ASE 389P.4 Methods of Orbit Determination
Homework 1: Basic Orbit Propagation

Assigned:	Thursday, February 4, 2021
Due:	Thursday, February 11 @ 12:30pm

In this assignment, you will create a tool to numerically propagate a circular orbit about the Earth and convert between Cartesian and Keplerian orbital elements. The software you implement in this assignment will be used later in the course, and will also provide additional background and/or a review of basic orbital mechanics.

Please include all software as an appendix to the turned in homework assignment.

Problems

1. Given the Earth orbiting spacecraft position and velocity vectors in Cartesian coordinates

$$\underline{R} = -2436.45\hat{\imath} - 2436.45\hat{\jmath} + 6891.037\hat{k}\ km \tag{1}$$

$$\underline{V} = \dot{\underline{R}} = 5.088611\hat{\imath} - 5.088611\hat{\jmath} + 0.0\hat{k}\ km/s \tag{2}$$

solve for the Keplerian elements (a, e, i, Ω, ω, ν). Provide your values in the write-up. See the lecture notes

Assume $\mu = 398600.5$ km^3/s^2.

2. Convert the Keplerian elements from Problem 1 back to position and velocity and provide the values in the write-up. See the lecture notes:

3. Given the gravity potential function $U = \mu/R$, solve for the two-body acceleration due to gravity, i.e.,

$$\nabla U = \frac{\partial U}{\partial x}\hat{\imath} + \frac{\partial U}{\partial y}\hat{\jmath} + \frac{\partial U}{\partial z}\hat{k} \tag{3}$$

where $R = \underline{R} \bullet \underline{R}$. Include your derivation in your solution to the assignment.

4. Develop the necessary code to numerically integrate the equations of motion using the position and velocity from Problem 1 as the initial conditions. Compute the future position and velocity at 20-second intervals for two full orbits. Plot the magnitude of the position, velocity, and acceleration as a function of time for two full orbits and provide the figure. Compute the specific orbital angular momentum vector for these two full orbits and plot that as well, as a function of time, as a 3D scatter plot ($\underline{h} = \underline{R}\ X\ \underline{V}$). Assume that the motion is only due to the accelerations derived from Eq(3)

5. Compute the specific kinetic energy and specific potential energy as a function of time and plot the change in total specific energy to show that it remains constant over the two orbits. (i.e. plot $dE = E(t) - E(t_0)$). Include the image in your write-up. Why is the change in total specific energy not constant?