A Few Tips to Succeed on this HW and the OD Final Project.
Vishnuu Mallik
March 10th, 2019

1. **Set up force model**

GRAVITY MODEL
At LEAST, model acceleration due to 2-body + J2 + J3+J4
Better, model acceleration due 4x4 or 6x6 gravity field.
BEST, model acceleration due to 20x20 EGM-96 gravity field.

You can find the equations and some of the coefficients for spherical, zonal, and tesseral harmonics expansions in both Statistical Orbit Determination and the Text by Vallado. You can compute the rest of the missing coefficients by looking at an EGM-96 file. (if you know what to look for). Note that these may be normalized. MATLAB may also have a routine to compute gravity fields in it's Aerospace blockset. Just know how it works and how to use it.

DRAG MODEL
AT LEAST, Have a Cannon Ball Model for Drag.
BETTER, Have Full Fidelity Spacecraft Model with Drag face as the face in the Spacecraft Velocity Direction.

SOLAR RADIATION PRESSURE (SRP)
AT LEAST, have a Cannon Ball Model for SRP
BETTER, Model the SRP due to Solar Panel
BEST, Attitude Dependent, Facet Based SRP Model (Refer to Precise Orbit Determination for TOPEX/POSEDION). Include Specular and Diffuse reflectivity for each face.

Effect of Earth's Shadow on SRP
You need to take into account the effects of the Earth's Shadow. If the Spacecraft is in the Earth's Shadow, then no light shines on it, so there is no solar radiation pressure force experienced!! A very simple algorithm to compute if the spacecraft is in the shadow or not (based on Line of Sight vectors) can be found in Vallado.

LUNI-SOLAR PERTUBATIONS
AT LEAST, Have point mass lunar and solar perturbation models set up. Follow Algorithm from Vallado and beware of Errata's and being in the right plane.

2. **Compute A Matrix**

Compute you're a matrix using acceleration due to 2body + J2 + J3 + J4 + LuniSolar Effects + SRP due to Solar Panel Only and Drag Due to the side exposed to the velocity vector.

3. Set up Measurement/Sensor Model

Set up the functionality to calculate range and range rate from the given tracking stations to the satellite. Note that the station coordinates are given in an Earth Fixed Reference Frame, and the satellite state is propagated in the ECI frame. You will have to use the full transformation (that includes polar motion, nutation, precession etc.) that you derived in the previous Homework to compute the satellite position and velocity in the Fixed System and derive a Range and Range Rate model. Refer to Tapley Shutz and Born for the measurement model. From this derive the H matrix.

4. Include Light Time Correction

The measurements given to you are light time corrected aka apparent range and range rate measurements, as opposed to instantaneous measurements. This means that the time taken by the signal to travel from the satellite to the ground station has been taken into account. If you don't correct for this in the final project, you will be off on the order of 50 meters. You can neglect atmospheric extinction and delays.

1. Calculate initial guess for light time using the range at the current time.

$$lt = \rho/c$$

c is the speed of light.

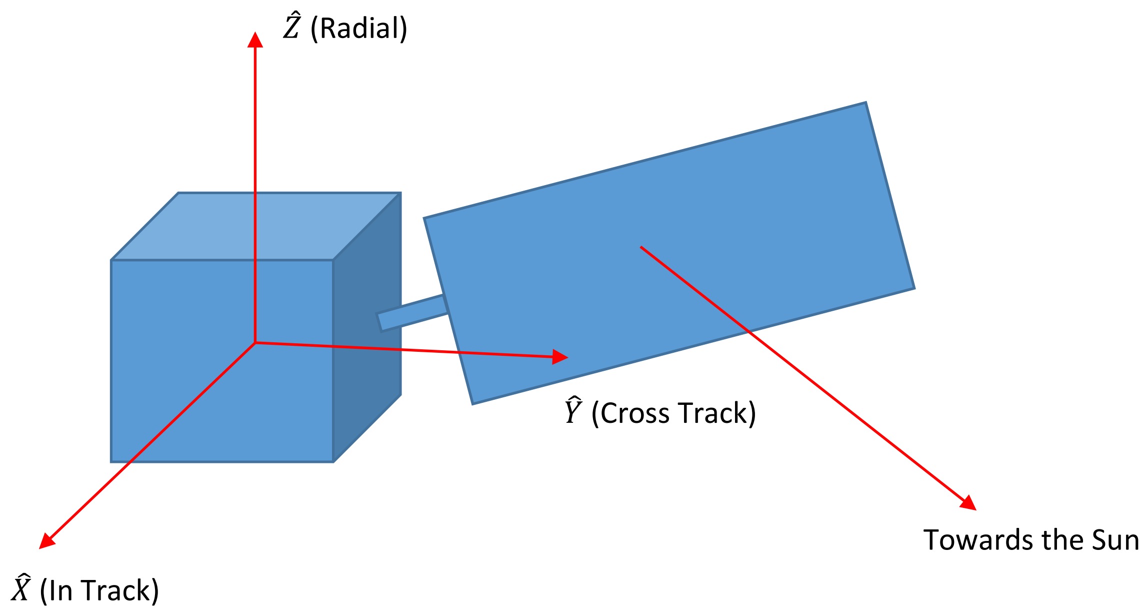
While $\Delta > \boldsymbol{tolerance}$

2. $t_{-lt} = t - lt$ (Compute light time corrected time, where t is the current time)
3. $JD_{-lt} = JD - lt/86400$ (Compute light time corrected Julian Date)
4. $X\_lt = f(t, t_{-lt})$ (Propagate the Satellite state backwards from the current time to the light time corrected time).
5. Get Transformation Matrix at JD_{-lt} and convert the satellite state X_lt into Earth Fixed System (or convert the station coordinates to ECI corresponding to JD_{-lt})
6. Calculate new guess for light time by computing the range.
7. Compute the difference in the satellite position (in Earth fixed system) between the current iteration of the while loop and the previous iteration). This is **Δ**
8. If the difference is not within the tolerance, repeat. Use new guess for light time in Step 2. Set the tolerance to a really small value – like 1mm.

Use the last value of X_lt for your range and range rate calculations.

<u>Spacecraft Model (ECI Reference Frame)</u>

NO NEED TO CONSIDER The BEAM JOINING THE SPACECRAFT BUS AND SOLAR PANEL. FOR ILLUSTRATIVE PURPOSES ONLY. Also assume the solar panel is double-gimbaled and always points towards the Sun (as long as the spacecraft is not in the Sun's Shadow).



$\hat{Z}$ (Radial)
$\hat{Y}$ (Cross Track)
Towards the Sun
$\hat{X}$ (In Track)