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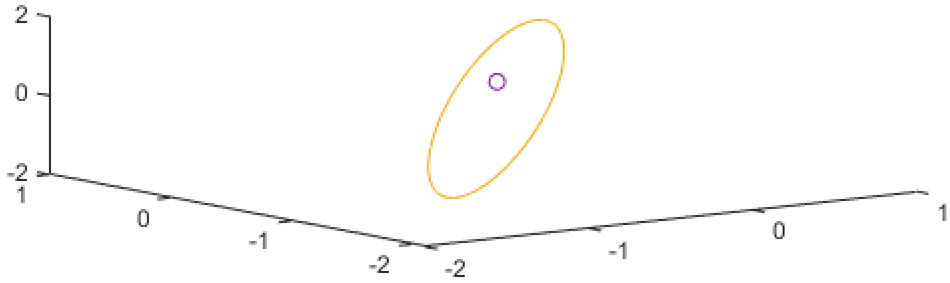
Homework 2 Orbital Brian Trybus

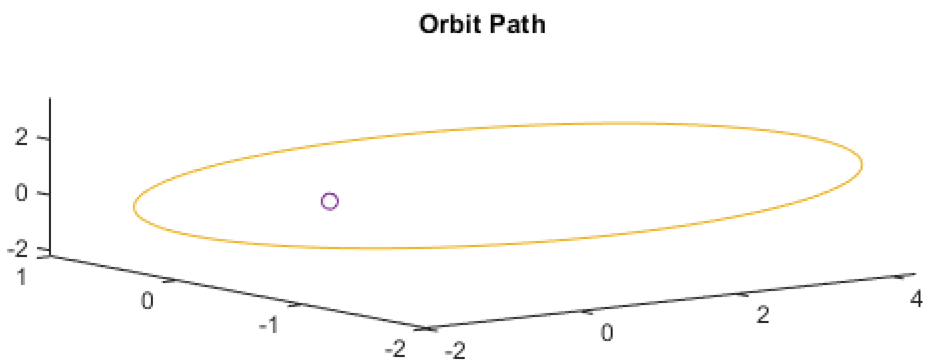
```
clear
```

Problem 2

```
%Part a
mu = 1;

Tspan = [0,17];

r = [-1,-1.8,1]';
r_dot = [0.3,0.3,0.4]';
initail = [r;r_dot];

tol = odeset('Reltol',10^-12,'AbsTol',10^-12);

[t,pos] = ode45(@(time,X)BodyEOM(time,X,mu),Tspan,initail,tol);

%Part b

Tspan = [0,45];

r = [2.4,-.24,-2]';
r_dot = [0.5,-0.2,0.2]';
initail = [r;r_dot];

tol = odeset('Reltol',10^-12,'AbsTol',10^-12);

[t1,pos1] = ode45(@(time,X)BodyEOM(time,X,mu),Tspan,initail,tol);

%Plot
figure(1)
subplot(2,1,1);
plot3(pos(:,1),pos(:,2),pos(:,3));
hold on
scatter3(0,0,0)
subplot(2,1,2);
plot3(pos1(:,1),pos1(:,2),pos1(:,3));
hold on
scatter3(0,0,0)
```

```
title("Orbit Path")
```





Problem 3

```
clear

mu =1;

% part a
r = [3;2;1];
rdot = [-0.2,0.4,0.4]';

opa = VecECI2OP(r,rdot,mu)

%part b
r = [-2.5;-1.7;-2.5];
rdot = [0.3,-0.3,0.4]';

opb = VecECI2OP(r,rdot,mu)

%part c
r = [1.5;1;0.8];
rdot = [-0.5,-0.3,-0.2]';

opc1 = VecECI2OP(r,rdot,mu)
```

```
r = [0.4819;0.2782;0];
rdot = [-0.5392,1.6132,0]';

Cp_n = M3(170*(pi/180))*M1(90*(pi/180))*M3(200*(pi/180));

r = Cp_n'*r;

rdot = Cp_n'*rdot;

opc2 = VecECI2OP(r,rdot,mu)
```

Problem 4

```
%DeltaE, E, and f
    clear
    t = 1e-3;
    %t = 1;
    %t = 5;

    %p/2pi = 1/n -> n = 2pi/p
    n = pi;
    e = (1/3);
    M = n*t;
    error = 1.e-9;
    %...Select a starting value for E:
    if M < pi
        E = M + e/2;
    else
        E = M - e/2;
    end
    %...Iterate on Equation 3.17 until E is determined to within
    %...the error tolerance:
    ratio = 1;
    i = 1;
    while abs(ratio) > error
        ratio = (E - e*sin(E) - M)/(1 - e*cos(E));
        delta(i) = ratio;
        E = E - ratio;
        Earry(i) = E;
        f(i) = 2*atan((sqrt((1+e)/(1-e)))*tan(E/2));
        i = i + 1;
    end
  %Got The buck of this method from textbook appendex d11
```

