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2.004 Dynamics and Control II
Spring 2008

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DEPARTMENT OF MECHANICAL ENGINEERING

Dynamics and Control II
Spring Term 2008

Problem Set 9

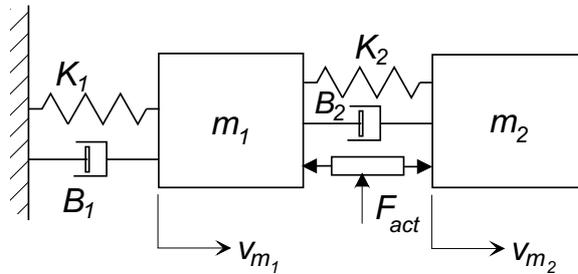
Assigned: April 18, 2008

Due: April 25, 2008

Reading:

- Nise Secs. 8.1 — 8.7

Problem 1: (Laboratory Preparation for week 2 of the project.)



(a) In Problem Set 8 you were asked to derive the transfer function relating the velocity of the building v_{m_1} to the actuator force F_{act} . You will probably find it useful to have the transfer function relating the relative velocity $v_{rel} = v_{m_1} - v_{m_2}$ between the building and the sliding mass. So do it ...

Note: Do not start all over again. You can use the published solution from PS 8 (also in last week's lab handout) as the basis for your solution.

(b) Look at the structure of the system, and imagine that we might design a feedback system such that F_{act} is purely some function of the relative velocity v_{rel} . Describe (in words) what we would *really* be doing to the system if

1. we use proportional feedback so that $F_{act} = K_p v_{rel}$,
2. we use integral feedback so that $F_{act} = K_i v_{rel} / s$.

(Think about the type of element that the actuator would “masquerade” as.)

Problem 2: Nise Ch. 8, Problem 1 (p. 417 5th Ed., p. 474 4th Ed.).

Problem 3: Nise Ch. 8, Problem 2 (p. 417 5th Ed., p. 474 4th Ed.).

Problem 4: Nise Ch. 8, Problem 22 (4th Ed., p. 420).

This is the same as Problem 20 in the 4th Ed., p. 480)

Note: Don't do this by hand - use MATLAB's `rlocus()` function and explore the plot using the cursor.

Problem 5: For a unity feedback system with open-loop transfer function

$$G(s) = \frac{K(s^2 + 4s + 5)}{(s^2 + 2s + 5)(s + 3)(s + 4)}$$

- (a) Use MATLAB's `rlocus()` function to create a root locus for this system. (Print and submit a copy of this plot.)
- (b) Use the cursor to explore your plot and determine the gain K that yields a 1-second peak time T_p for the dominant closed-loop pole pair.
- (c) Use the `feedback()` function to create the closed-loop system with your chosen value of K from (b).
- (d) Plot the step response of the closed-loop system and compare the actual peak time with that predicted from closed-loop dominant poles. (Print and submit a copy of your plot.)

Problem 6: *This problem is designed to show you that the simple sketching rules we have discussed do not always give the complete picture. :-)*

A mechanical system with a transfer function

$$G_p(s) = \frac{48}{s^3 + 12s^2 + 44s + 48}$$

is placed under unity feedback closed-loop control with a PID controller

$$G_c(s) = K_p + K_d s + K_i \frac{1}{s}$$

where the controller has been designed so that the controller zeros are always at $s = -5 \pm j6$.

- (a) Determine the open-loop poles and zeros, and make a sketch of the root locus using our simple rules.
- (b) Use MATLAB's `rlocus()` function to make a root locus plot for the closed-loop system. Print and submit this plot.
- (c) While still in MATLAB, use the cursor to explore the locus and determine the range of values of the controller gain for which this system will be unstable (if any :-).