John Clouse IMD HW 4 Problem 1

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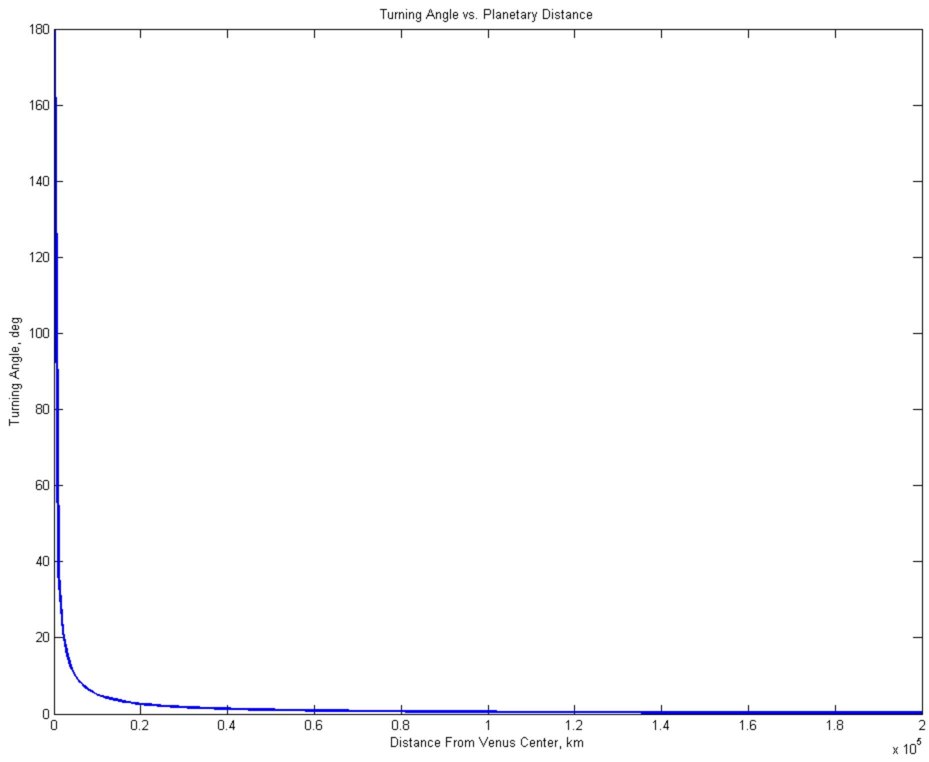
Initialize

```
clearvars -except hw_pub function_list

CelestialConstants

V_spacecraft_wrt_sun=[-10.8559 -35.9372]'; %km/s
v_venus = [15.1945 -31.7927]';%km/s
r_venus = [96948447.3751  46106976.1901]'; %km
mu_sun=1.32712440018e11; %km3/s2
mu_Venus=3.257e5; %km3/s2
R_Venus=    6052; %km

specific_energy_pre = norm(V_spacecraft_wrt_sun)^2/2-mu_sun/norm(r_venus);
fprintf('Heliocentric Energy: %3f km^2/s^2\n',specific_energy_pre);
```

```
Heliocentric Energy: -531.548249 km^2/s^2
```

