AOE 4134 Astromechanics Problem Sheet 8

Due: October 28, 2002

Read Chapter 4, 4.1-4.2, 4.6

36-39. Consider a trip from Earth to Mars using an orbit that is tangent to the Earth's orbit but not necessarily tangent to Mars' orbit. The minimum total Delta-V required to make the trip would be that necessary for a Hohmann transfer which is tangent to both orbits. The total Delta-V is the sum of the Delta-Vs for changing from Earth's orbit to the transfer (Hohmann) orbit and the Delta-V required to go from the transfer orbit to Mars' orbit. If the initial Delta-V is still tangent, but larger than that required for a Hohmann, the transfer orbit will be tangent to the Earth's orbit, but not tangent to Mars orbit. Hence the Delta-V at Mars will not be tangential, and must be determined using the law of cosines. For a Hohmann transfer, the initial Delta-V will be 1.0989-1.0 = 0.0989 AU/TU. Starting with this value, calculate the total Delta-V required for the Mars trip. Now increment the initial tangential Delta-V by 0.05 AU/TU, and calculate the new total Delta-V required for the Earth - Mars transfer. Repeat incrementing the initial Delta-V by 0.05 AU/TU and calculating the total Delta-V required until the transfer orbit eccentricity is 1.59 or greater. Note that the initial Hohmann transfer orbit eccentricity is e = 0.208. For each orbit determine the time of flight (TOF) in TU_{sun}. Make a table eccentricity, time of flight, ΔV (@ Earth - initial), ΔV (@ Mars-final, ΔV total. Make a graph of TOF vs ΔV total.

I would suggest using MATLAB (or whatever) to do these calculations. Essentially for each case you are given an initial radius and velocity. Earth's orbit radius is 1.0 AU and Mars' orbit radius is 1.524 AU. Given these, the following calculations are in order and can be programmed:

0. Calculate new speed by taking old speed and adding the Delta-V increment
1. Calculate Energy
2. Calculate the magnitude of the angular momentum
3. Calculate the eccentricity of the transfer orbit
4. Calculate velocity at Mars' orbit (use Energy Equation)
5. Calculate flight path angle at Mar's orbit (use angular momentum)
6. Calculate the second Delta-V at Mars using the law of cosines
7. Add the two Delta-Vs to get the total
8. Determine true anomaly at Mars' orbit
9. Determine the time of flight (TOF)

Make table and graph from results.