Homework 2 Code

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CJL3282

QUESTION 3:

```
clear
clc


rEarthMoonmag = 384.4 * 10^3;
muMoon = 4.902 * 10^3;
rEarthSunmag = 149.6 * 10^6;
muSun = 1.327 * 10^11;
positionvec = 6600:10:50000;
num = size(positionvec);
num = num(2);
accMoonTB = zeros(num, 1);
accSunTB = zeros(num, 1);

for j = 1: num
   rSatMoonStarvec = rEarthMoonmag - positionvec(j);
   accMoonTB(j) = muMoon * ( (1 / rSatMoonStarvec^2) - (1 / rEarthMoonmag^2) )* 1000;

   rSatSunStarvec = rEarthSunmag - positionvec(j);
   accSunTB(j) = muSun * ( (1 / rSatSunStarvec^2) - (1 / rEarthSunmag^2) )* 1000;
end

figure(9)
plot(positionvec, accMoonTB)
hold on
plot(positionvec, accSunTB)

xlabel('Satellite Position in km')
ylabel('Third Body acceleration in m/s^2')
title('Analysis of the Moon and Sun Third Body Perturbations')
legend('Moon Third Body', 'Sun Third Body')
```

Question 4:

```
clear
```

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clc

rch = [26493118 -132755488 -57556547];
rch(1) = rch(1) * 6.6845871226706e-9;
rch(2) = rch(2) * 6.6845871226706e-9;
rch(3) = rch(3) * 6.6845871226706e-9;
jdUTC = 2451545.0;
finJDUTC = 2457793.5;
differenceJD = finJDUTC - jdUTC;

%Part a
TUT1  = Tut1( jdUTC );
lmsun = 280.460 + 36000.771 * TUT1;
TTDB = TUT1;

Msun = 357.52772333 + 35999.0534 * TTDB;

Msun = dR(Msun);

lecl = lmsun + 1.914666471 * sin(Msun) + 0.019994643 * sin(2 * Msun);
lecl = dR(lecl);

rsunmag = 1.000140612 - 0.016708617* cos(Msun) - 0.000139589 * cos(2 * Msun);

epsilon = 23.439291 - 0.0130042 * TTDB;
epsilon = dR(epsilon);
rsunvec = [0 0 0];
rsunvec(1) = rsunmag * cos(lecl);
rsunvec(2) = rsunmag * cos(epsilon) * sin(lecl);
rsunvec(3) = rsunmag * sin(epsilon) * sin(lecl);
rsunvecMOD = rsunvec;

rsunvecGCRF = RofSun( finJDUTC )
rsuntest = RofSun(2451545);
rsuntest = 149597870 * rsuntest;

%Part b
J2000 = 2451545.0;
starttimeUTC = 2457793.5;
starttimeUTC = starttimeUTC - J2000;
for j = 1:365
   time(1) = starttimeUTC;
   time(j + 1) = starttimeUTC + j;
end

for k = 1:366
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    sunovertime(k, :) = RofSun(time(k));
end


deltaalphanot = 0.0146;
deltaalphanot = deltaalphanot * pi() / 648000;;
squiggle = -0.16617;
squiggle = squiggle * pi() / 648000;;
nnot = -0.0068192;
nnot = nnot * pi() / 648000;;
r1 = R3(-deltaalphanot);
r2 = R2(-squiggle);
r3 = R1(nnot);
Q = r1 * r2 * r3;
sunJ = Q * sunovertime';
sunJ = sunJ';
figure(1)
subplot(3,1,1)
plot(time, sunovertime(:, 1))
title('X-Axis Position of the Sun')
xlabel('Days since J2000')
ylabel('Distance from Earth, AU')
ylim([-1 1.1])
subplot(3,1,2)
plot(time, sunovertime(:, 2))
title('Y-Axis Position of the Sun')
xlabel('Days since J2000')
ylabel('Distance from Earth, AU')
subplot(3,1,3)
plot(time, sunovertime(:, 3))
title('Z-Axis Position of the Sun')
xlabel('Days since J2000')
ylabel('Distance from Earth, AU')
```

Question 5:

```
clear
clc

rvector = [39066, 221558, 268116];
vvector = [-1.19828, 0.211289, 0];
rvmatrix = [rvector,vvector];
muEarth = 398600;
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```
muSun = 1.327e11;

starttime = 2451545.0;
endtime = starttime+365;

startingsecond= 0;
totalseconds = 365 * 86400;

time = startingsecond:(0.5 * 86400):totalseconds;

[T,Y] = cartEarthSunSatODE(rvmatrix, time, muEarth, muSun );

num = length(T);

for jj = 1:num
   rv(jj,:) = Y(jj, :);
   elements(jj, :) = CartesiantoElements(rv(jj, :), muEarth);
end

figure(3)

subplot(3,2,1)
plot(T, rv(:, 1))
title('Position, X')
xlabel('Seconds since J2000')
subplot(3,2,2)
plot(T, rv(:, 2))
title('Position, Y')
xlabel('Seconds since J2000')
subplot(3,2,3)
plot(T, rv(:,3))
title('Position, Z')
xlabel('Seconds since J2000')
subplot(3,2,4)
plot(T, rv(:,4))
title('Velocity, X')
xlabel('Seconds since J2000')
subplot(3,2,5)
plot(T, rv(:, 5))
title('Velocity, Y')
xlabel('Seconds since J2000')
subplot(3,2,6)
plot(T, rv(:, 6))
title('Velocity, Z')
xlabel('Seconds since J2000')
```

