Homework 5

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                        6-1:
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-------------------------------------------------------------
impulse required to place the spacecraft onto the departure
hyperbola=       3.58060585
-------------------------------------------------------------
the angle beta =       0.51041057
-------------------------------------------------------------
impulse required to insert the spacecraft into the final orbit
relative to Mars=    2.08539

-------------------------------------------------------------
-------------------------------------------------------------
                        6-2:
-------------------------------------------------------------
-------------------------------------------------------------
impulse required to place the spacecraft onto the departure
hyperbola=       3.48315976
-------------------------------------------------------------
the angle beta =       0.43805679
-------------------------------------------------------------
impulse required to insert the spacecraft into the final orbit
relative to Venus=    3.31835

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                        6-3:
-------------------------------------------------------------
-------------------------------------------------------------
mean motion of earth =       0.00000020
-------------------------------------------------------------
mean motion of mars =       0.00000011
-------------------------------------------------------------
phase angle between earth and Mars at epoch =    0.77369
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--------------------------------------------------------------
phase angle required at departure from Mars =      -1.31069200
--------------------------------------------------------------
time available to the rover to collect samples = 780.24976 Days
--------------------------------------------------------------
impulse for departure = 2.94332462
impulse for arrival = 2.64779276
--------------------------------------------------------------
precise locations of Earth and Mars the day the astronauts leave
Mars = [-227900000.00000000, 0.00000000, 0.00000000]
Earth = [-38474333.08048677, 144567927.61194220, 0.00000000]

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--------------------------------------------------------------
                        6-4:
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--------------------------------------------------------------
Semi-major axis of the heliocentric orbit of the spacecraft
after fly by = 97140542.55614962 km
--------------------------------------------------------------
Turn angle =       3.14159265 radians
--------------------------------------------------------------
Altitude of the periapsis of Venus =  300.00000 km, taken from
question 2
--------------------------------------------------------------
eccententricity of helocentric orbit =       0.34061822
--------------------------------------------------------------
Whether or not it is possible for the spacecraft to cross the
orbit of Mercury = from using my values for the semi-major axis
of the heliocentric orbit as well as its eccentricity, I found
that the radius of the perihelion to be 64052703.60586181 km.
This value is larger than the distance from the sun to Mercury
by 11316703.60586181 km. Therefore, it will not be possible to
cross the orbitof Mercury.>>
```

1 Scripts

6-1

```
clc
clear all
%% 6-1
h0 = 350;
muEarth = 3.986e5;
muMars = 0.042828e6;
muSun = 1.327e11;
```

```
aEarth = 1.496e8;
aMars = 2.279e8;
rEarth = aEarth;
rMars = aMars;
rpMars = 3389.5 + h0;
A = (rEarth + rMars)/2;
tTransfer = pi*sqrt((A^3)/muSun);
%determine the impulse required to place the
%spacecraft onto the departure hyperbola
vinf = sqrt(muSun/rEarth)*(sqrt((2*rMars)/(rEarth + rMars)) - 1);
rp = h0 + 6371;
vcl = sqrt(muEarth/rp);
impEscape = vcl*(sqrt(2 + (vinf/vcl)^2)- 1);
% the angle beta between the line of apses
% of the departure hyperbola and the hyperbolic
% excess velocity
e = 1 + (rp*vinf^2)/muEarth;
Beta = acos(1/e);
%impulse required to insert the spacecraft into
% the final orbit relative to Mars
vinfMars = sqrt(muSun/rMars)*(1 - sqrt((2*rEarth)/(rEarth + rMars)));
vc2 = sqrt(muMars/rpMars);
impCapture = vc2*(sqrt(2 + (vinfMars/vc2)^2) - 1);

fprintf('------------------------------------------------------------\n');
fprintf('------------------------------------------------------------\n');
fprintf('                        6-1:                        \n');
fprintf('------------------------------------------------------------\n');
fprintf('------------------------------------------------------------\n');
fprintf('impulse required to place the spacecraft onto the departure\n');
fprintf('hyperbola= %16.8f \n' , impEscape);
fprintf('------------------------------------------------------------\n');
fprintf('the angle beta = %16.8f \n' , Beta);
fprintf('------------------------------------------------------------\n');
fprintf('impulse required to insert the spacecraft into the final orbit\n');
fprintf('relative to Mars= %10.5f\n', impCapture);
```

6-2

