Contents

Problem 2

```
clear all
clc

y = [4600 3250 3250 -5.537 3.915 3.9154]';

ydot = twobody(0,y);


% Problem 2.1

r0 = [6667.998 -831.435 -1531.486];
v0 = [-1.210185 -7.384715 -1.138699];

y = [r0 v0]';

ydot = twobody(0,y)
```

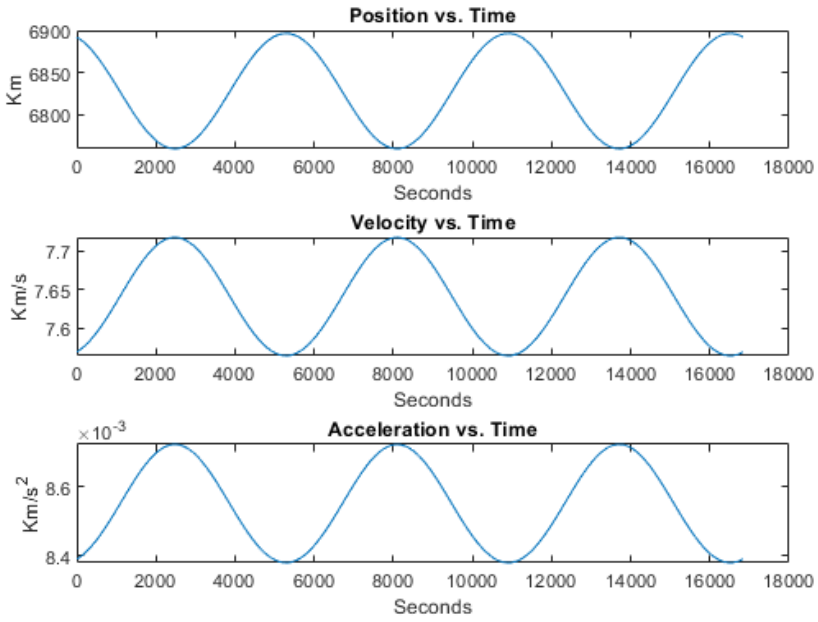
```
ydot =

  -1.210185000000000
  -7.384715000000000
  -1.138699000000000
  -0.008119092417092
   0.001012372469789
   0.001864769061041
```

