MAE180 Orbital Mechanics (Spacecraft GN&C)
Assignment 4
Due 9pm, Wednesday, 27 Nov.

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 will be added.

1. (5) Suppose an object is located at $(9000, -5000, 4000)$ km in the ECI coordinate system. Suppose the ECI and ECEF coordinate systems were aligned at midnight. What is its location in an ENU system (East-North-Up system) centered at a point with geodetic latitude $\phi = 0.57$ radians and longitude $\lambda = 4.24$ radians (and zero altitude) at 1AM PST? Would it be above the local horizontal?

2. (10) Using matlab (or python), generate a code that produces the groundtrack of a satellite in Earth orbit. That is, plot the *geocentric* latitude (between -90 deg and 90 deg) versus the longitude (between zero and 360 deg) of the point on the Earth directly below the satellite at each moment, over a specified period of time. Apply this to a satellite with orbital elements given by

$$a = 9,000 \text{ km}, \quad e = 0.25, \quad i = \frac{\pi}{6} \text{ radians},$$
$$\Omega = \frac{\pi}{3} \text{ radians}, \quad \omega = \frac{\pi}{4} \text{ radians and } \tau = 3\text{AM PST}.$$

   For simplicity, suppose ECI and ECEF are aligned at time $t = \tau$.

3. (5) Consider the simple rocket model discussed in class. Suppose the propellant specific impulse is $I_{sp} = 300$ sec, and take the sea-level gravitational acceleration to be 0.00981 km/sec^2. Assume the initial speed is zero, and that the rocket travels in a straight line with no external forces. If the initial mass was 5000 kg, and the terminal mass was 500 kg, what would the terminal speed be? What would it be if the terminal mass was only 100 kg?

4. (10) Suppose your vehicle is in a circular orbit above Mars ($\mu \simeq 42828$ $\frac{\text{km}^3}{\text{sec}^2}$), with orbital elements in an MCI (Mars-centered inertial) system

given by

$$a = 4000 \text{ km}, \quad e = 0, \quad i = 30 \text{ deg},$$
$$\Omega = 60 \text{ deg}, \quad \omega = 0 \text{ deg and } \tau = 3\text{AM PST}.$$

Suppose you would like to change the inclination to 33 deg, keeping the other elements unchanged. Where would you do the burn? What is the vector change in the velocity that you would require, i.e., the $\vec{\Delta}_V$? What is the magnitude of that change, i.e., the Δ_V? Estimate the approximate required fractional fuel mass expenditure Δ_m/m_0, using both the exponential expression and the linearized version thereof (that is, produce two estimates). Take $gI_{sp} = 3 \ \frac{\text{km}}{\text{sec}}$ for these mass estimates.