Register Number: ……………………..

B.E DEGREE EXAMINATIONS:APRIL/MAY 2014

(Regulation 2009)

Seventh Semester

AERONAUTICAL ENGINEERING

AER120**:** Space Mechanics and Missile Technology

Time: Three Hours **Maximum Marks: 100**

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. In the cruise phase of interplanetary mission, the gravitational attraction on a spacecraft is dominant by
   a) The earth b) The target planet
   c) The sun d) Any outer planet
2. The plane of the Earth's orbit around the Sun is defined as
   a) Equatorial plane b) Celestial plane
   c) Ecliptic plane d) Lunar plane
3. When the effective exhaust velocity of a vehicle in gravitationless space is 2000 m/sec, the mass ratio necessary to boost the vehicle velocity by 1600 m/sec is
   a) 0.150 b) 0.449
   c) 0.982 d) 1.500
4. The process of reducing the total energy and lowering the apogee of an orbit by atmospheric drag is called
   a) Regression of Nodes b) Orbital Decay
   c) Rotation of Line of Apsides d) Orbit Cranking
5. Which of the following happens when a spacecraft passing in front of a planet?
   a) Spacecraft's velocity increases with respect to Sun b) Spacecraft's energy decreases with respect to Sun
   c) Spacecraft's energy decreases with respect to the planet d) Spacecraft's velocity increases with respect to the planet
6. The phase of a ballistic missile trajectory from launch to thrust cutoff is
   a) Boost phase b) Free-flight phase
   c) Ballistic phase d) Re-entry phase
7. The desired Q value at burnout for a ballistic missile in order to attain the maximum free-flight range of 100° is
   a) 0.5332 b) 0.6892
   c) 0.7280 d) 0.8675

8. The pitch angle of a launch vehicle in its vertical motion is
   a) 0° b) 45°
   c) 90° d) –90°
9. The component of force in a direction perpendicular to both the lift and the drag measured in the horizontal plane in a missile is
   a) Normal Force b) Axial Force
   c) Thrust Force d) Side Force
10. Missiles are generally classified based on
   a) Size b) Launch mode
   c) Weight d) Flight time

PART B (10 x 2 = 20 Marks)

11. Explain the Geostationary orbit.
12. An Earth's satellite is observed to have a perigee height of 100 km and an apogee height of 600 km. Find the semi-major axis of its orbit and its orbital period. Given the radius of the Earth = 6378 km and the Earth's gravitational parameter $\mu = 398600.4418\ km^3/s^2$.
13. What is Sphere of Influence?
14. Define Eccentric anomaly of a satellite. Give an equation which relates Eccentric anomaly and True anomaly of a satellite in its orbit.
15. Consider an initial circular low earth orbit at 300 km altitude. What velocity increase would be required to produce an elliptical orbit with a 300 km altitude at periapsis and a 3000 km altitude at apoapsis?
16. What is Gravity-Assist maneuver and what is its importance?
17. What is meant by 'evection' in the Earth-Moon system?
18. What is plasma in Space environment?
19. List out the assumptions for a simplified case of lunar mission.
20. What is meant by tandem staging and parallel staging in rockets?

PART C (5 x 14 = 70 Marks)

21. a) Explain the various Coordinate Systems used in Space Applications.

(OR)

b) With a neat diagram explain the six classical Orbital Elements in detail.

22. a) (i) Obtain the expression for trajectory equation of a body orbiting the Earth. (8)

(ii) Write short notes on parabolic and hyperbolic trajectories. (6)

(OR)

b) (i) Derive the delta-V equations for Hohmann transfer. (9)

(ii) Calculate the total delta-V required to transfer a spacecraft from a circular earth orbit of altitude 300 km to a coplanar circular earth orbit of altitude 3000 km. (Radius of the Earth = 6378 km, μ = 398600.44 km^3/s^2) (5)

23. a) Estimate the total delta-V requirement for a transfer of spacecraft from a 150 km altitude of circular parking orbit around the earth to a 150 km altitude of circular capture orbit around the Mars. Furthermore, assume that the planets have coplanar circular orbits. (Mean distance from Earth to the Sun = 149.6 x 10^6 km (1 AU), Mean distance from Mars to the Sun = 1.524 AU, Sun's gravitational parameter μ_s = 1.327 x 10^{11} km^3/s^2, Earth's gravitational parameter μ_e = 398600.44 km^3/s^2, Mars' gravitational parameter μ_m = 42828.3 km^3/s^2, Radius of the Earth = 6378 km, Radius of the Mars = 3397 km)

(OR)

b) Derive the flight-path angle equation of a ballistic missile. Using the flight-path angle equation, find the expression for maximum free-flight range angle attainable with a given Q_{bo}.

24. a) (i) An intercontinental ballistic missile has the following nominal burnout conditions: h_{bo} = 430 km, v_{bo} = 6.8 km/s. Assuming a symmetrical trajectory, what must the flight path angle be at burnout for both low and high trajectories in order to attain a desired free-flight range of 6500 km? (8)

(ii) Describe the thermal and meteoroid/debris environments of space and their effects on spacecraft components. (6)

(OR)

b) Discuss the effects of Space Environment on the selection of materials for Spacecraft Systems.

25. a) Explain in detail the various external forces commonly acting on a missile flying in the earth's atmosphere.

(OR)

b) (i) Derive the expressions for velocity and distance travelled for a launch vehicle during its vertical motion in the Earth's gravitational field. (7)

(ii) Determine the total velocity and the flight path angle of a rocket at constant pitch angle during its inclined motion in the Earth's gravitational field. (7)

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