Homework 7

DUE: Wed 2025-12-03 @ 23:59 on *Canvas*

(PDF submissions only; can be pictures/scans as needed)

1. The code below (also available off the Canvas assignment page) will allow you do a Matlab simulation of a satellite around Earth orbit (you **can** use Matlab online at https://matlab.com/ with your UW ID for this simulation, you do *not* need to install Matlab locally to your computer):

```
% simulation timing parameters
startTime = datetime("now");
stopTime = startTime + days(5);      % simulation length
sampleTime = 60; % seconds           % how often the simulation calculates
data

sc = satelliteScenario(startTime, stopTime, sampleTime); % initialize the
scenario with timing parameters

% orbital elements for the mission
rE = 6378;    % radius of earth [km]
z = 450;      % altitude above  [km]
ecc = 0;      % eccentricity
rp = rE + z;    % periapsis at desired altitude
a = rp/(1-ecc);  % semi major axis  [km]
i = 51.6;     % inclination      [deg]
Omega = 0;    % RAAN             [deg]
omega = 0;    % argument of periapsis  [deg]
theta = 0;    % true anomaly     [deg]

% create a single satellite orbit
v = satelliteScenarioViewer(sc, "PlaybackSpeedMultiplier", 50,
"CameraReferenceFrame", "ECEF", "ShowDetails", false);

% setup the camera default position (optional really, it will be useful
to move things)
latitude = 0;                        % degrees
longitude = 0;                       % degrees
height = r*2*1000;                   % meters
campos(v, latitude, longitude, height);

% create the satellite using the propagation engine
```

```
sat = satellite(sc, a*1000 , ecc, i, Omega, omega, theta,
"OrbitPropagator", "two-body-keplerian", "Viewer", v, "Name", "Sat310");

% draw the ground tracks for 48 hours forward (lead) and back (trail)
leadTime = 2*24*3600;                                                  % seconds
trailTime = leadTime;
gt = groundTrack(sat, "LeadTime", leadTime, "TrailTime", trailTime);

% open the simulation
play(sc);
```

You can use `help satellite` to see all the ways that Matlab allows you to create a simulation. In the given code the parameters for the function are:

```
satellite(scenario,semimajoraxis,eccentricity,inclination,RAAN,argofperiapsis,trueanomaly)
```

where `scenario` is defined by the start/stop/sample times above, and the other 6 parameters are the *orbital elements* you learned in class [Ω, i, ω, e, h, Θ].

In addition to that, the function sets the following "name/value" pairs:

```
"OrbitPropagator" = "two-body-keplerian"
"Name" = "Sat310"
```

(in Matlab the name/value pairs are assigned by their locations after commas ",", not by the equal sign).

The setup also includes a "viewer" which allows you to specify:

`"PlaybackSpeedMultiplier" = 50`

How fast the simulation shows

`"CameraReferenceFrame" = "ECEF"`

Where camera viewpoint is "fixed", note the default is an Earth Centered frame

`"ShowDetails" = false`

Shows more details of the orbit during the animation (needs faster computer), otherwise you need to click on the elements to see their details.

Problem Statement:

Adjust any of the parameters of the `scenario`, `satelliteScenarioViewer`, or `satellite` (times, orbital elements or name/value pairs) in order to be able to visualize with certainty whether the Matlab simulation includes J2 effects or not. You may change any of the parameters as needed. It is fine to do 2 or more parameter sets for comparison.

Explain clearly how the parameters give you the ability to see *without doubt* whether the J2 effects are present or not.

Tips:

- Change parameters that have an effect on J2 effects.
- Try to isolate J2 effects.
- Understand all the parameters in the functions (aka, read Matlab help files, especially about the functions and parameters listed here)

Note: a yes/no answer will give you 1 out of 10 points; all the points come from explaining the parameters you chose and how that gives a certain answer.

Note: looking for the answer in the help files is not enough, it also only counts for 1/10 points. All the points come from explaining how the parameters you chose clearly make a motion that indicates the presence of J2 or not.

2. The Mission Project makes the assumption that the Earth and Mars are in co-planar orbits around the sun, this is not the reality. The inclination angle between the two orbits is 5.145° (Curtis Appendix A).

    a. Draw both a "top view" **and** a "side view" of the transfer, showing the inclination of Mars WRT the Earth-Sun plane.

    b. On the drawings from (a) clearly draw the points where the Δv's can happen to change the inclination.

    c. Does the Δ*i* have an effect on the timing of the mission (when you need to depart)? How?
    Note: You do not need to calculate the timing changes, only discuss based on the theory how the timing is affected or not.

    d. Calculate the Δv needed for *only* the plane (inclination) change (ignore <u>all</u> other needed Δv's), assuming circular velocity at
        i. Earth Departure (v_E = 29.789 km/s) [Answer: 2.6740 km/s]
        ii. Mars Arrival (v_M = 24.135 km/s) [Answer: 2.1665 km/s]
    Tip: the solution is obtained using 1 equation - the point is for you to use the right equation and <u>think about the result</u>: where to do the Δv, how much does this add, %-wise, to the total fuel for a Mars mission?

Note: the minimum Δv would be if you do both the inclination change and planar changes at the same time. However for everyone's sanity, you do not need to calculate the combined maneuver for this homework.