Homework #1: Equations of Motion and Basic Feedback Systems

Problems are from *Franklin, Powell, Emami, Feedback Control of Dynamic Systems, 5th Edition* (FPE).

1. Read Chapters 1, 2, and 3 of FPE.

2. Send me an email at elkaim@soe.ucsc.edu with the subject line: [EE-154] and your full email address in the body. For example, mine would be:

   "Gabriel Hugh Elkaim" <elkaim@soe.ucsc.edu>

3. FPE 1.1.

4. FPE 2.2.

5. FPE 2.14 (a) and (b).

6. A schematic for the satellite and scientific probe for the Gravity Probe-B (GP-B) experiment is sketched in Fig. 2.56. Assume that the mass of the spacecraft plus helium tank, \( m_1 \), is 2000 kg and that the mass of the probe, \( m_2 \), is 1000 kg. A rotor will float inside of the probe and will be forced to follow the probe with a capacitive forcing mechanism; however, this will have no effect on \( m_2 \). The spring constant of the coupling, \( k \), is \( 3.2 \times 10^6 \). The viscous damping, \( b \), is \( 4.6 \times 10^3 \).

   (a) Write the equations of motion for the system consisting of masses \( m_1 \) and \( m_2 \) using the inertial position variables, \( y_1 \) and \( y_2 \).

   (b) The actual disturbance, \( u \), is a micrometeorite and the resulting motion is very small. Therefore, rewrite your equations with the scaled variables \( z_1 = \frac{y_1}{10^3} \), \( z_2 = \frac{y_2}{10^3} \), and \( v = 1000u \).

   (c) Put the equations in state-variable form using the state \( x = [z_1 \ z_2 \ \dot{z}_2]^T \), the output \( y = z_2 \), and the input an impulse, \( u = 10^{-3} \delta(t) \) N·sec on mass \( m_1 \).

   (d) Using the numerical values, enter the equations of motion into MATLAB in the form

   \[
   \dot{x} = Fx + Gu, \tag{2.131}
   \]

   \[
   y = Hx + Ju \tag{2.132}
   \]

   and define the MATLAB system: \( \text{sysGPB} = ss(F,G,H,J) \). Plot the response of \( y \) caused by the impulse with the MATLAB command \( \text{impulse(sysGPB)} \). This is the signal the rotor must follow.