REPORT

Homework I

Attitude Determination and Control

UZB421E - 21265

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n = 48

Simulation of The Low Earth Orbit Satellite's Attitude Dynamics

I will explain the required information in the code.

```
n=48;               %Student Number
Worbit=0.0011;      %The angular orbit velocity of satellite
Nt=3.6*10^-10;      %The disturbance torque acting on the satellite
N=54000;            %The iteration number
dt=0.1;             %The sample time
t(1)=0;             %Initial Time

%The moments of inertia of the satellite
Jx=2.1*10^-3;
Jy=2*10^-3;
Jz=1.9*10^-3;

%Initial data of the attitude angles (rad)
q1(1)=0.002*n;
q2(1)=0.001*n;
q3(1)=0.005*n;
q4(1)=sqrt(1-q1(1)^2-q2(1)^2-q3(1)^2);

%The initial data of the satellite's angular velocities
Wx(1)=0.0002+0.0001*n;
Wy(1)=0.0003+0.0001*n;
Wz(1)=0.0004+0.0001*n;


C=cell(N,1);    %cell contains all transformation matrices C
```

So far, I have converted the given values in the homework into code.

```
for i=1:N  %for loop to perform iteration

    %Time Increase of 0.1 s per Iteration
    t(i+1)=t(i)+dt;
```

$$\omega_{x_{i+1}} = \omega_{x_i} + \frac{\Delta t}{J_x}\left(J_y - J_z\right)\omega_{z_i}\omega_{y_i} + \frac{\Delta t}{J_x}N_T$$

$$\omega_{y_{i+1}} = \omega_{y_i} + \frac{\Delta t}{J_y}\left(J_z - J_x\right)\omega_{x_i}\omega_{z_i} + \frac{\Delta t}{J_y}N_T$$

$$\omega_{z_{i+1}} = \omega_{z_i} + \frac{\Delta t}{J_z}\left(J_x - J_y\right)\omega_{x_i}\omega_{y_i} + \frac{\Delta t}{J_z}N_T$$

```
%The Angular Velocities Iteration
Wx(i+1)=Wx(i)+(dt/Jx)*(Wz(i)*Wy(i)+Nt)*(Jy-Jz);
Wy(i+1)=Wy(i)+(dt/Jy)*(Wx(i)*Wz(i)+Nt)*(Jz-Jx);
Wz(i+1)=Wz(i)+(dt/Jz)*(Wx(i)*Wy(i)+Nt)*(Jx-Jy);
```

$$q_{1_{i+1}} = q_{1_i} - 0.5\Delta t\left(q_{2_i}\omega_{x_i} + q_{3_i}\omega_{y_i} + q_{4_i}\omega_{z_i}\right)$$

$$q_{2_{i+1}} = q_{2_i} + 0.5\Delta t\left(q_{1_i}\omega_{x_i} - q_{4_i}\omega_{y_i} + q_{3_i}\omega_{z_i}\right)$$

$$q_{3_{i+1}} = q_{3_i} + 0.5\Delta t\left(q_{4_i}\omega_{x_i} + q_{1_i}\omega_{y_i} - q_{2_i}\omega_{z_i}\right)$$

$$q_{4_{i+1}} = q_{4_i} - 0.5\Delta t\left(q_{3_i}\omega_{x_i} - q_{2_i}\omega_{y_i} - q_{1_i}\omega_{z_i}\right)$$

