AOE 4134 Homework 4

Due: Wednesday September 20, 2000 at beginning of class

Modified on Friday September 15 to postpone Problems 4 and 5

Units are indicated using square brackets; *e.g.*, [km], [km/s^2].
"Discussion" questions require complete sentences.

1. Do Problem 2.12 in BMW. Although you're to do this "by inspection," you must explain your answers.

2. In an inertial reference frame, an Earth-orbiting satellite has position vector

$$\vec{\mathbf{r}} = -6000\,\vec{\mathbf{I}} + 10,000\,\vec{\mathbf{J}} + 5,000\,\vec{\mathbf{K}} \text{ [km]}$$

and velocity vector

$$\vec{\mathbf{v}} = -5\,\vec{\mathbf{I}} - 2\,\vec{\mathbf{J}} + 1\,\vec{\mathbf{K}} \text{ [km/s]}$$

Note: The gravitational parameter for the Earth is $\mu = 3.986 \times 10^5\,\text{km}^3/s^2$.

a) Determine the orbital elements a, e, i, Ω, ω, and ν_0.

b) Determine the time of periapsis passage, T, the longitude of periapsis, Π, the argument of latitude at epoch, u_0, and the true longitude at epoch, ℓ_0.

c) Determine the components of the unit vectors of the perifocal reference frame in terms of the unit vectors of the ECI frame. In other words, determine P_1, P_2, and P_3 so that $\hat{\mathbf{P}} = P_1\,\vec{\mathbf{I}} + P_2\,\vec{\mathbf{J}} + P_3\,\vec{\mathbf{K}}$, *etc.*.

d) Determine the position and velocity vectors when the satellite has moved from ν_0 to $\nu_0 + 21°$. Approximately how long does the satellite take to move through $\Delta\nu = 21°$?

3. Do Problem 2.15 in BMW. Explain your answers.

4. In an inertial reference frame, an Earth-orbiting satellite has position vector

$$\vec{\mathbf{r}} = 6000\,\vec{\mathbf{I}} - 10,000\,\vec{\mathbf{J}} + 3,000\,\vec{\mathbf{K}} \text{ [km]}$$

and velocity vector

$$\vec{\mathbf{v}} = 5\,\vec{\mathbf{I}} + 2\,\vec{\mathbf{J}} - 2\,\vec{\mathbf{K}} \text{ [km/s]}$$

Note: The gravitational parameter for the Earth is $\mu = 3.986 \times 10^5\,\text{km}^3/s^2$.

a) Determine the orbital elements a, e, i, Ω, ω, and ν_0.

b) Determine the time of periapsis passage, T, the longitude of periapsis, Π, the argument of latitude at epoch, u_0, and the true longitude at epoch, ℓ_0.

c) Determine the components of the unit vectors of the perifocal reference frame in terms of the unit vectors of the ECI frame. In other words, determine P_1, P_2, and P_3 so that $\hat{\mathbf{P}} = P_1\,\vec{\mathbf{I}} + P_2\,\vec{\mathbf{J}} + P_3\,\vec{\mathbf{K}}$, *etc.*.

d) Determine the position and velocity vectors when the satellite has moved from ν_0 to $\nu_0 + 21°$. Approximately how long does the satellite take to move through $\Delta\nu = 21°$?

Problems 4 and 5 are not due with this homework assignment. They will be due with the next homework assignment.

5. Do Problem 2.17 in BMW.

6. An object is observed by a radar station in Goose Bay, Labrador (you'll need to consult a map to find the coordinates of this site). The radar measures the following variables at epoch t_o (0300 UTC Sep 11, 2000):

$$\begin{array}{cc} \rho = 200 \text{ km} & \dot{\rho} = 0.1 \text{ km/s} \\ \text{Az} = 45^\circ & \dot{\text{Az}} = 2^\circ/\text{s} \\ \text{El} = 60^\circ & \dot{\text{el}} = 2^\circ/\text{s} \end{array}$$

a) Determine $\vec{\mathbf{r}}$ and $\vec{\mathbf{v}}$ at epoch (km, km/s, in ECI frame).

b) Determine the orbital elements a, e, i, Ω, ω, and ν_0.

c) Is it possible that this object is a ballistic missile? You must explain your reasoning in answering this question. A simple "yes" or "no" gets zero credit.