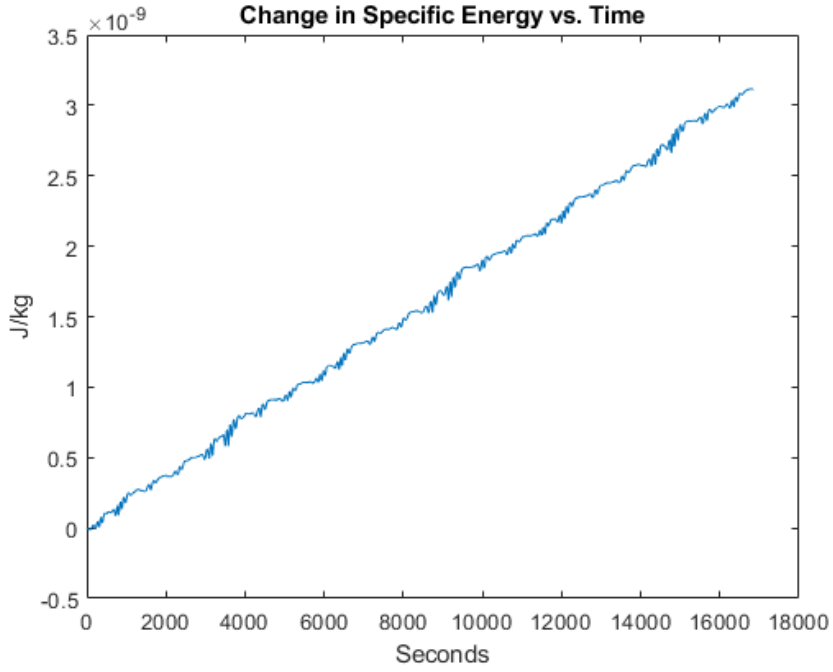
Problem 3

```
r0 = [6667.998 -831.435 -1531.486];
v0 = [-1.210185 -7.384715 -1.138699];
mu = 398600.4415;
[a,emag,i,raan,argp,ta] = rv2oe(r0,v0,mu);

per = 2*pi*sqrt((a^3)/mu);
time = 0:20:(3*per);
odeoptions = odeset('RelTol', 1e-10,'AbsTol',1e-20);


y0 = [r0 v0]';
[T,Y] = ode45(@twobody,time,y0,odeoptions);

% 3.1

rf = Y(length(Y),1:3) % Position Vector after 3 periods
vf = Y(length(Y),4:6) % Velocity Vector after 3 periods

% 3.2

rt = ((Y(:,1).^2)+(Y(:,2).^2)+(Y(:,3).^2)).^0.5;
vt = ((Y(:,4).^2)+(Y(:,5).^2)+(Y(:,6).^2)).^0.5;
at = zeros(length(time),3);
for i = 1:length(time)  % Sorry for this for loop looking a lot like the one in the video. I can't think of a better way to do this.
    inter = twobody(0,Y(i,:)');
    at(i,:) = inter(4:6);
end

at = ((at(:,1).^2)+(at(:,2).^2)+(at(:,3).^2)).^0.5;
```

```
fig = 1;
figure(fig);
subplot(3,1,1)
plot(T,rt)
title('Position vs. Time')
xlabel('Seconds')
ylabel('Km')
hold on

subplot(3,1,2)
plot(T,vt)
title('Velocity vs. Time')
xlabel('Seconds')
ylabel('Km/s')

subplot(3,1,3)
plot(T,at)
title('Acceleration vs. Time')
xlabel('Seconds')
ylabel('Km/s^2')

% 3.3
e0 = (((norm(v0))^2)/2)-(mu/norm(r0));
et = ((vt.^2)./2) - (mu./rt);

deltae = et-e0;

fig = 2;
figure(fig);
plot(T,deltae)
title('Change in Specific Energy vs. Time')
xlabel('Seconds')
ylabel('J/kg')

% As the propogation goes on, the error linearly increases. The error is
% negligible, but it still increases. The error is neglibible because of
% the tolerances put on the odeoptions.
```

```
rf =

   1.0e+03 *

   6.674606093008216  -0.790328889932328  -1.525121121264686


vf =

  -1.164986953962358  -7.390208723221724  -1.149053251032248
```





Problem 4

```
clear all
clc

% The twobodyj2 function was created for this problem

% 4.1
r0 = [6667.998 -831.435 -1531.486];
v0 = [-1.210185 -7.384715 -1.138699];
y = [r0 v0]';

ydot = twobodyj2(0,y)
```

```
ydot =

   -1.210185000000000
```

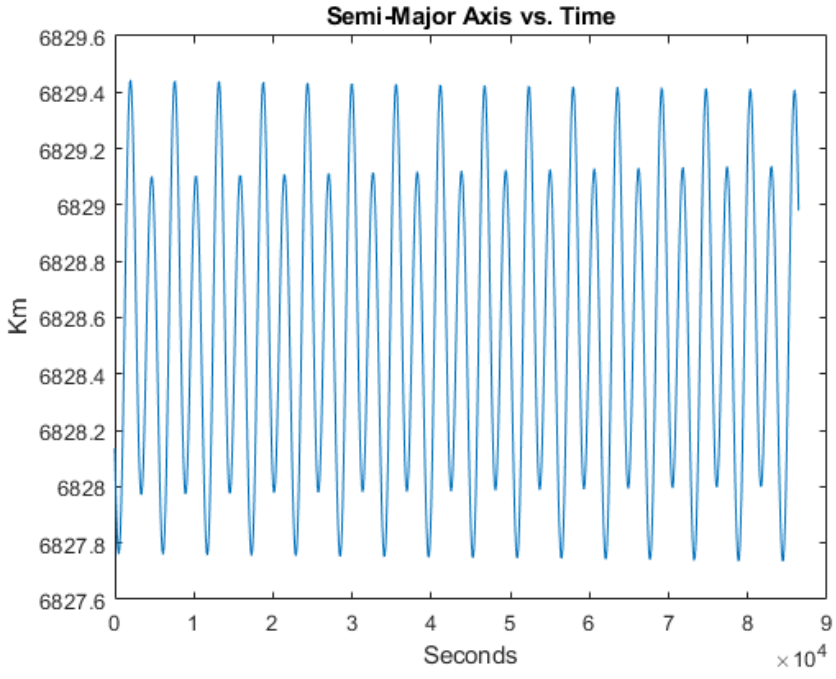
```
   -7.384715000000000
   -1.138699000000000
   -0.008127595529765
    0.001013432725878
    0.001871908477782
```

