Register Number: ……………………..

B.E., DEGREE EXAMINATIONS: NOV/DEC 2012

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. A location of an object in a north or south of the celestial equator can be identified by

    a) Right Ascension   b) Vernal Equinox

    c) Autumnal Equinox   d) Declination

2. Which one of the following defines the shape of a trajectory?

    a) Semi-major axis   b) Inclination

    c) Eccentricity   d) Semi-minor axis

3. The true anomaly of a satellite at perigee and apogee are, respectively

    a) 0 deg and 180 deg   b) 0 deg and 90 deg

    c) 90 deg and 0 deg   d) 180 deg and 0 deg

4. 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

5. In the cruise phase of interplanetary mission, the gravitational attraction on a spacecraft is dominated by

    a) The Earth   b) The target planet

    c) The Sun   d) Any outer planet

6. When a spacecraft passes in front of a planet, its velocity will

    a) Increase with respect to the Sun   b) Increase with respect to the planet

    c) Decrease with respect to the Sun   d) Decrease with respect to the planet

7. A cross-range error in a ballistic missile is caused by

    a) Incorrect burnout Flight-path angle   b) Incorrect Launch Azimuth

    c) Incorrect burnout height   d) Incorrect speed at burnout

8. Which one of the following belongs to thermal environment in space?

    a) Ionospheric plasma   b) Solar radiation

    c) Neutral gas particles   d) Natural magnetic field

9. Which one of the following is an airframe component of a missile?

a) Canards   b) Seeker

c) Guidance system   d) Radome

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. Define the term 'Ecliptic'.

12. State Kepler's second law of planetary motion.

13. The period of revolution of a satellite is 106 minutes. Find the apogee altitude if the perigee altitude is 200 km. (Radius of the Earth = 6378 km, $\mu = 398600.44$ km^3/s^2)

14. Mention the primary forces which perturb a satellite orbit.

15. Define synodic period of a planet.

16. What is meant by patched conic approximation? Give an example.

17. Define low trajectory and high trajectory of a ballistic missile.

18. A ballistic missile was observed to have a burnout speed and altitude of 7.4 km/s and 478 km respectively. What must be the maximum free-flight range capability of this missile? (Radius of the Earth = 6378 km, $\mu = 398600.44$ km^3/s^2)

19. What is a gravity-turn trajectory?

20. Give two fundamental reasons for staging in rockets.

PART C (5 x 14 = 70 Marks)

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

(OR)

b) (i) Explain any four Orbital Elements with a clear diagram.   (8)

(ii) Prove Kepler's third law of planetary motion using Newton laws.   (6)

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.   (10)

(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, $\mu = 398600.44$ km^3/s^2)   (4)

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) A lunar probe is sent to the Moon on a trajectory with the following injection conditions: r_0 = 6700 km, v_0 = 10.88 km/s, flight-path angle, ϕ_0 = 0°. Upon arrival at the Moon's sphere of influence, λ_1 = 30°. Assume the lunar orbit has a circular radius of 384,400 km, Calculate the time of flight from injection to arrival at the lunar sphere of influence. (Radius of the lunar sphere of influence = 66,183 km, μ = 398600.44 km^3/s^2)

24. a) (i) Derive an expression for the free-flight range equation of a ballistic missile. (6)

   (ii) During the test firing of a ballistic missile, the following measurements were made: h_{bo} = 400 km, v_{bo} = 5.6 km/s, h_{apogee} = 960 km. Assuming a symmetrical trajectory, what was the free-flight range of the missile during this test in nautical miles? (Radius of the Earth = 3444 nautical mile, μ = 398600.44 km^3/s^2) (8)

(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 burnout range expression for a missile under constant thrust. (7)

   (ii) Obtain the burnout altitude for the missile in vertical flight and homogeneous gravitational field. (7)

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