KUMARAGURU
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Register Number:……………………..

B.E DEGREE EXAMINATIONS: NOV / DEC 2014

(Regulation 2009)

Seventh Semester

AERONAUTICAL ENGINEERING

AER 120:Space Mechanics And Missile Technology

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

Answer all the Questions:-

PART A (10 x 1 = 10 Marks)

1. Law which relates the orbital period of a planet with its mean orbital radius is

    a) Kepler I law   b) Kepler II law

    c) Kepler III law   d) Newton law of gravitation

2. In Heliocentric coordinate system, the origin is

    a) Earth   b) Sun

    c) Moon   d) Mars

3. The angle which gives the instantaneous position of the satellite in the orbit measured from the periapsis of an elliptical orbit is

    a) Longitude of ascending node   b) Argument of perigee

    c) Inclination   d) True anomaly

4. If Vc is the circular orbital velocity of a probe at an orbital radius of R, then this probe will escape from the planetary gravitational field if the instantaneous velocity V becomes

    a) zero   b) Less than Vc

    c) $Vc < V < \sqrt{2}$ times Vc   d) $V \geq \sqrt{2}$ times Vc

5. Patched conics technique is used in

    a) Geo-synchronous orbit   b) Inter-planetary orbit

    c) Sun-synchronous orbit   d) Molynia orbit

6. In the motion of Earth – Moon system,

a) Moon rotates around Earth   b) Earth rotates around Moon

c) the Earth and moon revolve around a common center of mass   d) Moon rotates around Sun

7. The ballistic flight phase of an ICBM is a part of a

a) Circle   b) Ellipse

c) Parabola   d) Hyperbola

8. To include the effect of earth rotation on the ICBM trajectory, the relative velocity of the missile is added with the eastward rotational velocity of the

a) Launch site   b) Injection point

c) Reentry point   d) Impact point

9. The rocket flight phase in which the angle of attack is kept small from aerodynamic load point of view is

a) Vertical rise   b) Gravity turn

c) Pitch down in the vacuum   d) Injection

10. The missile which ascends above the atmosphere and reenters back towards target is

a) Ballistic Missile   b) Surface to air missile

c) Air to air missile   d) Cruise missile

PART B (10 x 2 = 20 Marks)

11. Define mean sidereal day.

12. Name the different coordinate systems having Earth, Moon, Sun and Mars as the origin.

13. Calculate the orbital period of International Space Station which is orbiting the earth at an altitude of 250km in a circular orbit. ($\mu_{earth} = 398600.44 \text{ km}^3/\text{s}^2$, Radius of Earth = 6378km)

14. Calculate the semi-major axis, semi-minor axis and eccentricity of an orbit with the perigee and apogee altitudes of 2500km and 5000km. (Radius of Earth = 6378km)

15. Differentiate between planetary capture and planetary flyby.

16. Define impulsive shot.

17. What are the forces used for the reentry flight phase computation for a ballistic missile flight capable of maneuvering towards the target?

18. Calculate the velocity (speed and direction) imparted to the missile due to earth rotation (i) at the equator and (ii) at North Pole.

19. What causes skin friction drag, pressure drag and base drag in a rocket?

20. What are two common ways of separating two serial rocket stages?

PART C (5 x 14 = 70 Marks)

21. a) (i) Explain the different regions of atmosphere. (7)

    (ii) Write a short note on celestial sphere and different timing systems (7)

(OR)

   b) (i) List the six classical orbital elements and explain briefly about each of them. (7)

    (ii) An artificial Earth satellite is in an elliptical orbit with an altitude of 552 km at perigee and an altitude of 2208 km at apogee. Calculate the eccentricity, energy, angular momentum, velocities at apogee and perigee and orbital period. ($\mu_{earth} = 398600.44$ km^3/s^2, Radius of Earth = 6378 km) (7)

22. a) (i) A spacecraft is in a circular parking orbit with an altitude of 200 km. Calculate the velocity change required to perform a Hohmann transfer to a circular orbit at geosynchronous altitude of 35,768km. ($\mu_{earth} = 398600.44$ km^3/s^2, Radius of Earth = 6378 km) (7)

    (ii) Explain with a diagram the significance of true anomaly, eccentric anomaly, mean anomaly and the relationship between them. (7)

(OR)

   b) (i) Calculate the velocity change required to transfer a satellite from a circular 600 km orbit with an inclination of 28 degrees to an orbit of equal size with an inclination of 20 degrees. ($\mu_{earth} = 398600.44$ km^3/s^2, Radius of Earth = 6378 km) (7)

    (ii) A satellite is launched into Earth orbit where its launch vehicle burns out at an altitude of 250 km. At burnout, the satellite's velocity is 7,900 m/s and the angle with respect to the vertical is 89°. Calculate the perigee and apogee altitudes of the satellite orbit. Calculate the eccentricity of the orbit for the satellite. ($\mu_{earth} = 398600.44$ km^3/s^2, Radius of Earth = 6378 km) (7)

23. a) (i) Explain the method of patched conics used in interplanetary trajectories (7)

    (ii) Calculate the radius of the earth's sphere of influence. Mass of Earth = 5.974×10^{24} kg, Mass of Sun= 1.989×10^{30} kg, and mean orbital radius of Earth is 149.6 (7)

$\times 10^6$ km.

(OR)

b) (i) Explain gravity assist trajectory. (7)

(ii) A spacecraft is launched on a mission to Mars starting from a 300 km circular parking orbit. Calculate the delta-v required and the amount of propellant required as a percentage of the spacecraft mass before the delta-v burn, assuming a specific impulse of 300 seconds. Use $\mu_{sun} = 1.327 \times 10^{11}$ km^3/s^2, $\mu_{earth} = 398600$ km^3/s^2, Orbital radii of Earth and Mars are 149.6×10^6 km and 227.9×10^6 km respectively. (Radius of Earth = 6378 km) (7)

24. a) (i) Draw a diagram and explain the in-plane trajectory geometry of a ballistic missile. (7)

(ii) Derive the equations for the minimum injection velocity and the optimum flight path angle for the minimum energy trajectories. (7)

(OR)

b) (i) Discuss on plasma of space environment and its effect on spacecraft. (6)

(ii) Derive the expression for influence coefficients of ballistic missile. (8)

25. a) (i) Draw a typical air-to-air missile configuration and explain about the different sub-systems. (7)

(ii) Explain the various types of staging in rockets. (7)

(OR)

b) (i) Explain the aerodynamic characteristics, of different airframe configurations of a missile. (7)

(ii) A single stage rocket is launched vertically. The lift off mass, specific impulse, burn time and propellant mass flow rate are 1000kg, 280 seconds, 10 seconds and 50 kg/seconds respectively. Calculate the ideal velocity at burn out. Also calculate the gravity corrected velocity, peak altitude and time to reach peak altitude considering constant gravity of 9.8 m/s^2 and ignoring aerodynamic forces. (7)

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