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Problem 3

```
% 1D perturbation
re = 0;
rs = 6600:100:50000;
rsun = 149.6E6;
rm = 384.4E3;

musun = 1.327E11;
mum = 4.902E3;

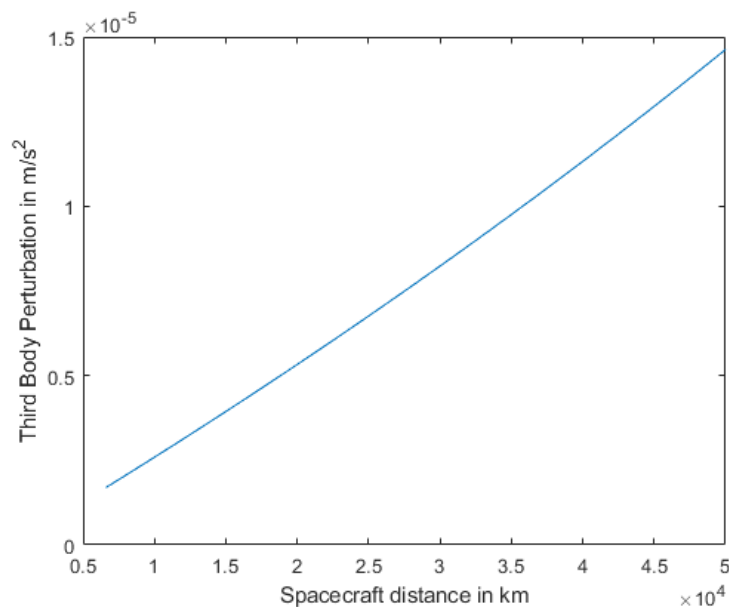
atbsun = musun.*((1./(rsun - rs).^2)-(1/(rsun - re).^2));
atbm = mum.*((1./(rm - rs).^2)-(1/(rm - re).^2));

atbtot = atbsun + atbm; % in km/s^2

atbtot = atbtot*1000; % in m/s^2
figure(1);
plot(rs, atbtot)
% hold on % Here's how I found the moon had a higher effect than the Sun.
% plot(rs, atbm*1000)
% plot(rs,atbsun*1000)
% legend('atbtot','atbm', 'atbsun')
xlabel('Spacecraft distance in km')
ylabel('Third Body Perturbation in m/s^2')

disp('The moon has a stronger perturbation than the sun.');
```

The moon has a stronger perturbation than the sun.



Problem 4

```
% 4.1
jdutc = 2451545.0;
jdut1 = jdutc2jdut1(jdutc, 0);

Tut1 = ((jdut1 - 2451545)/36525);

me1 = 280.460 + 36000.771*Tut1;
```

```

ma = 357.52772333 + 35999.0534*Tut1;

el = mel + 1.914666471*sin(deg2rad(ma)) + 0.019994643*sin(deg2rad(2*ma));

r = 1.000140612 - 0.016708617*cos(deg2rad(ma)) - 0.000139589*cos(2*deg2rad(ma));

obe = 23.439291 - 0.0130042*Tut1;

rtod = [r*cos(deg2rad(el)) r*cos(deg2rad(obe))*sin(deg2rad(el)) r*sin(deg2rad(obe))*sin(deg2rad(el))];

rmod = rtod;

zeta = 206.2181*Tut1 + 0.30188*(Tut1^2) + 0.017998*(Tut1^3); % in arcseconds
theta = 2004.3109*Tut1 - 0.42665*(Tut1^2) - 0.041833*(Tut1^3);
z = 2306.2181*Tut1 + 1.09468*(Tut1^2) + 0.018203*(Tut1^3);

zeta = zeta / 3600;
theta = theta / 3600;
z = z / 3600;

Qtodgcrf = R3(deg2rad(zeta))*R2(deg2rad(-theta))*R3(deg2rad(z));

rgcrf = Qtodgcrf*rmod;

disp('This is the GCRF position of the Sun at 2457793.5 UTC:');
disp(rgcrf);

% 4.2

clear all
clc

jdutc = 2457793.5:0.25:(2457793.5+365.25);
prop = zeros(3,length(jdutc));
for i = 1:length(jdutc)
    prop(1:3,i) = sun(jdutc(i));
end

t = jdutc - 2457793.5;

figure(2);
subplot(3,1,1)
plot(t, prop(1,:))
title('i Component vs. Time')
xlabel('Time (Days)')
ylabel('Distance (AU)')
hold on

subplot(3,1,2)
plot(t, prop(2,:))
title('j Component vs. Time')
xlabel('Time (Days)')
ylabel('Distance (AU)')

subplot(3,1,3)
plot(t, prop(3,:))
title('k Component vs. Time')
xlabel('Time (Days)')
ylabel('Distance (AU)')

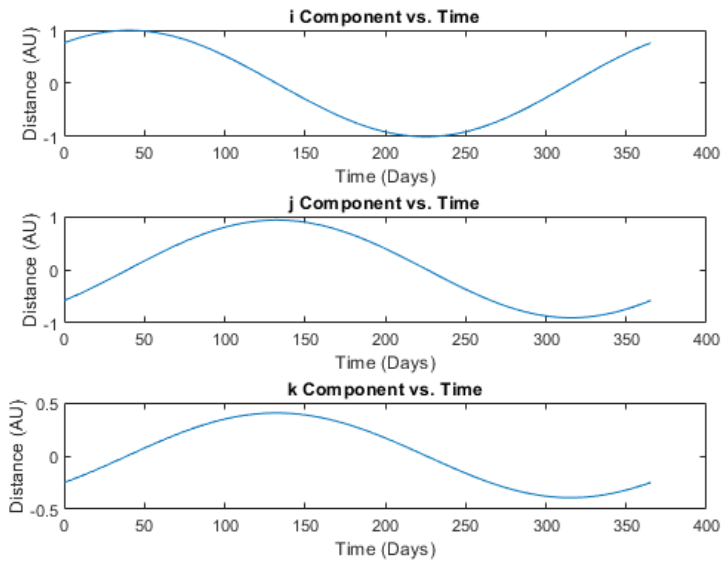
```

