John Clouse IMD HW5 problem 1

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Initialize

```
clearvars -except hw_pub function_list

AU = 1.49597870691e11; %km
GMs = 1.32712440018e20;
GMem = 4.035032351966808e14;

mu = GMem/(GMs+GMem);

x=15e7;
y = 6e3;
z = 1450;

vx = 0.00075;
vy = 0.08;
vz = 0.019;

t = 450;

period = 2*pi*sqrt(AU*AU*AU/GMs);
```

Results

```
fprintf('Position:\n')
fprintf('x = %.5e\n', x/(AU/1e3));
fprintf('y = %.5e\n', y/(AU/1e3));
fprintf('z = %.5e\n', z/(AU/1e3));
fprintf('\nVelocity:\n')
fprintf('Vx = %.5e\n', vx/(AU/1e3)*period/2/pi);
fprintf('Vy = %.5e\n', vy/(AU/1e3)*period/2/pi);
fprintf('Vz = %.5e\n', vz/(AU/1e3)*period/2/pi);
fprintf('\nTime = %.4f\n',t/(period/3600/24)*2*pi);
```

```
Position:
x = 1.00269e+00
y = 4.01075e-05
z = 9.69265e-06

Velocity:
Vx = 2.51807e-05
Vy = 2.68594e-03
```

```
Vz = 6.37912e-04

Time = 7.7409
```

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John Clouse IMD HW5 problem 2

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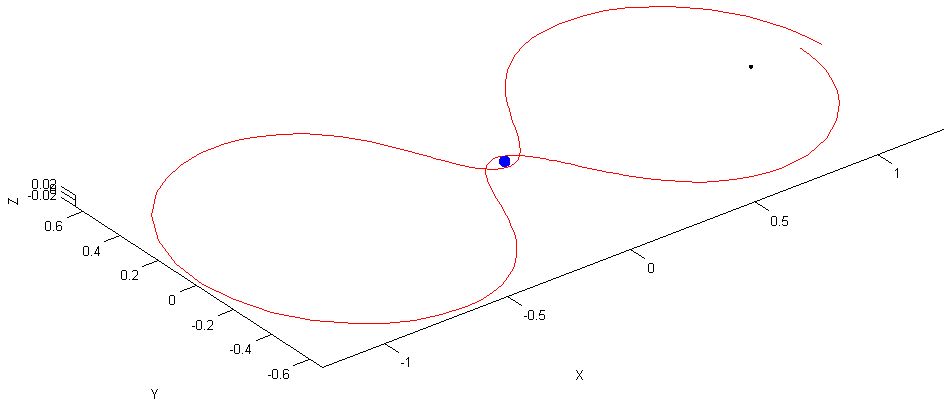
Initialize

```
clearvars -except hw_pub function_list
close all

x0 = 1.2;
x_dot0 = 0;
y0 = 0;
y_dot0 = -1.049657509830343;
X = [x0; y0; 0; x_dot0; y_dot0; 0];

mu = 0.012150585609624;
dunit = 384747.962856037;

T = 6.192169331319632;
```

Integrate and plot

```
[~,X_out] = ode45(@CRTBP, [0,T], X, odeset(),mu);

figure('Position', hw_pub.figPosn)
plot3(X_out(:,1), X_out(:,2), X_out(:,3), 'r')
hold on
axis equal
rad_vec = [0:0.1:2*pi, 2*pi];
my_circ = [cos(rad_vec); zeros(1, length(rad_vec)); sin(rad_vec)]';
for ang = rad_vec
    for blah = 1:length(my_circ)
        new_circ(blah,:) = (Euler2DCM('3', ang)*my_circ(blah,:)')';
    end
    earth =  new_circ * 6378.1/dunit;
    moon =  (new_circ * 1737/dunit);
    plot3(earth(:,1), earth(:,2), earth(:,3))
    plot3(moon(:,1) + 1, moon(:,2), moon(:,3), 'k')
end
xlabel('X'); ylabel('Y'); zlabel('Z');
```



Conclusion

This is not a periodic orbit, since the final position on the XZ plane is not the same as the initial position on the plane. It ends up further from the Moon than it started.

