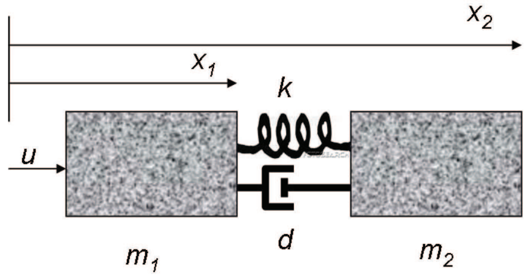
ECSE 6460 **Multivariable Control** Aug 29, 2006

## Homework # 1

Due: September 8, 2006 (Friday)

1. (50%) Consider the simplified 1-D version of the linear stage control problem that we discussed in class.




The equation of motion is

$$\begin{aligned} m_1\ddot{x}_1 &= u - k(x_1 - x_2) - d(\dot{x}_1 - \dot{x}_2) \\ m_2\ddot{x}_2 &= -k(x_2 - x_1) - d(\dot{x}_2 - \dot{x}_1) \\ y = x_2. & \end{aligned}$$

Use the following numerical values:

$$m_1 = 34.12\text{Kg}, \quad m_2 = 10.47\text{Kg}, \quad k = 5.44 \times 10^7\text{Kg/s}^2, \quad d = 1.56 \times 10^3\text{Kg/s}.$$

The closed loop sampling frequency is 5KHz.

(a) (20%) Express the equation of motion in the state space and transfer function forms.

(b) (30%) Design a controller so the output tracks the desired trajectory given by the sinusoidal acceleration profile over a 10mm move with maximum velocity 200m/s and maximum acceleration $9.8\text{m/s}^2$ (use the code `sineprofile.m` on the homework page). Try to design the controller to achieve the following specification (don't spend too much time to meet the spec, just show the iteration to get close to the spec).

- The maximum position tracking error should be less than $5\mu$m.
- The $2\mu$m settling time should be no more than .6 sec.
- Overshoot should be less than $10\mu$m.
- Gain margin of at least 10dB and phase margin of at least 40 degrees. How much actuator gain variation and measurement phase delay do these margins represent?

2. (25%) Problem 2.2 from text (describe an algorithm to solve the problem for any $D_0$ and code it up in MATLAB).
3. (25%) Problem 2.10
4. (Bonus: 25%) Problem 2.14