Problem 5

```
clear

r = [7642;170;2186];
r_dot = [0.32;6.91;4.29];
initail = [r;r_dot];

%Constants
```

```
mu = 3.986*(10^5);

%Part a

Tspan = [0,13000];

tol = odeset('Reltol',10^-9,'AbsTol',10^-9);

[t5,pos5] = ode45(@(time,X)BodyEOM(time,X,mu),Tspan,initail,tol);

    op5 = VecECI2OP(r,r_dot,mu);

    a = op5(1);

    e0 = op5(2);

    Omega = op5(4);

    i = op5(3);

    w = op5(5);

    n = sqrt(mu/(a^3));

    p = a*(1-e0^2);

    Cp_n = (M3(w)*M1(i)*M3(Omega));


for i = 1:length(t5)

    M = n*t5(i);

    E = kepler_E(e0,M);

    f = 2*atan((sqrt((1+e0)/(1-e0)))*tan(E/2));

    R = a*(1-(e0*cos(E)));

    %rp = [a*(cos(E)-e);a*(sqrt(1-(e^2)))*(sin(E));0];

    rp = R*[cos(f);sin(f);0];

    rp_dot = (sqrt(mu/p))*[-sin(f);(e0+cos(f));0];

    rK(i,1:3) = Cp_n*rp;
    rK(i,4:6) = Cp_n*rp_dot;

    h(i,1:3) = (cross(rK(i,1:3),rK(i,4:6)))';
    E(i) = (1/2)*dot(rK(i,4:6),rK(i,4:6)) - (mu/norm(rK(i,1:3)));
    e(i) = norm((1/mu)*(cross(rK(i,4:6),h(i,1:3))-(mu*rK(i,1:3)/
norm(rK(i,1:3)))));
    H(i) = norm(h(i,1:3));
end
```

```
% Now to plot

figure(2)

subplot(2,2,1)

plot3(rK(:,1),rK(:,2),rK(:,3));
hold on
scatter3(0,0,0)
title("Orbit Path")

subplot(2,2,2)

plot(t5,H)
title("Angular Momentum")
xlabel('time[sec]')
ylabel('Angular Momentum[(kgkm^2)/sec]')

subplot(2,2,3)

plot(t5,E)
title("Energy")
xlabel('time[sec]')
ylabel('Energy[kJ/kg]')

subplot(2,2,4)

plot(t5,e)
title("Eccentricity")
xlabel('time[sec]')
ylabel('Eccentricity')

figure(3)

for i = 1:length(t5)
    h(i,1:3) = (cross(pos5(i,1:3),pos5(i,4:6)))';
    E(i) = (1/2)*dot(pos5(i,4:6),pos5(i,4:6)) - mu/norm(pos5(i,1:3));
    e(i) = norm((1/mu)*(cross(pos5(i,4:6),h(i,1:3))-(mu*pos5(i,1:3)/
norm(pos5(i,1:3)))));
    H(i) = norm(h(i,1:3));
end

subplot(2,2,1)

plot3(pos5(:,1),pos5(:,2),pos5(:,3));
hold on
scatter3(0,0,0)
title("Orbit Path")

subplot(2,2,2)
```

```
plot(t5,H)
title("Angular Momentum")
xlabel('time[sec]')
ylabel('Angular Momentum[(kgkm^2)/sec]')

subplot(2,2,3)

plot(t5,E)
title("Energy")
xlabel('time[sec]')
ylabel('Energy[kJ/kg]')

subplot(2,2,4)

plot(t5,e)
title("Eccentricity")
xlabel('time[sec]')
ylabel('Eccentricity')
```

Functions used

```
function op = VecECI2OP(r,rdot,mu)

    h = cross(r,rdot);


    k = [0 0 1]';
    i = atan2(norm(cross(k,h)),dot(k,h));


    n = cross(k,h);
    ihat = [1,0,0]';
    Omega = atan2(norm(cross(ihat,n)),dot(ihat,n));

    e = (1/mu)*(cross(rdot,h)-(mu*(r/norm(r))));

    w = atan2(norm(cross(n,e)),dot(n,e));

    p = (norm(h)^2)/mu;

    a = p/(1-(norm(e)^2));

    f = atan2(norm(cross(e,r)),dot(e,r));

    op = [a norm(e) i Omega w f];
end

function dsdt = BodyEOM(time,state,mu)
%Simple 2 body equations
r = state(1:3);
r_dot = state(4:6);

%mu = 3.986(10^5);
```

```
R = norm(r);

A = (-mu/(R^3))*r;

dsdt = [r_dot; A];


end

function out = M1(a)

     out = [1,0,0;0,cos(a),sin(a);0,-sin(a),cos(a)];

end

function out = M2(b)

     out = [cos(b),0,-sin(b);0,1,0;sin(b),0,cos(b)];

end

function out = M3(c)
%DCM
     out = [cos(c),sin(c),0;-sin(c),cos(c),0;0,0,1];

end

function E = kepler_E(e, M)
% From the TextBook
%{
This function uses Newton’s method to solve Kepler’s
equation E - e*sin(E) = M for the eccentric anomaly,
given the eccentricity and the mean anomaly.
E - eccentric anomaly (radians)
e - eccentricity, passed from the calling program
M - mean anomaly (radians), passed from the calling program
pi - 3.1415926...
User m-functions required: none
%}
% -----------------------------------------------
%...Set an error tolerance:
    error = 1.e-9;
    %...Select a starting value for E:
    if M < pi
        E = M + e/2;
    else
        E = M - e/2;
    end
    %...Iterate on Equation 3.17 until E is determined to within
    %...the error tolerance:
    ratio = 1;
    while abs(ratio) > error
        ratio = (E - e*sin(E) - M)/(1 - e*cos(E));
```

```
        E = E - ratio;
    end

end
```

```
opa =

    5.7299    0.4281    0.7383    0.2783    0.5365    0.9449


opb =

    5.8888    0.6104    0.8560    1.7439    0.6618    1.6662


opc1 =

    1.5772    0.9955    1.1362    0.3805    2.7512    3.0684


opc2 =

    1.4262    0.6300    1.5708    2.7925    2.9672    0.5234
```

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