Homework #4 – ASEN 5050

Due: Tuesday, 9/29/2015

Note: Use Appendix D of the book for all constants not given in the problem. Show the steps you take to arrive at your answers, unless otherwise noted.

1. **(25 pts) Hohmann Transfer:** A satellite is in an orbit about the Earth with a periapse altitude of 250 km and an apoapse altitude of 600 km. We need the satellite in a new orbit that has a periapse altitude of 2000 km and an apoapse altitude of 5000 km. We decide to perform a two-impulse tangent-ΔV transfer (e.g., a Hohmann Transfer). Answer the following:

   a) **(6 pts)** Build a transfer that departs the initial orbit at **periapse (250 km alt)** and arrives at the target orbit at its **apoapse (5000 km altitude)**. Please provide the magnitude of each ΔV and the total ΔV for the transfer.
   b) **(6 pts)** Build a transfer that departs the initial orbit at **periapse (250 km alt)** and arrives at the target orbit at its **periapse (2000 km alt)**. Please provide the magnitude of each ΔV and the total ΔV for the transfer.
   c) **(6 pts)** Build a transfer that departs the initial orbit at **apoapse (600 km alt)** and arrives at the target orbit at **apoapse (5000 km alt)**. Please provide the magnitude of each ΔV and the total ΔV for the transfer.
   d) **(6 pts)** Build a transfer that departs the initial orbit at **apoapse (600 km alt)** and arrives at the target orbit at **periapse (2000 km alt)**. Please provide the magnitude of each ΔV and the total ΔV for the transfer.
   e) **(1 pt)** Which transfer requires the least ΔV?

   The following table may be used to present your results, making sure to show enough work for us to know how you got these answers. Show 2 or 3 digits past the decimal.

Transfer Option	ΔV_1 (m/s)	ΔV_2 (m/s)	Total ΔV (m/s)
a. Peri-Apo			
b. P-P			
c. A-A			
d. A-P			

2. **(25 pts)** Write a function (Matlab, etc) that converts an ECI position into an ECEF position given the Greenwich Sidereal Time:

$$\bar{r}_{ECEF} = ROT3(\theta_{GST})\bar{r}_{IJK}$$

This function call should look something like this:

function [*pos_ecef*] = eci2ecef(*pos_eci*, *theta_GST*)

where *pos_ecef* and *pos_eci* are the ECEF and ECI position vectors. Use this function to compute the ECEF position vector given the following ECI position vector:

$$\bar{r} = \begin{bmatrix} -5634 \\ -2645 \\ 2834 \end{bmatrix} \text{ km}$$

and $\theta_{GST} = 82.75°$. Compute the geocentric latitude, longitude, and altitude (relative to a sphere of radius 6378.1363 km) of this position. Note that geocentric latitude (ϕ), longitude (λ), and radius (r=*altitude*+6378.1363 km) are related to the *xyz* ECEF position components as:

$$x = r\cos\phi\cos\lambda$$
$$y = r\cos\phi\sin\lambda$$
$$z = r\sin\phi$$

Please include your (commented) code with this assignment.

3. **(25 pts)** Write a function that does the opposite, i.e., it converts an ECEF position into an ECI position given the Greenwich Sidereal Time. This function call should look something like this:

function [*pos_eci*] = ecef2eci(*pos_ecef*, *theta_GST*)

Use this function to compute the ECI position of Boulder, Colorado (ϕ=40.01°, λ=254.83°, h=1615 m) given a θ_{GST} = 103°.

4. **(25 pts)** Write a function that computes the range, elevation, and azimuth of a satellite given an ECEF satellite position and the latitude, longitude, and altitude of the tracking station. This function call should look something like this:

function [*pos_topo*] = ecef2topo(*pos_ecef*, *lat*, *lon*, *alt*)

Use this routine to compute the azimuth, elevation, and range relative to Boulder (ϕ=40.01°, λ=254.83°, *alt*=1615 m) of the following ECEF satellite position:

$$\bar{r} = \begin{bmatrix} -1681 \\ -5173 \\ 4405 \end{bmatrix} \text{ km}$$

Please include your (commented) code with this assignment.