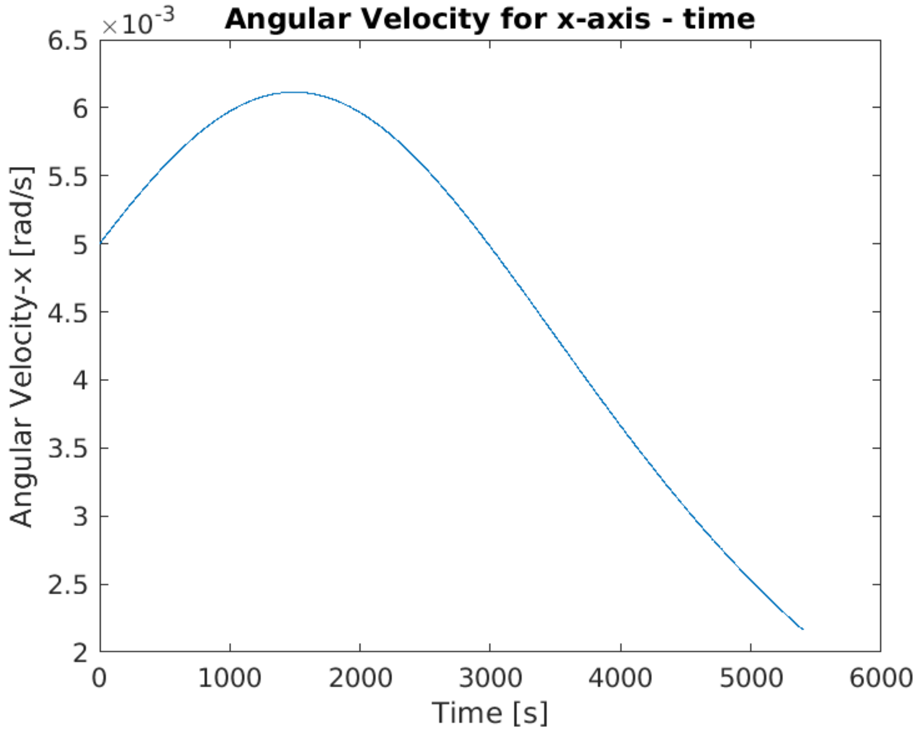
```
%The Quaternions
q1(i+1)=q1(i)-0.5*dt*(q2(i)*Wx(i)+q3(i)*Wy(i)+q4(i)*Wz(i));
q2(i+1)=q2(i)+0.5*dt*(q1(i)*Wx(i)-q4(i)*Wy(i)+q3(i)*Wz(i));
q3(i+1)=q3(i)+0.5*dt*(q4(i)*Wx(i)+q1(i)*Wy(i)-q2(i)*Wz(i));
q4(i+1)=q4(i)-0.5*dt*(q3(i)*Wx(i)-q2(i)*Wy(i)-q1(i)*Wz(i));
```

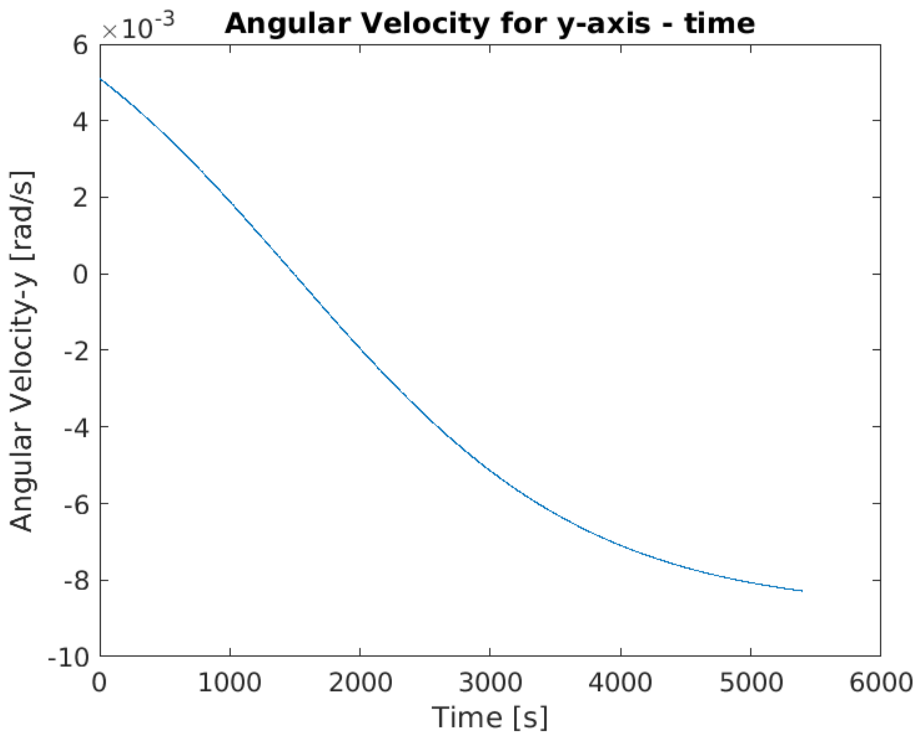
$$C = \begin{bmatrix} q_1^2 - q_2^2 - q_3^2 + q_4^2 & 2\left(q_1q_2 + q_3q_4\right) & 2\left(q_1q_3 - q_2q_4\right) \\ 2\left(q_1q_2 - q_3q_4\right) & -q_1^2 + q_2^2 - q_3^2 + q_4^2 & 2\left(q_2q_3 - q_1q_4\right) \\ 2\left(q_1q_3 + q_2q_4\right) & 2\left(q_2q_3 - q_1q_4\right) & -q_1^2 - q_2^2 + q_3^2 + q_4^2 \end{bmatrix}$$

