AAE 532 – Orbit Mechanics
Problem Set 10
Due: 2459194.1875 (UT)

Problem 1: Recall the example problem that was discussed in class concerning a small robotic explorer sent to the Martian system to observe and characterize the two moons – Phobos and Deimos. The Martian moons Phobos and Deimos are assumed to be in circular and coplanar about Mars, with a radius equal to the semi-major axis listed in the Table of Constants for moons and dwarfs under Supplementary Documents on Brightspace. Let's again assume that the spacecraft has completed its observations in the orbit of Phobos and must transfer to the orbit of Deimos. But, now an option for a transfer with different characteristics is sought. [Assume that it is reasonable to assume a relative two-body problem and consider only the gravity of Mars.]

(a) In the class example, recall that the planned transfer is based on a $240°$ transfer angle and a minimum energy transfer. But, recall that a wide variety of elliptical arcs could be used to connect these two orbits. Perhaps the maneuver costs could be improved by extending the transfer time. Use the space triangle, but try to extend the transfer time to 15 hours.
Produce the transfer and include the following: $type, a, p, e, \mathcal{E}, v_{dep}, v_{arr}, \theta^*_{dep}, \theta^*_{arr}, \gamma_{dep}, \gamma_{arr}$.
As usual, supply all the appropriate justifications for these results. Include the r_p and r_a distances for the transfer ellipse. Does the difference in the true anomalies equal the transfer angle?

(b) Determine the maneuvers at departure and arrival, i.e., $|\Delta\bar{v}|$ and α. Transform the maneuvers to VNB coordinates. How do the maneuvers compare to the minimum energy transfer in terms of time and total maneuver cost?

(c) Plot the transfer in GMAT. Plot a full revolution of the spacecraft orbit as the circular orbit of Phobos. Then apply the departure maneuver. Upon arrival, implement the arrival maneuver; end with a complete revolution in the final orbit (i.e., the circular orbit of Deimos.

Does the transfer pass through periapsis or apoapsis?

(d) To implement such a transfer and rendezvous with Deimos, it is necessary to phase the departure correctly. What is the required phase angle between Phobos and Deimos at departure? How often does the correct phase angle recur (in hours)? Compare this result to the periods of Phobos and Deimos.