```
clc
clear all
%% 6-2
h0 = 300;
muEarth = 3.986e5;
muVenus = 3.24859e5;
```

```
muSun = 1.327e11;
aEarth = 1.496e8;
aVenus = 1.082e8;
rEarth = aEarth;
rVenus = aVenus;
rpVenus = 6051.8 + h0;
A = (rEarth + rVenus)/2;
tTransfer = pi*sqrt((A^3)/muSun);
%determine the impulse required to place the
%spacecraft onto the departure hyperbola
vinf = sqrt(muSun/rEarth)*(sqrt((2*rVenus)/(rEarth + rVenus)) - 1);
rp = h0 + 6371;
vcl = sqrt(muEarth/rp);
impEscape = vcl*(sqrt(2 + (vinf/vcl)^2)- 1);
% the angle beta between the line of apses
% of the departure hyperbola and the hyperbolic
% excess velocity
e = 1 + (rp*vinf^2)/muEarth;
Beta = acos(1/e);
%impulse required to insert the spacecraft into
% the final orbit relative to Mars
vinfMars = sqrt(muSun/rVenus)*(1 - sqrt((2*rEarth)/(rEarth + rVenus)));
vc2 = sqrt(muVenus/rpVenus);
impCapture = vc2*(sqrt(2 + (vinfMars/vc2)^2) - 1);

fprintf('--------------------------------------------------------------\n');
fprintf('--------------------------------------------------------------\n');
fprintf('                        6-2:                             \n');
fprintf('--------------------------------------------------------------\n');
fprintf('--------------------------------------------------------------\n');
fprintf('impulse required to place the spacecraft onto the departure\n');
fprintf('hyperbola= %16.8f \n' , impEscape);
fprintf('--------------------------------------------------------------\n');
fprintf('the angle beta = %16.8f \n' , Beta);
fprintf('--------------------------------------------------------------\n');
fprintf('impulse required to insert the spacecraft into the final orbit\n');
fprintf('relative to Venus= %10.5f\n', impCapture);
```

6-3

```
clc
clear all
%% 6-3
muSun = 1.327e11;
aEarth = 1.496e8;
```

```
aMars = 2.279e8;
rEarth = aEarth;
rMars = aMars;
A = (rEarth + rMars)/2;
tTransfer = pi*sqrt((A^3)/muSun);

% find mean motion of earth
tauEarth = 2*pi*sqrt((aEarth^3)/muSun);
nEarth = (2*pi)/tauEarth;

% find mean motion of mars
tauMars = 2*pi*sqrt((aMars^3)/muSun);
nMars = (2*pi)/tauMars;

% find the phase angle between earth and
% Mars at epoch
phi0 = pi - nMars*tTransfer;

% find the phase angle required at departure
% from Mars
phif = pi - nEarth*tTransfer;

% time available to the rover to collect samples
tauSyn = (2*pi)/(nEarth-nMars);
timeDays = tauSyn/60/60/24;
%impulses required to accomplish the orbit transfer

impD = sqrt(muSun/rEarth)*(sqrt((2*rMars)/(rEarth + rMars)) - 1);
impA = sqrt(muSun/rMars)*(1 - sqrt((2*rEarth)/(rEarth + rMars)));