```
a = elements(:, 1);
e = elements(:, 2);
i = elements(:, 3);
Omega = elements(:, 4);
w = elements(:, 5);
nu = elements(:, 6);

figure(2)
subplot(3,2,1)
plot(T, a)
title('Semimajor Axis')
xlabel('Seconds since J2000')
ylabel('Kilometers')
xlim([0 3.3e7])
subplot(3,2,2)
plot(T, e)
title('Eccentricity')
xlabel('Seconds since J2000')
xlim([0 3.3e7])
ylim([.125 .325])
subplot(3,2,3)
plot(T, i)
title('Inclination')
xlabel('Seconds since J2000')
ylabel('Degrees')
xlim([0 3.3e7])

subplot(3,2,4)
plot(T, Omega)
title('Right Ascension of Ascending Node')
xlabel('Seconds since J2000')
ylabel('Degrees')
xlim([0 3.3e7])
subplot(3,2,5)
plot(T, w)
title('Angle of Periapsis')
xlabel('Seconds since J2000')
ylabel('Degrees')
xlim([0 3.3e7])
subplot(3,2,6)
plot(T, nu)
title('True Anomaly')
xlabel('Seconds since J2000')
ylabel('Degrees')
xlim([0 3.3e7])
```

FUNCTIONS:

```
function [T, Y] = cartEarthSunSatODE( rv, time, muEarth, muSun )

odeoptions = odeset('RelTol',1e-10,'AbsTol',1e-20);

[T,Y] = ode45( @(t,y) dy3(t, y, muEarth, muSun), time, rv, odeoptions);

function dy = dy3(t,y, muEarth, muSun)
    startTime = 2451545.0;

    JD = startTime + t/86400 - 32/86400;
    rSun = RofSun(JD);
    rSun = 149597870 * rSun;

    rSatSun = rSun - y(1:3);
    MagSatSun = norm(rSatSun);
    rEarthSun = rSun;
    MagEarthSun = norm(rEarthSun);
    y1to3 = norm(y(1:3));
    a4 = (-muEarth * y(1) / (y1to3)^3) + muSun * ((rSatSun(1)/(MagSatSun)^3) -
(rEarthSun(1)/(MagEarthSun)^3));
    a5 = (-muEarth * y(2) / (y1to3)^3) + muSun * ((rSatSun(2)/(MagSatSun)^3) -
(rEarthSun(2)/(MagEarthSun)^3));
    a6 = (-muEarth * y(3) / (y1to3)^3) + muSun * ((rSatSun(3)/(MagSatSun)^3) -
(rEarthSun(3)/(MagEarthSun)^3));
    dy = [y(4); y(5); y(6); a4; a5; a6];

end

end


function [rsunvecGC] = RofSun( jdUTC )
TUT1  = Tut1( jdUTC );
lmsun = 280.460 + 36000.771 * TUT1;
TTDB = TUT1;

Msun = 357.52772333 + 35999.0534 * TTDB;
Msun = dR(Msun);

lecl = lmsun + 1.914666471 * sin(Msun) + 0.019994643 * sin(2 * Msun);
lecl = dR(lecl);

rsunmag = 1.000140612 - 0.016708617* cos(Msun) - 0.000139589 * cos(2 * Msun);
```

```
epsilon = 23.439291 - 0.0130042 * TTDB;
epsilon = dR(epsilon);
rsunvec = [0 0 0];
rsunvec(1) = rsunmag * cos(lecl);
rsunvec(2) = rsunmag * cos(epsilon) * sin(lecl);
rsunvec(3) = rsunmag * sin(epsilon) * sin(lecl);
rsunvecMOD = rsunvec;
rsunvecGC = modGCRF( jdUTC, rsunvec );

end

function [ rGCRF ] = modGCRF( UTC, mod )
TT = UTC + (69 / 86400);
TTT = Ttt(TT);
zeta = 2306.2181*TTT + 0.30188*TTT^2 + 0.017998*TTT^3;
theta = 2004.3109*TTT - 0.42665*TTT^2 - 0.041833*TTT^3;
z = 2306.2181*TTT + 1.09468*TTT^2 + 0.018203*TTT^3;
zeta = zeta * pi() / 648000;
theta = theta * pi() / 648000;
z = z * pi() / 648000;
GCRF1 = R3(zeta);
GCRF2 = R2(-theta);
GCRF3 = R3(z);
matrixGCRF =  GCRF1 * GCRF2 * GCRF3;
rGCRF = matrixGCRF * mod';

end

function [elements] = CartesiantoElements(rv, mu)
i = [1 0 0]; j = [0 1 0]; k = [0 0 1];
rvec = [rv(1) rv(2) rv(3)];
rmag = norm(rvec);
vvec = [rv(4) rv(5) rv(6)];
vmag = norm(vvec);
hvec = cross(rvec, vvec);
hmag = norm(hvec);
nvec = cross(k, hvec);
nmag = norm(nvec);
evec = ( (vmag^2 - mu/rmag)*rvec - (dot(rvec,vvec))*vvec) / mu;
emag = norm(evec);
energy = (vmag^2 / 2) - (mu / rmag);
a = -mu / (2 * energy);
p = a * (1 - emag^2);
i = acos(hvec(3) / hmag);
i = rD(i);
Omega = acos(nvec(1) / nmag);
```

```
Omega = rD(Omega);
if nvec(2) < 0
    Omega = 360 - Omega;
end
omega = acos( dot(nvec, evec) / (nmag * emag));
omega = rD(omega);
if evec(3) < 0
    omega = 360 - omega;
end
nu = acos( dot(evec, rvec) / (emag * rmag));
nu = rD(nu);
if dot(rvec, vvec) < 0
    nu = 360 - nu;
end
elements = [a emag i Omega omega nu];

end
```