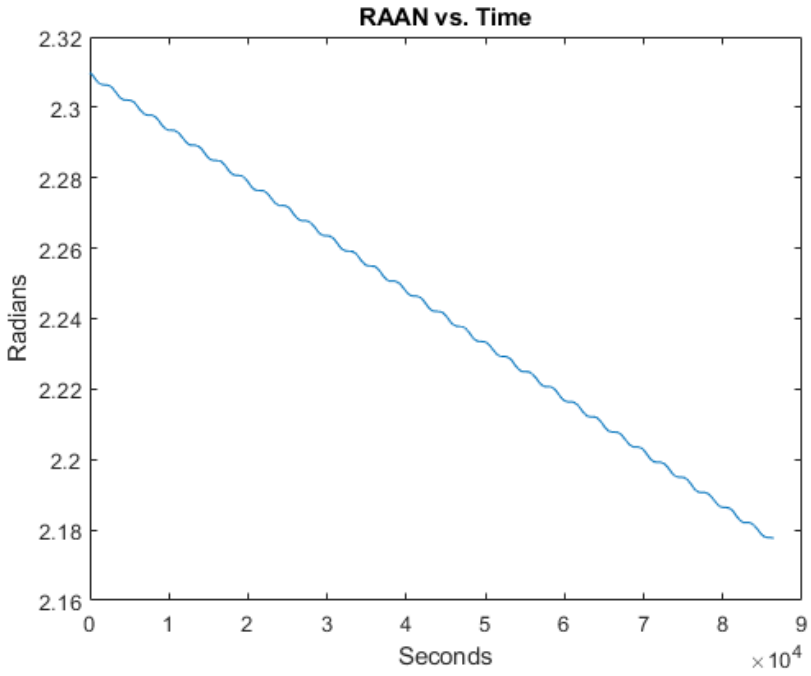
Problem 5

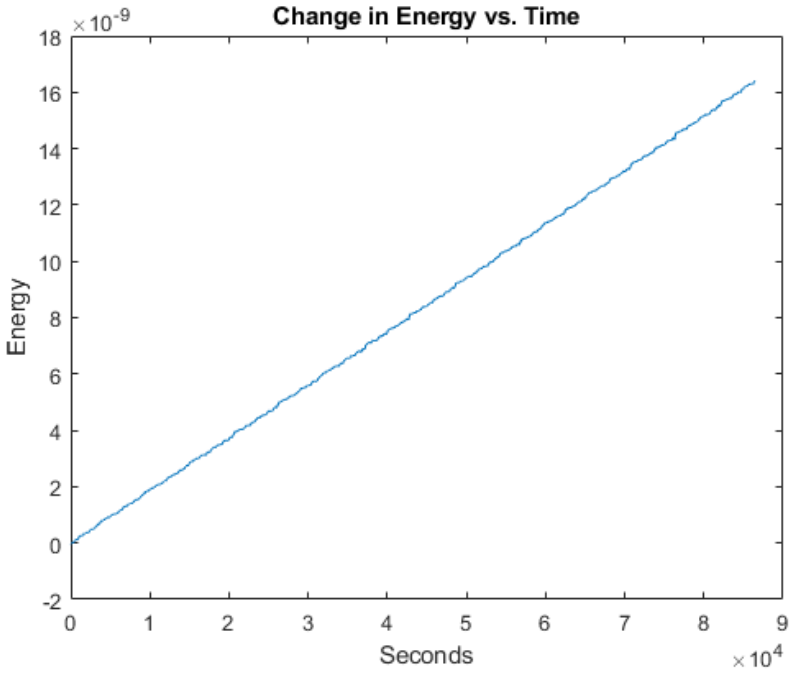
```
clear all
clc

mu = 398600.4415;
time = 0:100:86400;

odeoptions = odeset('RelTol', 1e-10,'AbsTol',1e-20);
r0 = [6667.998 -831.435 -1531.486];
v0 = [-1.210185 -7.384715 -1.138699];
y0 = [r0 v0]';
[T,Y] = ode45(@twobodyj2,time,y0,odeoptions);

% 5.1

rf = Y(length(Y),1:3)
vf = Y(length(Y),4:6)

% 5.2

rt = Y(:,1:3);
vt = Y(:,4:6);
a = zeros(length(rt),1);
for i = 1:length(time)
    a(i) = rv2oe(rt(i,:),vt(i,:),mu);
end

fig = 3;
figure(fig);
plot(time,a)
title('Semi-Major Axis vs. Time')
xlabel('Seconds')
ylabel('Km')

perorbit = 2*pi*sqrt((a(1)^3)/mu);


% The period of the semi-major axis oscillations seems to be about 1-1.5x
% the period of the orbit. The orbit period was calculated using the
% original r and v values.

% 5.3

raan = zeros(length(rt),1);
for i = 1:length(time)
    [a,emag,in,raa,argp,ta] = rv2oe(rt(i,:),vt(i,:),mu);
    raan(i) = raa;
end

fig = 4;
figure(fig);
plot(time,raan)
title('RAAN vs. Time')
xlabel('Seconds')
ylabel('Radians')

% 5.4

j2 = .00108248;
[a,e,in,raa,argp,ta] = rv2oe(r0,v0,mu);
re = 6378.1363000;
nodal = ((-1*1.5*sqrt(mu)*j2*re^2)/(((1-e^2)^2)*a^(7/2)))*cos(in)

% This does not agree with what I saw in the plot. In the plot, the change
