# ENAE 791 PROBLEM SET 2 – SPRING, 2024

DUE 2/29/24

(1) A spacecraft is in orbit around the Earth. Its position and velocity can be expressed in an inertial Cartesian frame centered on the gravitational center of the Earth with the Z axis oriented through the north pole as $\bar{X}$={0, 11681, 0} (km) and $\bar{V}$={5.134, 4.226, 2.787} (km/sec). Write a computer routine (program, MatLab script, or Excel spreadsheet, whatever works for you) to numerically integrate the planar state equations derived in class. Starting with the state specified, propagate the orbit forward through one orbital period. What are the position and velocity errors in your numerical prediction as compared to the calculated orbital state? (Note: we're going to be adding on to this program throughout the term to incorporate atmospheric drag, lift, and launch thrust, as well as out-of-plane motions. It's in your enlightened self-interest to write the code cleanly enough you can continue to modify and reuse it throughout the term.)

(2) Extend your computer routine from (1) to incorporate aerodynamic lift and drag and numerically integrate the planar state equations derived in class as necessary for the following problems.

  (a) A spacecraft in low Earth orbit has performed a deorbit burn and will encounter the atmosphere at an altitude of 122 km, velocity $v_e = 7700$ m/sec, and flight path angle $\gamma = -5.0^o$. The spacecraft has a ballistic coefficient $\beta = 1000$ kg/m$^2$. I would like you to calculate entry trajectories (i) based on atmospheric density, (ii) based on altitude, and (iii) integrating the equations of motion, and plot them together on a single plot for each case. I would like to see plots of altitude vs. downrange distance, acceleration vs. time, and velocity vs. altitude for these three cases.

  (b) Repeat (a) for a lifting entry with the lift vector pointed upwards and an L/D of 0.25, all other parameters remaining the same. In this case, just plot the equilibrium glide approximation vs. the numerical integration results.