical flight. Find the general equation for the acceleration of the rocket in vertical flight. [16]
7. For a vertical ascent of a 2 stage rocket, find expression for culmination altitude and show that it decreases with the increase in the coast time between burn out of stage one and ignition of stage 2. Derive the expression for maximum culmination height. [16]
8. Compare the aluminium and titanium alloys in respect for use in the structures at cryogenic temperatures. What is the material used in the leading edge of a wing of a rocket or missile? What properties the material is required to have. [16]

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1. (a) What is the function of valves in rocket engines; explain the various types of the valves used in the propellant supply.
(b) Show the position of valves by a neat sketch. [12+4]
2. What is the ratio of burning area to the nozzle area for a solid propellant unit with the characteristics as given below:
Specific gravity=1.71
Chamber pressure= 14 MPa
Burning Rate= 38 mm/sec
Temperature sensitivity= $0.007(^{\circ}\text{K})^{-1}$
Specific Heat Ratio=1.27
Chamber Gas Pressure= 2220°K
Molecular Mass= 23 Kg/mole [16]
3. (a) Explain the various methods of jet controls and state their merits and demerits.
(b) What are the various aerodynamic controls employed on a missile, discuss the salient features of all. [6+10]
4. (a) Find the expression for the pitching moment coefficient for the wing of a missile.
(b) What is load factor find the expression for the load factor per unit control deflection for the missile with forward control? [6+10]
5. (a) What are the assumptions for deriving the equations of motion of a rocket in free space?
(b) Derive the expressions for the velocity increment of rocket in free space. [8+8]
6. What is thrust termination, in which case it is needed; Describe the different methods of thrust termination in solid propellant rocket motors? [16]
7. Prove that for an N stage rocket with identical stages with same structural factor ϵ and payload ratio of λ .
Speed ratio $v = -n \ln(\epsilon(i - \lambda) + \lambda)$ [16]
8. Discuss the suitability of the Tungsten, Tantalum and Molybdenum metals for the structures at very high temperatures in case of missile and rockets. [16]

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1. What is the ignition system in the rocket motors; describe all the components of ignition system in the case of liquid propellant rockets. [16]
2. Explain the following with respect to solid rocket motor:
 - (a) Erosive burning
 - (b) Thrust termination
 - (c) Chuffing
 - (d) Hazard properties of solid propellants [16]
3. (a) What is a jet control? Under which circumstances jet control becomes necessary
(b) With the help of neat sketches discuss the different aerodynamic control configurations of the missiles. [6+10]
4. For a cruciform type of missile discuss:
 - (a) The cause of induced roll
 - (b) Design consideration for lateral control
 - (c) Damping in roll. [5+6+5]
5. (a) Derive the relation between the time and flight path angle for the gravity turn trajectory of a rocket with constant specific thrust.
(b) Define kick angle, vertical rise time and velocity factor. [10+6]
6. What do you mean by thrust vector control? Explain various methods of thrust vector control in the liquid propellant rockets? [16]
7. What do you mean by parallel staging? What are the advantages and disadvantages of it? Give examples of the rockets where parallel and/or tandem staging is used. Define structure factor and coast time for a two stage rocket. [16]
8. Describe the different material used for different parts of the rockets and missiles with their properties. [16]

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1. (a) What are the main parameters for designing the injectors of a liquid propellant rocket engine?
(b) What are the different feed systems for delivering the propellant from the tanks to the rocket engine? [12+4]
2. What is geysering effect in case of missiles, what are the effects of it, how can these effects be controlled. [16]
3. A missile motion is represented by $A\Phi'' + B\Phi' + C\Phi = K$. Discuss its various roots and hence the various motions represented by these roots. [16]
4. Describe the various modes which represent the response characteristics of missile when disturbed from the equilibrium. Derive the equations of motion in a fixed axes system. [16]
5. (a) What are various rocket parameters affecting the motion of the rocket in free space.
(b) Define the terms, payload ratio and propellant ratio, how does the propellant ratio depend upon the ideal velocity of the rocket. [8+8]
6. Explain the terms burnout velocity, burnout altitude and Culmination altitude for rocket motion in homogeneous gravitational field and show, by curves, how they depend upon thrust-to weight-ratio. [16]
7. Derive the expressions for the total time to culmination for a rocket with N stages. [16]
8. Discuss the economic factors affecting the material selection for the rockets and missiles. Describe the special methods or processes of using relatively cheap materials. [16]
