ASEN 5050 – Homework #2

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1. (40 pts) Write a computer program (any language you like, though I suggest making your life easier and using Matlab) that converts ECI position and velocity vectors into orbital elements (Algorithm 9 in the textbook). To be perfectly useful, also include the gravitational parameter, μ, as an input. The function call should look like:

   function [a, e, i, Ω, ω, ν] = RV2COE(Rijk, Vijk, μ)

   You can test if your function works by reproducing Example 2-5 in the textbook. Once you have a working function, compute orbital elements for the following ECI position/velocity:

$$\vec{r} = \begin{bmatrix} -5633.9 \\ -2644.9 \\ 2834.4 \end{bmatrix} km \qquad \vec{v} = \begin{bmatrix} 2.425 \\ -7.103 \\ -1.800 \end{bmatrix} \frac{km}{s}$$

   The goal is to make a program that works in as many circumstances as possible, reliably and in the most useful way. Test it out on many types of orbits!

From the given position and velocity:

Semi-major axis:	$\boldsymbol{a = 6993.499\ km}$
Eccentricity:	$\boldsymbol{e = 0.0221}$
Inclination:	$\boldsymbol{i = 28.402^o}$
Right ascension of the ascending node:	$\boldsymbol{\Omega = 82.522^o}$
Argument of periapsis:	$\boldsymbol{\omega = 118.251^o}$
True anomaly:	$\boldsymbol{\nu = 1.134^o}$

2. (40 pts) Write a computer program that converts orbital elements to ECI position and velocity vectors (Algorithm 10 in the textbook). The function call should look like:

   function [Rijk, Vijk] = COE2RV(a, e, i, Ω, ω, ν, μ)

   You can test if your function works by reproducing Example 2-6 in the textbook.

   Once you have a working function, compute the ECI position and velocity for the International Space Station (ISS) using the following NORAD Two Line Element Set (TLE) (http://www.celestrak.com/NORAD/documentation/tle-fmt.asp), which I downloaded from the CelesTrak web site (http://www.celestrak.com/). Note: TLEs use mean orbital elements; treat the values as instantaneous values.

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ISS (ZARYA)
1 25544U 98067A 01260.91843750 .00059354 00000-0 74277-3 0 4795
2 25544 51.6396 342.1053 0008148 106.9025 231.8021 15.5918272116154
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Based on the given TLE:

$$\vec{r} = \begin{bmatrix} 5530.5 \\ -3394.8 \\ -1934.7 \end{bmatrix} km \qquad \vec{v} = \begin{bmatrix} 4.018 \\ 3.362 \\ 5.602 \end{bmatrix} \frac{km}{s}$$

3. (20 pts) Write a program that computes the eccentric anomaly (E) given the mean anomaly (M) and the eccentricity (e) (Algorithm 2 in the textbook). You can test your program using Example 2-1 in the textbook. Embed this in a program that computes the true anomaly given the time since periapsis passage. Use this routine and "COE2RV" from Problem 2 to predict the position and velocity of the ISS 1 hour past the epoch of the TLE.

At 1 hour past epoch of the TLE:

$$\overrightarrow{r_{1hr}} = \begin{bmatrix} -1049.5 \\ -4075.4 \\ -5307.5 \end{bmatrix} km \qquad \overrightarrow{v_{1hr}} = \begin{bmatrix} 7.347 \\ -2.186 \\ 0.224 \end{bmatrix} \frac{km}{s}$$