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John Clouse IMD HW5 problem 3

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Initialize

```
clearvars -except hw_pub function_list
close all;
```

Initial conditions

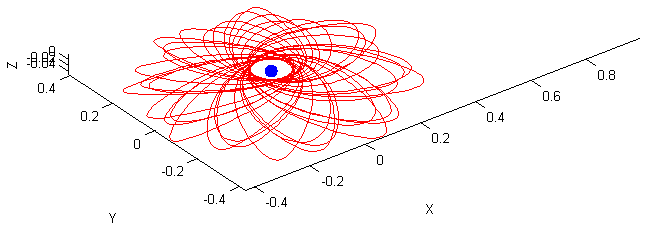
```
IC_set(:,1) = [
    -0.08
-0.03
0.01
3.5
-3.1
-0.1
26];

IC_set(:,2) = [0.05
-0.05
0
4.0
2.6
0
25];

IC_set(:,3) = [0.8300
0
0.114062816271683
0
0.229389507175582
0
15];

IC_set(:,4) = [-0.05
-0.02
0
4.09
-5.27
0
15];

% Constants
```

```
mu = 0.012150585609624;
dunit = 384747.962856037;
```

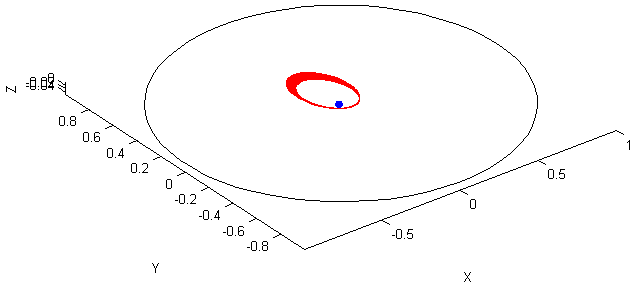
Loop through the conditions

```
for ii = 1:4
    X = IC_set(1:end-1,ii);

    T = 6.192169331319632;

    [T_out,X_out] = ode45(@CRTBP, [0,IC_set(end,ii)], X, odeset(),mu);

    figure('Position', hw_pub.figPosn)
    subplot(2,1,1);
    plot3(X_out(:,1), X_out(:,2), X_out(:,3), 'r')
    hold on
    rad_vec = [0:0.1:2*pi, 2*pi];
    my_circ = [cos(rad_vec); zeros(1, length(rad_vec)); sin(rad_vec)]';
    for ang = rad_vec
        for blah = 1:length(my_circ)
            new_circ(blah,:) = (Euler2DCM('3', ang)*my_circ(blah,:)')';
        end
        earth =  new_circ * 6378.1/dunit;
        moon =  (new_circ * 1737/dunit);
        plot3(earth(:,1) - mu, earth(:,2), earth(:,3))
        plot3(moon(:,1) + 1-mu, moon(:,2), moon(:,3), 'k')
    end
    axis equal; xlabel('X'); ylabel('Y'); zlabel('Z');
    title(['IC ' num2str(ii) ', Rotating Frame'])

    % For the inertial plots
    X_inrt = X_out;
    X_inrt(:,1) = X_inrt(:,1) + mu;
    for jj = 1:length(T_out)
        t = T_out(jj);
        ang = t;
        X_inrt(jj,1:3) = (Euler2DCM('3', -ang)*X_inrt(jj,1:3)')';
    end
    subplot(2,1,2);
    plot3(X_inrt(:,1), X_inrt(:,2), X_inrt(:,3), 'r')
    hold on
    for ang = rad_vec
    for blah = 1:length(my_circ)
        new_circ(blah,:) = (Euler2DCM('3', ang)*my_circ(blah,:)')';
    end
    earth =  new_circ * 6378.1/dunit;
    plot3(earth(:,1) - mu, earth(:,2), earth(:,3))
    end
    plot3(my_circ(:,1), my_circ(:,3), my_circ(:,2), 'k')
    axis equal; xlabel('X'); ylabel('Y'); zlabel('Z');
    title(['IC ' num2str(ii) ', Inertial Frame'])

end
```

