
MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

VI SEMESTER B.TECH. (AERONAUTICAL ENGINEERING)

MAKEUP EXAMINATION, JUNE 2017

SUBJECT: SPACEFLIGHT DYNAMICS [AAE 4015]

REVISED CREDIT SYSTEM
(22/06/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

1A. What is meant by osculating plane in particle dynamics? **(02)**

1B. Let the position vector be **(03)**

$$\bar{r} = (2 + 3t + 4t^2)\hat{e}_1 + (t + 2t^3)\hat{e}_2 + 7t^4.\hat{e}_3$$

Find the velocity and acceleration at time, t = 4s.

1C. Relative to a Cartesian coordinate system, the position, velocity, and acceleration of a particle P at a given instant are **(05)**

$$\bar{r} = 250\hat{e}_1 + 630\hat{e}_2 + 430\hat{e}_3$$
$$\bar{V} = 90\hat{e}_1 + 125\hat{e}_2 + 170\hat{e}_3$$
$$\bar{a} = 16\hat{e}_1 + 125\hat{e}_2 + 30\hat{e}_3$$

Find the coordinates of the center of curvature at that instant.

2A. State whether the following statements are true or false **(02)**

a. If a hyperbolic, parabolic, elliptic and circular orbits intersect at one point in the space, a satellite at point P would have a higher orbital speed if it is orbiting on the hyperbolic orbit.

b. The longitude of the ascending node of an equatorial orbit is undefined.

2B. 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 km. The perigee and apogee radius are $6.6017 \times 10^6 \text{m and } 7.1751 \times 10^6 \text{m}$ respectively. **(03)**

2C. Suppose we observe an object in the ECI frame at position **(05)**

$$\bar{r} = 0.67\hat{i} + 0.67\hat{j} + 0.55\hat{k}\ (\text{DU})$$

Moving with velocity

$$\bar{v} = 0.61\hat{i} - 0.01\hat{j} - 0.74\hat{k}\ (\text{DU/TU})$$

a. Calculate the specific mechanical energy of the spacecraft, and specific angular momentum of the spacecraft.
b. Determine the eccentricity vector and characterize the shape of the orbit.
c. Calculate the perigee and apogee altitudes of the orbit.

3A. Justify that the Hohmann transfer is most efficient orbital transfer compare to Bi-elliptic transfer. **(02)**

3B. Write down the steps that are involved in the iteration to find orbital periods of rendezvous problem for two vehicles in same elliptical orbit. **(03)**

3C. A satellite is in an orbit with a semi-major axis of 7,500 km and eccentricity of 0.1. Calculate the time it takes to move from a position 30 degrees past perigee to 90 degrees past perigee. **(05)**

4A. Write any two conditions for the matrix to be symmetry. **(02)**

4B. For the cuboid, the moment of inertia is given as the following. Find the principal moment of inertia. **(03)**

$$[\bar{\bar{I}}] = \begin{bmatrix} \frac{2}{3}Ma^2 & -\frac{Ma^2}{4} & -\frac{Ma^2}{4} \\ -\frac{Ma^2}{4} & \frac{2}{3}Ma^2 & -\frac{Ma^2}{4} \\ -\frac{Ma^2}{4} & -\frac{Ma^2}{4} & \frac{2}{3}Ma^2 \end{bmatrix}$$

4C. The satellite in Figure 1 is rotating about the z axis at a constant rate N. The xyz axes are attached to the spacecraft, and the z-axis has a fixed orientation in inertial space. The solar panel rotate at a constant rate θ in the direction shown. Relative to point o, which lies at the center of the spacecraft and on the centerline of the panels, calculate its absolute velocity and absolute acceleration for point A on the panel. **(05)**

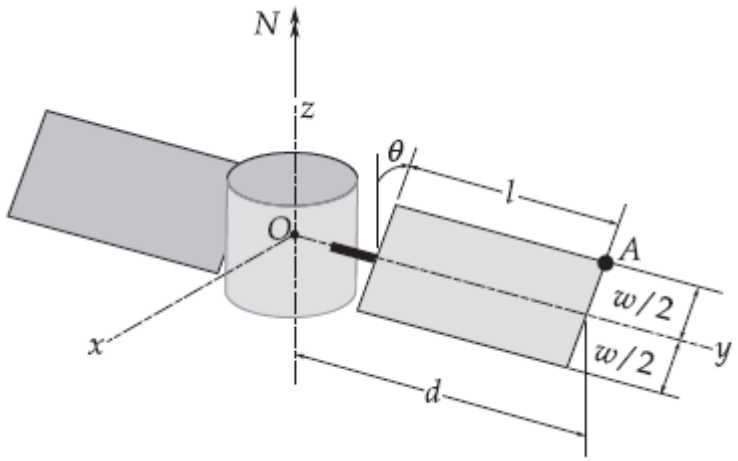

Figure 1: Rotating solar panel on a rotating satellite

5A. Name any two important factors that affects the atmospheric re-entry of the space vehicle? **(02)**

5B. Calculate the radius of sphere of influence around the Earth. **(03)**

Mass of the Earth = 5.972×10^{24} kg; Mass of the Sun = 1.989×10^{30} kg; Distance between the Earth and the Sun = 149.6×10^{6} km.

5C. Compare the advantages and disadvantages of ballistic re-entry and skip re-entry of space vehicles. **(05)**