MAE 2: Introduction to Aerospace Engineering
Assignment 3
Due Thursday, 11/1

1. (10) A spacecraft is on a hyperbolic trajectory with respect to Planet X. At a closest approach of 700 km above the planet surface, how slow could the spacecraft speed possibly be? (Assume the planet radius is 6200 km, and the planet \( \mu = Gm = 325000.0 \text{ km}^3/\text{sec}^2 \).)

2. (10) At perigee (periapsis in an Earth orbit), a spacecraft has an altitude of 1000 km, and a speed of 9 km/sec. Without any burns, will the spacecraft reach an altitude of 2000 km? If so, what will its speed when it reaches that altitude? (Assume a spherical Earth model with radius \( r_e = 6378 \text{ km} \).)

3. (10) A spacecraft is in circular orbit around the Earth, with orbit radius, 30000 km. What is the minimal \( \Delta v \) required to get it into an escape trajectory (i.e., to an orbit of zero energy)? If the fuel has \( I_{g0} = 3 \text{ km/sec} \), what fraction of the spacecraft mass (including fuel) will be needed to achieve this? Plot percent of vehicle mass needed versus circular orbit radius for a vehicle in Earth orbit, with this fuel. Use the simple linear approximation that was obtained in class for required fuel mass.

4. (5) Perform the same estimates, but with the exponential fuel consumption model given in class.

5. (10) For a vehicle in circular Earth orbit with this same fuel, consider orbit plane change. Suppose the orbit radius is 7000 km, and that one wants to change the orbit plane by 0.05 radians. What fraction of the vehicle mass would be required? (Use the simple linear approximation that was obtained in class for required fuel mass.) What fraction of the mass would be required if the radius was 70000 km? How about for 700000 km?

6. (10) Determine the \( \Delta v \) for a Hohmann transfer from circular orbit with radius 4000 km to circular orbit with radius 6000 km around Planet X (with \( \mu_X = 40000 \text{ km}^3/\text{sec}^2 \)).