% in RAAN was negative over time, but the Nodal Regression calculated was
```

```
% positive.


% 5.5
rkt = Y(:,3);
rt = ((Y(:,1).^2)+(Y(:,2).^2)+(Y(:,3).^2)).^0.5;

U = (mu./rt) - (mu./rt).*(j2/2).*((re./rt).^2).*(3.*((rkt./rt).^2) - 1);
ept = zeros(length(time),1);
for j = 1:length(time)
    ept(j) = dot(vt(j,:),vt(j,:))/2 - U(j);
end
ep0 = dot(vt(1,:),vt(1,:))/2 - U(1);

deltaep = ept - ep0;


fig = 5;
figure(fig);
plot(time,deltaep)
title('Change in Energy vs. Time')
xlabel('Seconds')
ylabel('Energy')

% This plot makes sense as the error throughout the timespan is very small.
% The error goes up linearly throughout the propogation. I expected this
% since the error should propogate throughout the calculations and grow as
% they go on.
```

```
rf =

   1.0e+03 *

  -6.247273024744436  -2.314817188092024   1.064237454897996


vf =

  -2.346382921252279   7.173691198810277   1.680304638217825


nodal =

     1.527258349002443e-06
```


Semi-Major Axis vs. Time
Km
Seconds
$\times 10^4$
6829.6
6829.4
6829.2
6829
6828.8
6828.6
6828.4
6828.2
6828
6827.8
6827.6
0 1 2 3 4 5 6 7 8 9


RAAN vs. Time
Radians
Seconds
$\times 10^4$
2.32
2.3
2.28
2.26
2.24
2.22
2.2
2.18
2.16
0 1 2 3 4 5 6 7 8 9



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