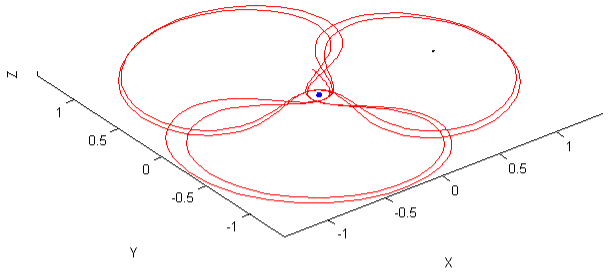
IC 1, Rotating Frame



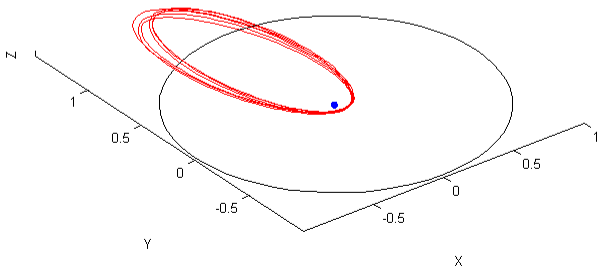
IC 1, Inertial Frame



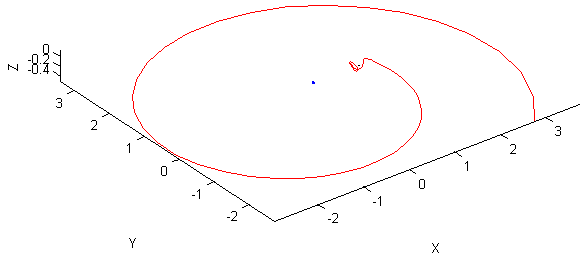
IC 2, Rotating Frame



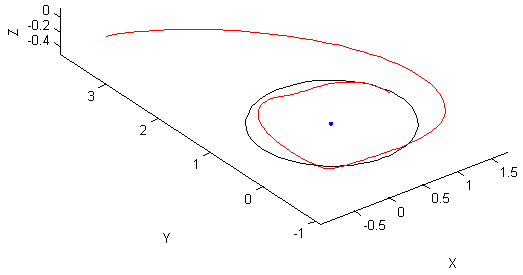
IC 2, Inertial Frame



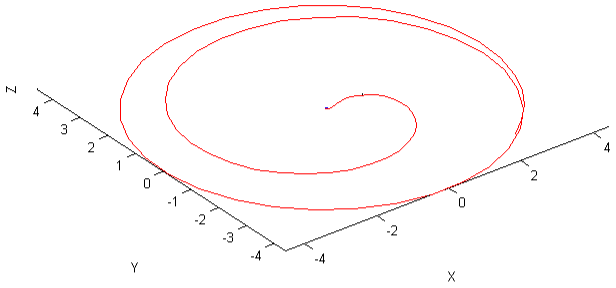
IC 3, Rotating Frame



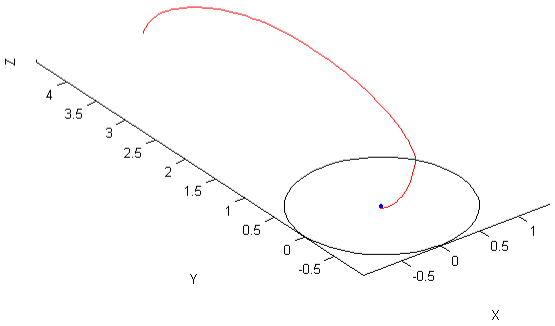
IC 3, Inertial Frame



IC 4, Rotating Frame



IC 4, Inertial Frame



Plot 1 Conclusion

For the first case, a two-body, point-mass propagation would yeild an elliptical (0<e<1) orbit that would follow previous orbit passes exactly, not changing any of the Keplerian orbital elements. The lunar perturbation is evident in the raising of the apogee as time progresses.

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John Clouse IMD HW5 problem 4

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Initialize

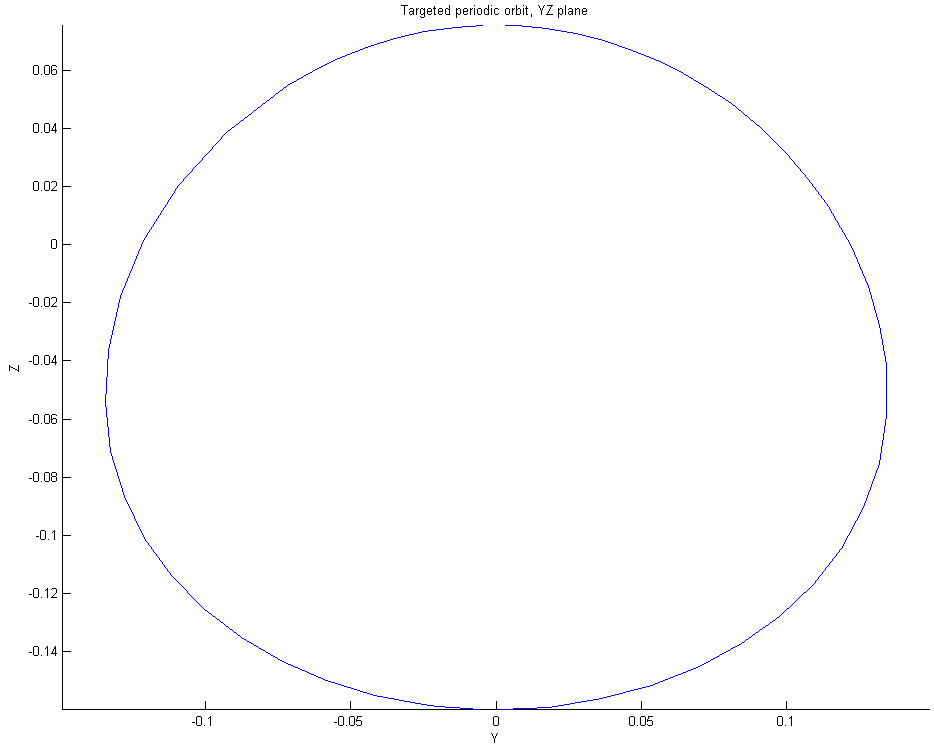
```
clearvars -except hw_pub function_list
close all


X_ini = [
1.142198291366583
0
-0.1599
0
-0.223
0];

% Constants
mu = 0.012150585609624;
dunit = 384747.962856037;
```

