ME 190, Lab 2 – Simulink Exercise

<u>Learning Objectives</u>: By the end of the lab, you should be able to:

- Simulate differential equation model of a basic suspension system in Simulink
- Send data from Simulink to Matlab and vice versa
- Obtain frequency response plot of the suspension system

<u>Exercises and What to Submit</u>

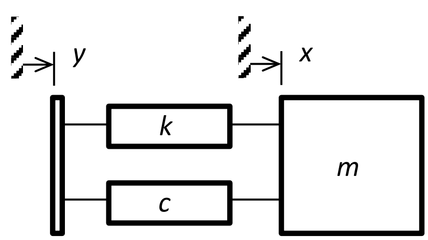
Submit a report that documents your simulation results and Simulink block diagrams. The first section of your submission must be a brief summary of what you did, how you did it, and what you learned. Don't forget your name and date in the published report.

<u>Problem Statement:</u>

The equations of motion for a mass-spring-damper trio with base excitation (shown in the figure) is given by:

$$m\ddot{x} + c\dot{x} + kx = c\dot{y} + ky$$

where *x* is the position of the mass, and *y* is the position of the base, which is the excitation input.



Exercise 1) Create a block diagram model of the system in Simulink assuming *y*(*t*) is the excitation input, and *x*(*t*) is the output. Refer to the lecture note on Intro to Simulink for help on creating simulation models from differential equations. Simulate the system for:

k = 1000 [N/m]
m = 10 [kg]
c = 100 [N-s/m]
x(0) = 0 [m]
xdot(0) = 0 [m/s]
y(*t*) = 0. 01 [m] * *u*(*t*-1)   (where *u*(*t*-1) is the unit step function at *t* = 1 [s])
solver: Fixed step (ODE 5)
dt = 0.001 [s]
t_end = 10 [s]

Use both the “Scope” block to see the data in Simulink, and “To Workspace” block to send data to Matlab and plot it there.

Exercise 2) Create a Matlab code that changes the value of the damping parameter *c* within the range of [50:50: 200] inside a “for” loop and runs the Simulink model from Matlab. Compare the resulting *x* trajectories by plotting them vs time inside (or outside) the “for” loop.

Hints: You need to replace the value of *c* in the damper gain blocks to letter “*c*” and assign values to it in the Matlab script. Use Matlab’s “sim” command to run the Simulink file. Use the “hold” command to plot additional data without erasing the previously plotted data on the same figure.

Exercise 3) In this exercise, we would like to Simulate the system by sending an input signal from Matlab. Let’s create a sinusoidal signal at 2 Hz and apply it to the Simulink model:

1- Replace the “Step” block in your Simulink file with the “From Workspace” block. Double click on it and set its’ Data value to “y_input”. Now we need to create “y_input” in Matlab and use it in Simulink as an input.
2- Create a new Matlab script, and create a time vector and sinusoidal signal at 2 Hz frequency as follows:

```
c = 100;  % Change damping back to the initial value
time_t = [0:0.001:10];          % Creates a time vector
freq = 2;
signal _y = 0.01*sin(2*pi*freq*time_t);
y_input = [time_t’, signal_y’];
sim(‘Simulink_fileName’)
```

Print and show the simulation result (*x* vs *time*) in your report.

Exercise 4) In this exercise, we would like to obtain the frequency response plot of the system. We need to vary the frequency of the input signal within [0.2:0.1:5] Hz, and plot the ratio of amp(x)/amp(y) vs. frequency at the steady state condition, where “amp” stands for amplitude. Note that amp(y) is 0.01 [m]. So, we need to find amp(*x*) from the Simulink simulations at different excitation frequencies. We can take the steady state amplitude of *x* as the maximum value of the second half of *x*. Note that *x* is varying symmetrically around zero. So, its amplitude is approximately equal to its maximum value provided that the second half of *x* includes a full cycle.

```
time_t = [0:0.001:10];          % Creates a time vector

freq = [0.2:0.1:5] % Frequencies at which we would like to examine the system

for i = 1:length(freq)
      create y_input signal here
      Simulate the Simulink model
      Calculate the steady-state amplitude of x
      Calculate Amp_ratio(i) = ... (amp of x/0.01)
end
```

4.a) Plot Amp_ratio vs freq.

4.b) Write a piece of code that finds the resonant frequency of the system, the frequency at which the Amp_ratio is maximum.

4.c) Repeat 4.a and 4.b for the case of c = 50 [N-s]/m and c = 200 [N-s]/m. How do the Amp_ratio and the resonant frequency change as a function of the system damping?

Try to create a report using Matlab's "Publish" feature, and append your simulink files and additional information to it.