b) turn angle

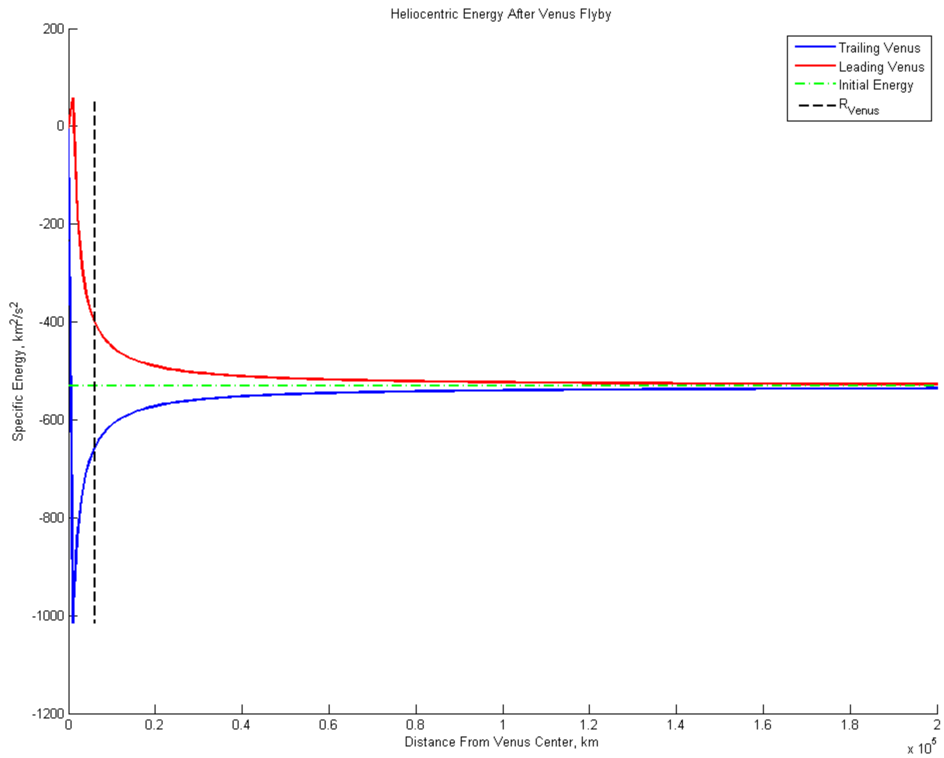
```
v_inf = V_spacecraft_wrt_sun - v_venus;
v_inf_2 = norm(v_inf)^2;
num_pts = 200;
rp = linspace(00,200000,num_pts);
turn_angle_store = zeros(1,num_pts);
for ii = 1:num_pts
    turn_angle_store(ii) = pi - 2*acos( 1/(1+v_inf_2*rp(ii)/mu_Venus));
end

figure('Position', hw_pub.figPosn);
plot(rp,turn_angle_store*180/pi,'LineWidth',hw_pub.lineWidth);
title('Turning Angle vs. Planetary Distance')
xlabel('Distance From Venus Center, km')
ylabel('Turning Angle, deg')
```



c) heliocentric energy

```
energy_leading_pass = zeros(1,num_pts);
energy_trailing_pass = zeros(1,num_pts);
for ii = 1:num_pts
    turn_DCM = Euler2DCM('3',turn_angle_store(ii));
    energy_leading_pass(ii) = norm(turn_DCM(1:2,1:2)*v_inf+v_venus)^2/2 ...
        -mu_sun/norm(r_venus);
    turn_DCM = Euler2DCM('3',-turn_angle_store(ii));
    energy_trailing_pass(ii) = norm(turn_DCM(1:2,1:2)*v_inf+v_venus)^2/2 ...
        -mu_sun/norm(r_venus);
end

figure('Position', hw_pub.figPosn);
hold on
plot(rp,energy_leading_pass,'b','LineWidth',hw_pub.lineWidth);
plot(rp,energy_trailing_pass,'r','LineWidth',hw_pub.lineWidth);
plot([rp(1) rp(end)], ...
    [specific_energy_pre specific_energy_pre],'g-.',...
    'LineWidth',hw_pub.lineWidth);
plot([R_Venus R_Venus], ...
    [max(energy_trailing_pass) min(energy_leading_pass)],'k--',...
    'LineWidth',hw_pub.lineWidth);
legend('Trailing Venus', 'Leading Venus', 'Initial Energy', 'R_{Venus}')
title('Heliocentric Energy After Venus Flyby')
```

```
xlabel('Distance From Venus Center, km')
ylabel('Specific Energy, km^2/s^2')
```



d) What does the plot of energy vs. flyby closest approach tell you?

The spacecraft cannot exit the solar system from just this flyby, as it would have to go below the radius of Venus to do so. In addition, the energy for both leading and trailing the planet asymptotically approach the original energy. This means that the furthest approaches don't add much to the heliocentric energy, so trajectories that need to raise their aphelian should fly closer.

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