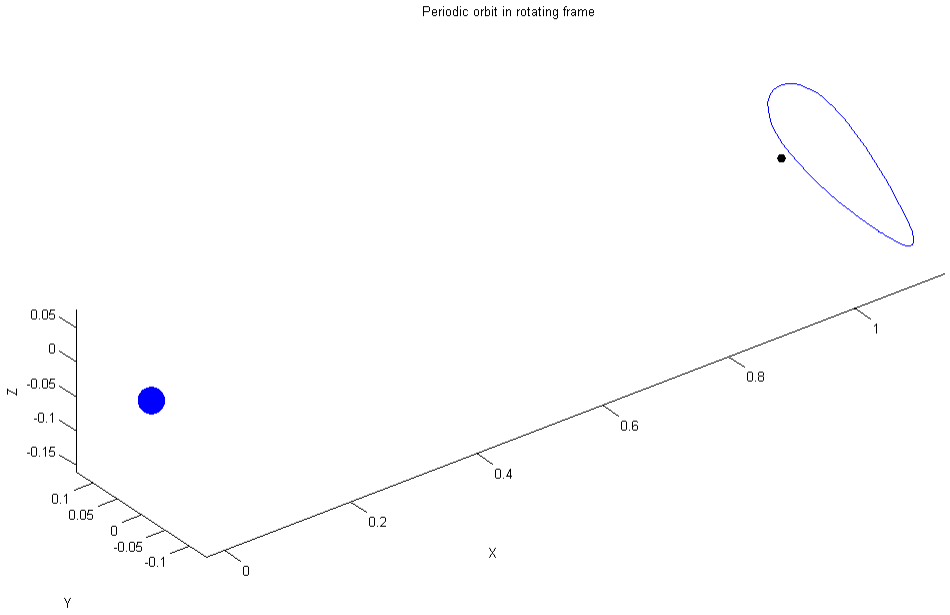
Target a periodic orbit

```
d = [1;1];
tol = 1e-13;
figure('Position', hw_pub.figPosn)
hold on
while abs(d(1)) > tol && abs(d(2)) > tol
    X = [X_ini; reshape(eye(6),36,1)];

    [T_out,X_out] = ode45(@CRTBP_Halo_Target, [0,2*pi], X, ...
        odeset('Events', @y_crossing),mu);

    d = -[X_out(end,4); X_out(end,6)];
    % STM
    STM = reshape(X_out(end,7:end),6,6);
    y_dot = X_out(end,5);
    state_dot = CRTBP(0,X_out(end,1:6)',mu);

    % The correction while holding x constant
    correction = ([STM(4,3) STM(4,5); STM(6,3) STM(6,5)] ...
        - 1/y_dot*[state_dot(4);state_dot(6)]*[STM(2,3) STM(2,5)])\d;
```

```
    X_ini(3) = X_ini(3) + correction(1);
    X_ini(5) = X_ini(5) + correction(2);
    d;
end
[T_out,X_out] = ode45(@CRTBP, [0,T_out(end)*2], X_ini', odeset(),mu);
plot(X_out(:,2), X_out(:,3))
axis equal; xlabel('Y'); ylabel('Z'); title('Targeted periodic orbit, YZ plane')

figure('Position', hw_pub.figPosn)
plot3(X_out(:,1),X_out(:,2),X_out(:,3))
hold on
rad_vec = [0:0.1:2*pi, 2*pi];
my_circ = [cos(rad_vec); zeros(1, length(rad_vec)); sin(rad_vec)]';
for ang = rad_vec
    for blah = 1:length(my_circ)
        new_circ(blah,:) = (Euler2DCM('3', ang)*my_circ(blah,:)')';
    end
    earth =  new_circ * 6378.1/dunit;
    moon =  (new_circ * 1737/dunit);
    plot3(earth(:,1) - mu, earth(:,2), earth(:,3))
    plot3(moon(:,1) + 1-mu, moon(:,2), moon(:,3), 'k')
end
axis equal; xlabel('X'); ylabel('Y'); zlabel('Z');
title('Periodic orbit in rotating frame')
fprintf('Initial Conditions:')
fprintf('\tx0 = %.8f\n',X_ini(1));
fprintf('\ty0 = %.8f\n',X_ini(2));
fprintf('\tz0 = %.8f\n',X_ini(3));
fprintf('\tvx0 = %.8f\n',X_ini(4));
fprintf('\tvy0 = %.8f\n',X_ini(5));
fprintf('\tvz0 = %.8f\n',X_ini(6));
```

```
Initial Conditions: x0 = 1.14219829
 y0 = 0.00000000
 z0 = -0.15999970
 vx0 = 0.00000000
 vy0 = -0.22256065
 vz0 = 0.00000000
```


