EAE143a/EME298 Winter 2016 – Homework #4 ***Due Sun 2/7/16 11:59pm***

1) Basic orbital parameters: remind yourself:
    a. Determine the kinetic, potential, and total energy per unit mass, and the magnitude of the moment of momentum (or, angular momentum due to orbital motion) for the HST

2) Assume your spacecraft is an elliptical transfer orbit, with perigee of 150km above Earth mean surface, and apogee at HST mean altitude.
    a. Compute the value (deg) of the true anomaly one hour after perigee passage.
    b. Compute the magnitude of the Earth-relative velocity of your spacecraft at this same point

3) Obtain the Two-Line-Element for HST at an epoch of your choosing.
    a. Write down the 6 orbital elements h, e, I, Ω, ω, and θ
    b. Also compute the eccentric anomaly E.
    c. Using class notes (Lecture 7, Thurs 1/26/16, "Compute State Vector from Orbital Elements"), find the HST state vector at this time, in the geocentric equatorial reference frame. (Also see Curtis book, Sec 4.6 and App D2 (SmartSite).

4) Plot the magnitudes vs θ of the three vector components of the perturbing gravitational potential **b** for one orbit of the HST (Lecture 8, p14, Thurs 1/28/16, Curtis eqn 12.30)

5) Drag forces:
    a. Estimate the drag force imposed on the HST at its actual altitude, and also as if it were at ISS altitude. Do this for two cases, solar min and solar max, using the NASA atmospheric model you used in HW #2. Assume a non-rotating Earth. List all other assumptions.
    b. Explain why drag tends to circularize an elliptical orbit.

6) Referring to the Gaussian form of the Lagrange Planetary Equations (eqn 4.34 in the text):
    a. For a retrograde burn, which orbital parameters will change, and by which sign?
    b. To change the orbital inclination, you must burn "out of plane". What other orbital parameters will this change, if any?
    c. To increase the argument of perigee, in which direction(s) could you generate thrust?
    d. For a purely in-plane burn, what is the relationship between tangential and radial thrust required to leave the argument of perigee unchanged?

7) Numerical propagation of perturbed orbits:
    a. Use the HST state vector found in Problem 3 as your initial conditions.
    b. Write the orbital equation of motion for perturbed orbits as two first order ODE's in **r** and **v**:

$$\frac{d}{dt}\begin{Bmatrix} \mathbf{r} \\ \mathbf{v} \end{Bmatrix} = \begin{Bmatrix} \mathbf{v} \\ \mathbf{a} \end{Bmatrix} = \begin{Bmatrix} \mathbf{v} \\ -\mu \frac{\mathbf{r}}{r^3} + \mathbf{p} \end{Bmatrix}$$

    c. The perturbation vector **p** is due to drag only, **p** = -1/2 ρv(C_D S)**v**
    d. Using RK4, solve for **r** and **v** on the time interval of one orbit, once with drag and once without. Plot the difference over time for the magnitudes of **r** and **v**.