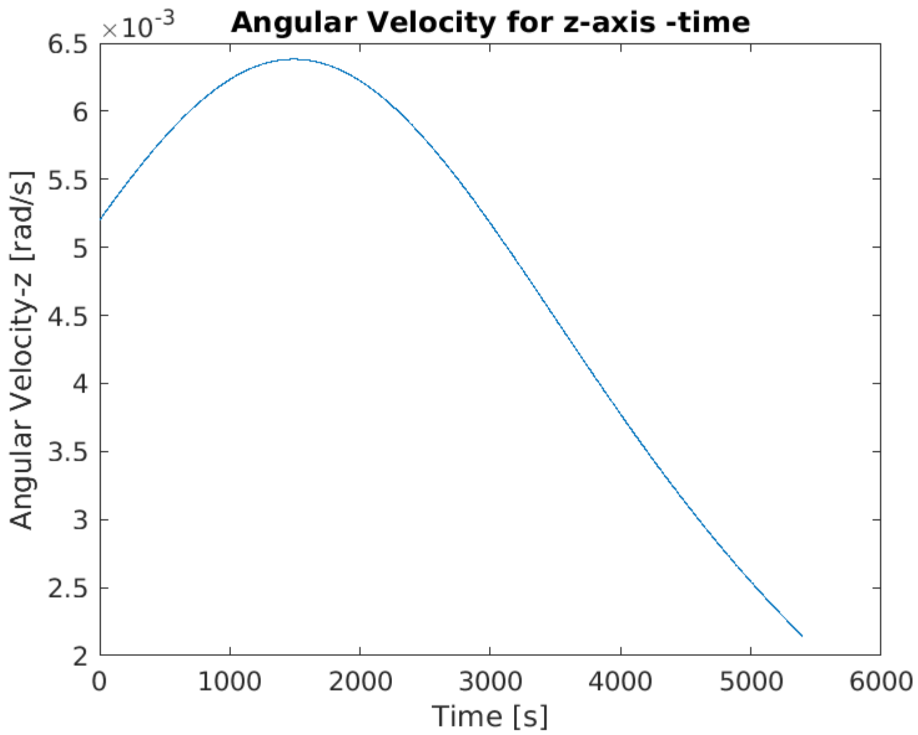
```
%The Transformation Matrix
c11(i)=q1(i)^2-q2(i)^2-q3(i)^2+q4(i)^4;
c12(i)=2*(q1(i)*q2(i)+q3(i)*q4(i));
c13(i)=2*(q1(i)*q3(i)-q2(i)*q4(i));
c21(i)=2*(q1(i)*q2(i)-q3(i)*q4(i));
c22(i)=-q1(i)^2+q2(i)^2-q3(i)^3+q4(i)^2;
c23(i)=2*(q2(i)*q3(i)-q1(i)*q4(i));
c31(i)=2*(q1(i)*q3(i)+q2(i)*q4(i));
c32(i)=2*(q2(i)*q3(i)-q1(i)*q4(i));
c33(i)=-q1(i)^2-q2(i)^2+q3(i)^2+q4(i)^2;

C{i}=[c11(i),c12(i),c13(i);c21(i),c22(i),c23(i);c31(i),c32(i),c33(i)
];

End
```

```matlab
%Angular Velocities Graphs
figure
plot(t,Wx);
title('Angular Velocity for x-axis - time')
xlabel('Time [s]')
ylabel('Angular Velocity-x [rad/s]')

figure
plot(t,Wy);
title('Angular Velocity for y-axis - time')
xlabel('Time [s]')
ylabel('Angular Velocity-y [rad/s]')

figure
plot(t,Wz);
title('Angular Velocity for z-axis -time')
xlabel('Time [s]')
ylabel('Angular Velocity-z [rad/s]')

%Quaternion Graphs
figure
plot(t,q1);
title('1. Quaternion (q1) - time')
xlabel('Time [s]')
ylabel('1. Quaternion')

figure
plot(t,q2);
title('2. Quaternion (q2) - time')
xlabel('Time [s]')
ylabel('2. Quaternion')

figure
plot(t,q3);
title('3. Quaternion (q3) - time')
xlabel('Time [s]')
ylabel('3. Quaternion')

figure
plot(t,q4);
title('4. Quaternion (q4) - time')
xlabel('Time [s]')
ylabel('4. Quaternion')
```

