EE-154/CMPE-241
Winter 2008
Due: 6PM, 17-Jan-2008

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:

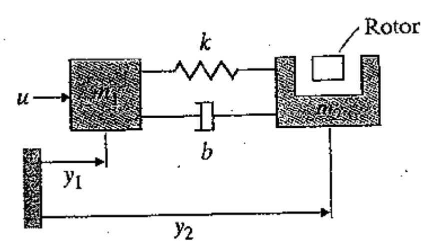
   "Gabriel Hugh Elkaim" <elkaim@soe.ucsc.edu>

3. FPE 1.1.

4. FPE 2.2.

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

Figure 2.56
Schematic diagram of the GP-B satellite and probe



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 3.2×10^6. The viscous damping, b, is 4.6×10^3.

   (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 $z_1 = \frac{y_1}{10^6}$, $z_2 = \frac{y_2}{10^6}$, and $v = 1000u$.

   (c) Put the equations in state-variable form using the state $\mathbf{x} = [z_1 \quad \dot{z}_1 \quad z_2 \quad \dot{z}_2]^T$, 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

$$\dot{\mathbf{x}} = \mathbf{F}\mathbf{x} + \mathbf{G}u, \qquad (2.131)$$

$$y = \mathbf{H}\mathbf{x} + Ju \qquad (2.132)$$

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