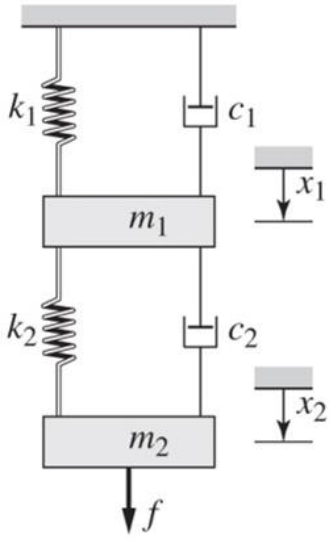
# MECE-606 Systems Modeling

## Computer Project #1: *Two Mass-Spring-Damper Simulation*




**Spring-Damper System**

**Goal**: Simulate the dynamic model of the two mass-spring-damper system. The equations of motion are as follows.

$$m_1\ddot{x_1} + k_1x_1 - k_2(x_2 - x_1) + c_1\dot{x_1} - c_2(\dot{x_2} - \dot{x_1}) = 0$$

$$m_2\ddot{x_2} + k_2(x_2 - x_1) + c_2(\dot{x_2} - \dot{x_1}) = f$$

where

$$m_1 = 2;\ m_2 = 1, \quad k_1 = 2, \quad k_2 = 0.2, \quad c_1 = 1, \quad c_2 = 2$$

for time t=0 to 30 seconds with a sample rate of **10Hz**.

Simulate the system four ways:

1. **Matlab** using the linear state-space command **ss**(A,B,C,D) with the "**initial**" (Case 1) and "**lsim**" (Case 2) commands.
2. **Simulink** using only integrator blocks (1/s), summations, and gains. (No TF or SS blocks). *Hint*: use To Workspace sink for plotting.
3. **Matlab** using **ode45** function call. You must pass the coefficent values ($m_1$, etc) from outside the ode function call. (There are many ways to do this.)
4. **Simscape** develop the two mass model graphically (for the linear models only) . *Hint*: You will need to force the system from Simulink and output the positions to the Workspace for plotting.

**Case 1**: no forcing (*f=0*) with I.C.s $x_1 = 1, x_2 = 0, \dot{x_1} = 0, \dot{x_2} = 0$

**Case 2**: forcing as a step function *f=1*; with I.C.'s =0

- The output plots should be only of the displacement of mass 1 ($x_1$) and velocity of mass 2 ($\dot{x_2}$), *Hint*: use the subplot command.
- For each Case plot all three simulation methods (Matlab, Simulink, Matlab-ode45) on the same plot with different markers. Be sures to include a legend to denote the difference.
- Redo Case 1 and Case 2 using simulation methods #2 (simulink) and #3 (ode45) above with a nonlinear spring. Replace $k_1x_1$ with $k_{1,NL}{x_1}^3$ where $k_{1,NL} = 5$. Include an additional plot (for each case) comparing the ode45 results from the linear spring simulation with the nonlinear spring simulation.

**Considerations**: How does the simulation tools compare? Which do you prefer and why? Parameterizing the model coefficients in the header of an m-file to be loaded into the workspace and called by Simulink or ode45 is very advantageous for system modeling. This is as much a plotting exercise as it is a modeling exercise? Can you get the data out of the simulation tools and plotted on a common figure in a clear and concise manner with all important information displayed? This is critical when comparing data to simulation. Finally, being able to easily model nonlinear systems is very important and tools such as ode45, Simulink, and Simscape make this simple.

**Deliverable**: A concise three page (max.) report on the simulation approaches with a description of the results. The number of plots should be kept to a minimum but be of high quality and description (legends, captions). Always combine results when appropriate. **(I don't want 10 pages of plots in a row)** A portion of the grade is reserved for the quality of the written report. **Style counts.** Please submit all of your Matlab/Simulink code separately as well and consolidate it to as few pages as possible.

**Due Date**: Two weeks after the assigned date.