AE3521
Spring 2004 Homework #8
Due: Monday March 22, 2004 at 9:30am (beginning of class) or before

1. Consider the torque-free rotational motion of the space shuttle orbiter that has lost attitude control. An inertia matrix is given for principal body axis in Wiesel p. 163 (axes illustrated in Figure 5.23 on the same page) as

$$I^b = \begin{bmatrix} 1.29 & 0 & 0 \\ 0 & 9.68 & 0 \\ 0 & 0 & 10.1 \end{bmatrix} \times 10^6 kg - m^2$$

Assuming torque-free, we have $0 = I^b \dot{\omega}^{bi} + \tilde{\omega}^{bi}\left(I^b \omega^{bi}\right)$. Therefore body rotational dynamics can be described by:

$$\dot{\omega}_1 = -\frac{I_z - I_y}{I_x}\omega_2\omega_3,\ \dot{\omega}_2 = -\frac{I_x - I_z}{I_y}\omega_3\omega_1,\ \text{and}\ \dot{\omega}_3 = -\frac{I_y - I_x}{I_z}\omega_1\omega_2$$

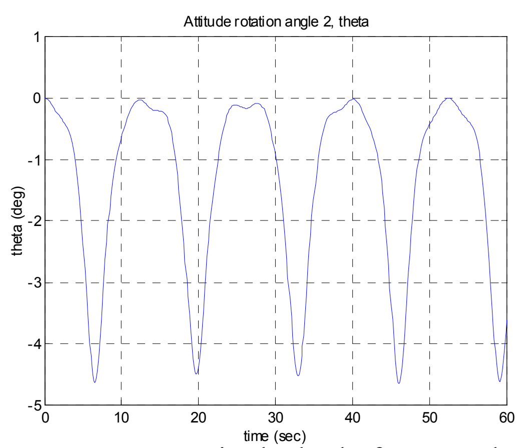
Using the attitude rotation angle order presented in class

$$R^{ib} = R_1(\phi)R_2(\theta)R_3(\psi)$$

we have rotational kinematics described by:

$$\begin{bmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{bmatrix} = \begin{bmatrix} 1 & \sin\phi\tan\theta & \cos\phi\tan\theta \\ 0 & \cos\phi & -\sin\phi \\ 0 & \sin\phi\sec\theta & \cos\phi\sec\theta \end{bmatrix} \begin{bmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{bmatrix}$$

The orbiter is initially spinning at $\omega_1(0) = 1^o/\sec$, $\omega_2(0) = 90^o/\sec$, $\omega_3(0) = 0$, and has an attitude defined by $\phi(0) = 90^o$, $\theta(0) = 0^o$, and $\psi(0) = 0^o$. From (a) and (b), things are now in the form $\dot{x} = f(x)$. Use these results to do a simulation with these initial conditions out to 60 seconds. You my use MATLAB (using a command such as ode45), or Simulink, solve the exact analytic solution, or any other method you wish (except using someone else's solution). You'll know things are going well when your plot of $\theta(t)$ looks like:



Include plots of all three angular rate components in the body frame and the three attitude rotation angles. Also include all source code, scripts, etc. that you used to get the results. (hint: watch units - our equations for dynamics only work when angular velocity is expressed in radians per second)

2. (a) Wiesel chapter 5, problem 1, pp. 160-161.