MAE180A Spacecraft Guidance, Navigation, and Mission Design
Assignment 2
Due Wednesday, 23 Oct.

Note: You must show all your work in order to get credit!

Problems to hand in (Not all problems may be graded.)

Partial list of problems. More may be added.

1. (10) A spacecraft is in orbit around Mars. Suppose that it was previously observed to have speed $5 \text{ km/sec}$ while at a distance $r = 5000 \text{ km}$ from planet center. Suppose it is now at a distance $r = 6000 \text{ km}$ from planet center. What speed would you expect it to be traveling at now? Note that for Mars we have $Gm_{\text{Mars}} = \mu_{\text{Mars}} \simeq 42,828 \text{ km}^3/\text{sec}^2$.

2. (10) Suppose that a spacecraft goes into orbit about an unknown moon. Suppose that the altitude (above the surface) at periapsis is $1000 \text{ km}$ (kilometers) and at apoapsis the altitude (above the surface) is $5000 \text{ km}$. Suppose that the radius of the moon is approximately $1000 \text{ km}$. The period of the vehicle’s orbit about the moon is $9.5 \text{ hours}$. Estimate the mass of this moon. The universal gravitational constant is

$$G = 6.668 \times 10^{-20} \frac{\text{km}^3}{\text{sec}^2 \text{kg}}$$

where sec stands for seconds and kg for kilograms. Also, based on this, would you estimate that the composition of this moon is largely rock or largely iron?

3. (5) Consider an elliptical orbit around a planet, with semi-major axis, $a = 10,000 \text{ km}$, and eccentricity, $e = 0.25$. Sketch the orbit, including the location of the planet center. What are the periapsis distance, the apoapsis distance and the semi-minor axis length?

4. (5) Consider a hyperbolic trajectory relative to a planet with semi-major axis, $a = 10,000 \text{ km}$, and eccentricity, $e = 1.5$. Sketch the trajectory, including the location of the planet center. Indicate the asymptotes, and their angles. What is the minimal distance of the trajectory from the planet center?
5. (5) Suppose that at time $t$, the mean anomaly, $M(t)$, of a vehicle in an elliptical orbit is 2.0 radians, where the orbit has eccentricity 0.1. Obtain the eccentric anomaly, $E(t)$, at that time. (Obtain this to at least six decimal places.)

6. (15) Let a spacecraft be in elliptical orbit around Mars. Suppose we know that $a = 8000$ km, $e = 0.25$, $i = \frac{\pi}{3}$ radians, and $\tau = 1$AM PST (Earth time), where we recall that $\tau$ is the time of periapsis passage. Recall that we let $(\vec{I}_1', \vec{I}_2', \vec{I}_3')$ define a coordinate system with the $\vec{I}_1'$ unit vector pointing toward periapsis, the $\vec{I}_2'$ unit vector perpendicular to that, and the $\vec{I}_3'$ unit vector pointing along the angular momentum vector, where this is a right-handed coordinate system. The origin of the coordinate system is at the planet center. What is the position of the vehicle in that coordinate system at 9AM PST the same morning? (Recall that $\mu_{\text{Mars}} \simeq 42,828 \text{ km}^3\text{ sec}^{-2}$.)