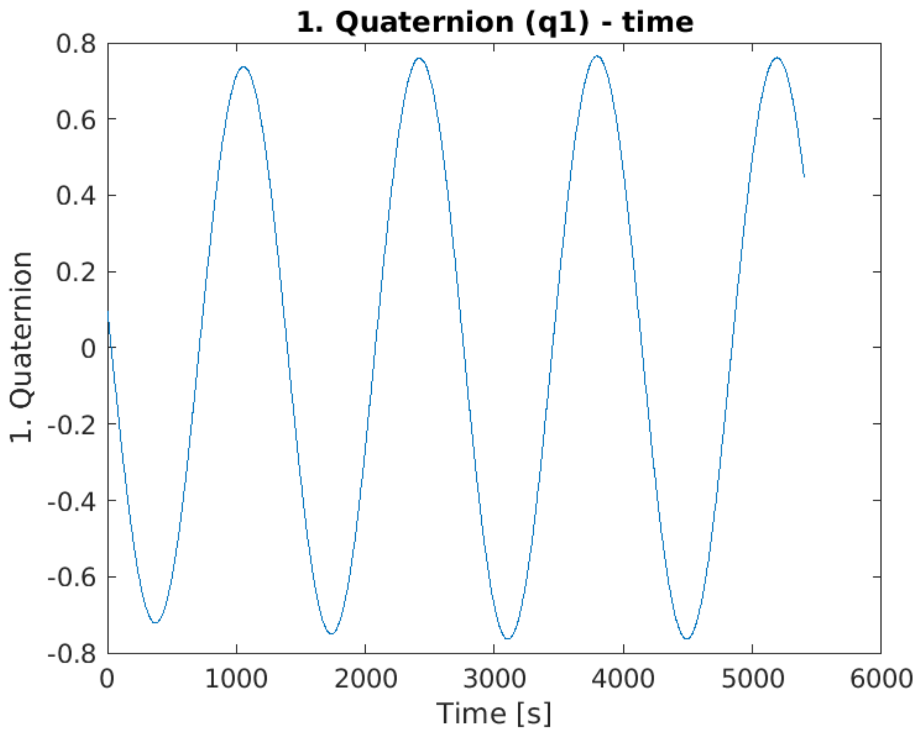
Graphs of Angular Velocities for x, y, z axes