%precise locations of Earth and Mars the day the
%astronauts leave Mars
marsLocation = [-rMars, 0, 0];
earthLocation = [-rEarth*cos(phif), -rEarth*sin(phif), 0];


fprintf('------------------------------------------------------------\n');
fprintf('------------------------------------------------------------\n');
fprintf('                        6-3:                         \n');
fprintf('------------------------------------------------------------\n');
fprintf('------------------------------------------------------------\n');
fprintf('mean motion of earth = %16.8f \n' , nEarth);
fprintf('------------------------------------------------------------\n');
fprintf('mean motion of mars = %16.8f \n' , nMars);
fprintf('------------------------------------------------------------\n');
fprintf('phase angle between earth and Mars at epoch = %10.5f\n', phi0);
```

```
fprintf('------------------------------------------------------------\n');
fprintf('phase angle required at departure from Mars = %16.8f\n', phif);
fprintf('------------------------------------------------------------\n');
fprintf('time available to the rover to collect samples = %5.5f Days\n', timeDays);
fprintf('------------------------------------------------------------\n');
fprintf('impulse for departure = %10.8f\n', impD);
fprintf('impulse for arrival = %10.8f\n', impA);
fprintf('------------------------------------------------------------\n');
fprintf('precise locations of Earth and Mars the day the astronauts leave\n');
fprintf('Mars = [%10.8f, %10.8f, %10.8f] \n', marsLocation);
fprintf('Earth = [%10.8f, %10.8f, %10.8f] \n', earthLocation);
```

6-4

```
clc
clear all
%% 6-4
muSun = 1.327e11;
rVenus = 1.082e8;
%semi-major axis of the heliocentric orbit
%of the spacecraft after fly by
aMerc = 52.736e6; %distance of Mercury from the Sun
rMerc = aMerc;
tauMercury = 2*pi*sqrt((aMerc^3)/muSun);
tauHelio = (5/2)*tauMercury;
aHelio = nthroot(muSun*(tauHelio/(2*pi))^2,3);
%turn angle required to perform the planetary flyby
vplus = sqrt(muSun/rVenus);
vminus = sqrt((2*muSun)/rMerc)-(2*muSun)/(rVenus + rMerc);
Vp = sqrt(muSun/rMerc);
vinf = abs(Vp - vminus);
turnAngle = acos((vplus^2 -vinf^2 - Vp^2)/(2*Vp*vinf));
%altitude at the periapsis of Venus that corresponds
%to the turn angle computed in part b
h0 = 300; %from question 2
%the eccentricity of the heliocentric orbit of the
%spacecraft after the fly by
e = real(1/(sin(turnAngle/2)));
%whether or not it is possible for the spacecraft
%to cross the orbit of Mercury
rp = aHelio*(1-e);
difference = rp - aMerc;

fprintf('------------------------------------------------------------\n');
fprintf('------------------------------------------------------------\n');
fprintf('                          6-4:                          \n');
```

```
fprintf('-------------------------------------------------------------\n');
fprintf('-------------------------------------------------------------\n');
fprintf('Semi-major axis of the heliocentric orbit of the spacecraft \n');
fprintf('after fly by = %16.8f km \n' , aHelio);
fprintf('-------------------------------------------------------------\n');
fprintf('Turn angle = %16.8f radians\n' , turnAngle);
fprintf('-------------------------------------------------------------\n');
fprintf('Altitude of the periapsis of Venus = %10.5f km, taken from\n', h0);
fprintf('question 2\n');
fprintf('-------------------------------------------------------------\n');
fprintf('eccententricity of helocentric orbit = %16.8f\n', e);
fprintf('-------------------------------------------------------------\n');
fprintf('Whether or not it is possible for the spacecraft to cross the\n');
fprintf('orbit of Mercury = from using my values for the semi-major axis\n');
fprintf('of the heliocentric orbit as well as its eccentricity, I found\n');
fprintf('that the radius of the perihelion to be %16.8f km.\n', rp);
fprintf('This value is larger than the distance from the sun to Mercury\n');
fprintf('by %16.8f km. Therefore, it will not be possible to \n', difference);
fprintf('cross the orbitof Mercury.');
```