AAE 340

Homework #6

Due Friday, Oct. 6, 2017 at 9:30 AM

After a 15-minute grace period late HW will be given a zero.

The Galileo orbiter arrived at Jupiter on December 7,1995. It was targeted to overfly the probe at a radius of 4 RJ (Jovian radii) from the center of Jupiter. The probe entered the atmosphere (at 1 RJ) at the same time, having separated from the orbiter on July 13 ,1995.

Shortly after perijove, the orbiter performed the JOI (Jupiter Orbit Insertion) maneuver which, after a closer flyby with Io than expected, resulted in a capture orbit with a 198-day period.

1. Starting from the EOMs, show how to define state variables and indicate how to write a MATLAB program which propagates the trajectories of the orbiter and the probe. (Ignore the effect of Io.)

2. Using the following information:

$r = 300$ RJ (orbiter and probe at start)

$V\infty = 5.455$ km/s (orbiter and probe)

$\mu = 1.267 \times 10^8$ km^3/s^2 (gravitational parameter of Jupiter)

1 RJ = 71,398 km (radius of Jupiter)

show how to determine the initial conditions r(0), dr/dt(0), θ(0), and dθ/dt(0) for both the orbiter and the probe. (Note that there are 3 sets of ICs that must be determined: i) probe hyperbolic orbit, ii) orbiter hyperbolic orbit, and iii) orbiter elliptic orbit.

3. Assume that JOI occurs at perijove (not exactly true) and plot the trajectory of the 198-day capture orbit for one orbit period.

Combine all three plots on one figure to show:
3a. The orbiter hyperbolic trajectory from 300 R_J to 4 R_J.
3b. The orbiter elliptic trajectory from 4 R_J to 4 R_J(one full orbit).
3c. The probe trajectory from 300 R_J to 1R_J.
3d. Also plot a circle to represent Jupiter.

4. Compute the eccentricities of the three trajectories you plotted in **3a**, **3b**, and **3c**.

5. Give the magnitude of the ΔV for JOI. (Ignore sign.)

6. Simulate the flight of a space plane as follows.

6 a. Assume that there are no thrusters and there is no lift. Also assume that the atmospheric density is given by

$$\rho = \rho_{ref} \exp\left[(r_{ref} - r)/H\right]$$

where ρ_{ref} is the reference density at $r = r_{ref}$ and H is the scale height. This model is called an exponential atmosphere. Rewrite the EOM's for these assumptions. (See attachment: Derivation of Space Plane EOM's.)

6 b. Put the EOM's in state variable form.

6 c. Perform a simulation for the case of $C_D = 0$ (no drag). Simulate the case of a Hohmann ellipse connecting GEO to LEO (geostationary orbit to low Earth orbit). Use the following values.

$r_{ref} = 6458$ km

$\rho_{ref} = 7.7 \times 10^{-6}$ kg/m^3

$H = 5$ km

$m = 1000$ kg

S = cross sectional area = 1 m^2

$\mu = 3.986 \times 10^5$ km^3/s^2

$R_{earth} = 6376$ km

$r(0) = 42,166$ km

$\theta(0) = \pi = 3.14159$ radians

$V(0) = 1.59709$ km/s

$\gamma(0) = 0$

t_f = final time = 24 hours = 86,400 s

This simulation corresponds to a perigee of about 200 km. Make a plot of x and y from

$$x = r \sin\theta$$

$$y = r \cos\theta$$

Put x on the vertical axis and y on the horizontal.

On the same plot draw a circle of radius $r = 6376$ km to represent the Earth. Put your name at the top of the plot.