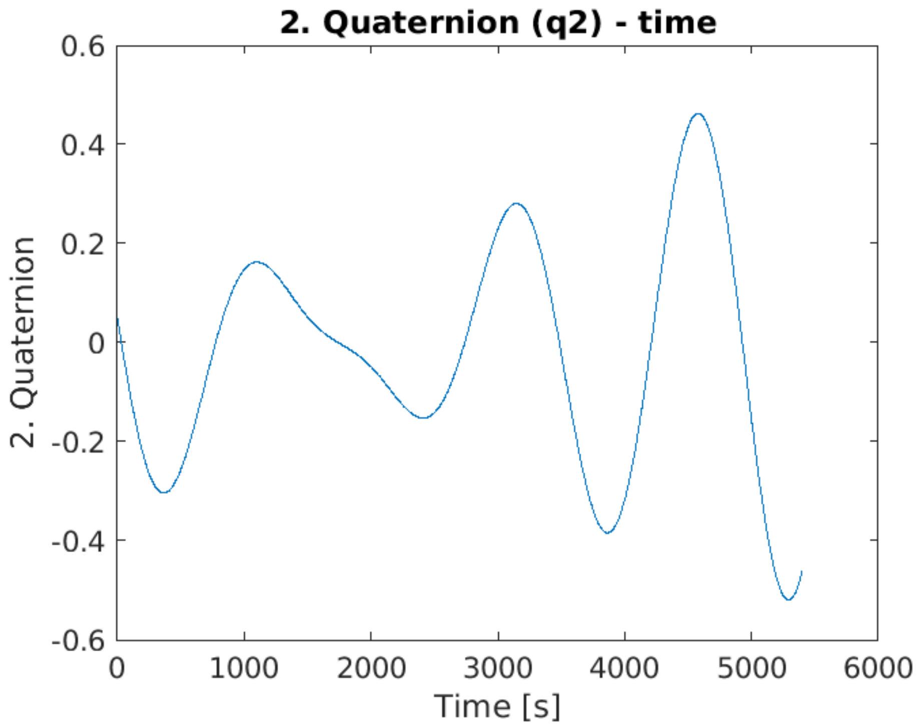


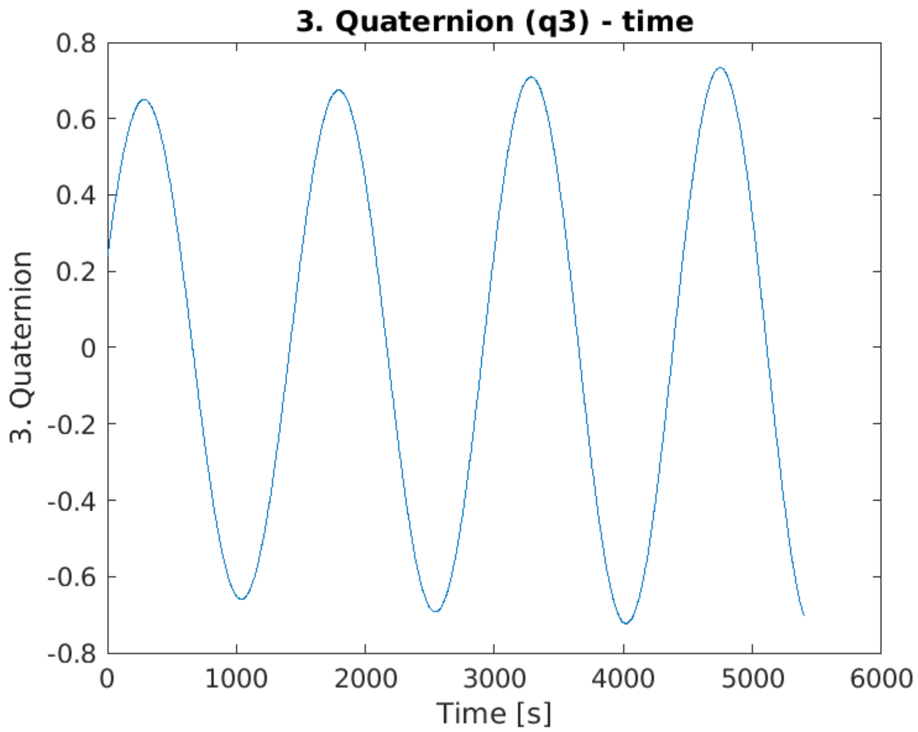


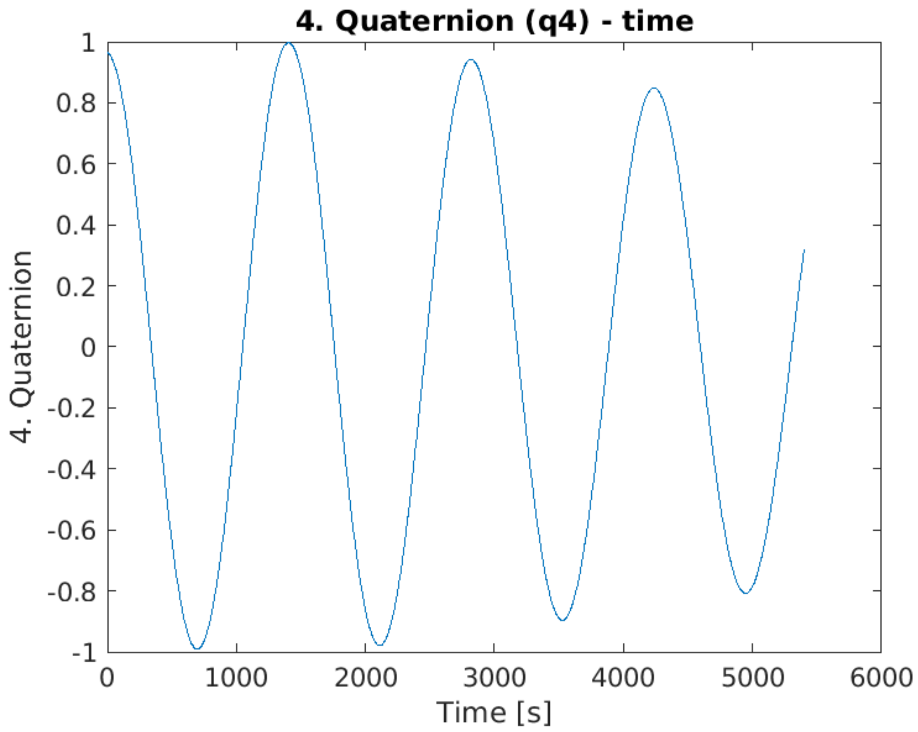


Graphs of Quaternions




2. Quaternion (q2) - time
2. Quaternion
Time [s]
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
0
1000
2000
3000
4000
5000
6000


3. Quaternion (q3) - time
3. Quaternion
Time [s]
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
1000
2000
3000
4000
5000
6000


4. Quaternion (q4) - time
4. Quaternion
Time [s]
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
1000
2000
3000
4000
5000
6000