This is the GCRF position of the Sun at 2457793.5 UTC:

```

0.1771
-0.8874
-0.3847

```



Problem 5

```
clear all
clc

r = [39066 221558 268116];
v = [-1.19828 0.211289 0];
mu = 398600;
time = 2451545:0.5:(2451545+365.25);
odeoptions = odeset('RelTol', 1e-10, 'AbsTol', 1e-20);
y0 = [r v]';
[T,Y] = ode45(@threebodiesun,time,y0,odeoptions);

r = Y(:,1:3);
v = Y(:,4:6);
for j = 1:length(Y)
    [a(j),emag(j),i(j),raan(j),argp(j),ta(j)] = rv2oe(r(j,:),v(j,:),mu);
end

time = time - 2451545;

figure(3);

subplot(5,1,1)
plot(time, a)
title('Semimajor Axis vs. Time')
xlabel('Time (Days)')
ylabel('a (km)')
hold on

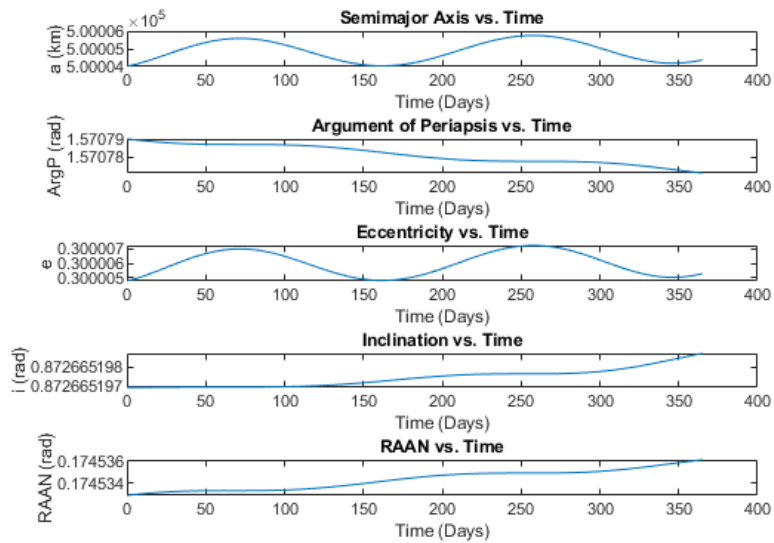
subplot(5,1,2)
plot(time, argp)
title('Argument of Periapsis vs. Time')
xlabel('Time (Days)')
ylabel('ArgP (rad)')

subplot(5,1,3)
plot(time, emag)
title('Eccentricity vs. Time')
xlabel('Time (Days)')
ylabel('e')

subplot(5,1,4)
plot(time, i)
title('Inclination vs. Time')
xlabel('Time (Days)')
ylabel('i (rad)')

subplot(5,1,5)
plot(time, raan)
title('RAAN vs. Time')
```

```
xlabel('Time (Days)')
ylabel('RAAN (rad)')
```



Extra Credit

```
clear all
clc
r = [39066 221558 268116];
v = [-1.19828 0.211289 0];
mu = 398600;
time = 2451545:0.5:(2451545+(15*(365.25)));
odeoptions = odeset('RelTol', 1e-10, 'AbsTol', 1e-20);
y0 = [r v]';
[T,Y] = ode45(@threebodysun,time,y0,odeoptions);

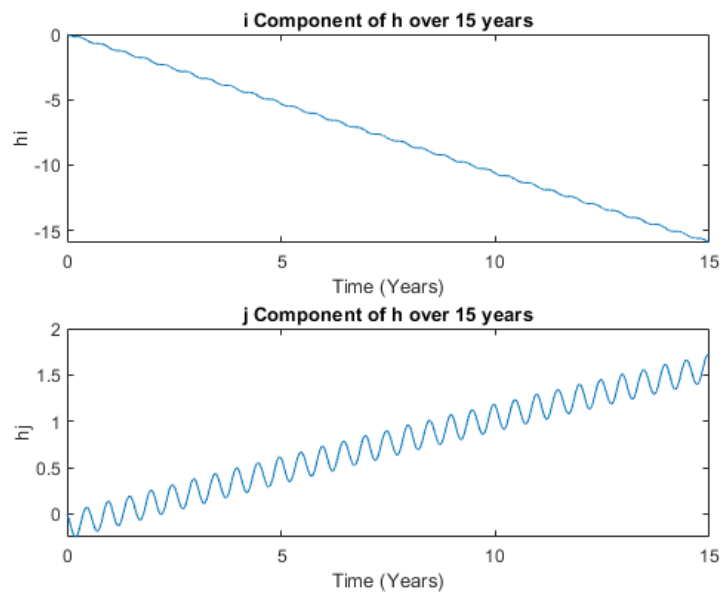
r = Y(:,1:3);
v = Y(:,4:6);

h = cross(r,v);
time = (time - 2451545)/365.25;

figure(4);

subplot(2,1,1)
plot(time,(h(:,1) - h(1,1)))
xlabel('Time (Years)')
ylabel('hi')
title('i Component of h over 15 years')
hold on

subplot(2,1,2)
plot(time,(h(:,2) - h(1,2)))
xlabel('Time (Years)')
ylabel('hj')
title('j Component of h over 15 years')
```



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