Targeted periodic orbit, YZ plane
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
Z
-0.1
-0.05
0
0.05
0.1
Y


Periodic orbit in rotating frame
0.05
0
-0.05
-0.1
-0.15
Z
0.1
0.05
0
-0.05
-0.1
Y
0
0.2
0.4
0.6
0.8
1
X

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```
function state_dot = CRTBP(t, state, mu)
fcnPrintQueue(mfilename('fullpath')) % Add this code to code app

x = state(1);
y = state(2);
z = state(3);
xd = state(4);
yd = state(5);
zd = state(6);
r1 = sqrt((x+mu)^2 + y*y + z*z);
r2 = sqrt((x+mu-1)^2 + y*y + z*z);
ax = -(1-mu)*(x+mu)/r1/r1/r1 - mu*(x-1+mu)/r2/r2/r2 +x +2*yd;
ay = -(1-mu)*y/r1/r1/r1 - mu*y/r2/r2/r2 + y - 2*xd;
az = -(1-mu)*z/r1/r1/r1 - mu*z/r2/r2/r2;

state_dot = [xd;yd;zd;ax;ay;az];
```

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```
function state_dot = CRTBP_Halo_Target(t, state, mu)
fcnPrintQueue(mfilename('fullpath')) % Add this code to code app

state_dot = CRTBP(t, state, mu);

x = state(1);
y = state(2);
z = state(3);
xd = state(4);
yd = state(5);
zd = state(6);
r1 = sqrt((x+mu)^2 + y*y + z*z);
r2 = sqrt((x+mu-1)^2 + y*y + z*z);

r1_3 = r1*r1*r1;
r2_3 = r2*r2*r2;
r1_5 = r1_3*r1*r1;
r2_5 = r2_3*r2*r2;

A41 = -(1-mu)/r1_3 + (1-mu)*(x+mu)*3/r1_5*(x+mu) ...
    -mu/r2_3 + mu*(x-1+mu)*3/r2_5*(x+mu-1) + 1;
A42 = (1-mu)*(x+mu)*3/r1_5*y + mu*(x-1+mu)*3/r2_5*y;
A43 = (1-mu)*(x+mu)*3/r1_5*z + mu*(x-1+mu)*3/r2_5*z;

A51 = (1-mu)*y*3/r1_5*(x+mu) + mu*y*3/r2_5*(x+mu-1);
A52 = -(1-mu)/r1_3 + (1-mu)*y*3/r1_5*y -mu/r2_3 + mu*y*3/r2_5*y + 1;
A53 = (1-mu)*y*3/r1_5*z + mu*y*3/r2_5*z;

A61 = (1-mu)*z*3/r1_5*(x+mu) + mu*z*3/r2_5*(x+mu-1);
A62 = (1-mu)*z*3/r1_5*y + mu*z*3/r2_5*y;
A63 = -(1-mu)/r1_3 - mu/r2_3 + (1-mu)*z*z*3/r1_5 + mu*z*z*3/r2_5;

A = [0 0 0 1 0 0;
    0 0 0 0 1 0;
    0 0 0 0 0 1;
    A41 A42 A43 0 2 0;
    A51 A52 A53 -2 0 0;
    A61 A62 A63 0 0 0];

Phi_dot = A*reshape(state(7:end),6,6);

state_dot = [state_dot; reshape(Phi_dot,36,1)];


end
```

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```
function fcnPrintQueue( filename )
global function_list;
if exist('function_list', 'var')
    file_in_list = 0;
    for idx = 1:length(function_list)
        if strcmp(function_list(idx), filename);
            file_in_list = 1;
            break
        end
    end
    if ~file_in_list
        function_list = [function_list, filename];
    end
end
end
```

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