Lab Session 05
Modelling Systems in Simulink

Exercise 01

Use Simulink to model the same systems that you have already modelled in Lab Sessions 03 and 04. Plot the same outputs and compare them with the data from the previous plots.

Mass Spring System (Lab Session 03)

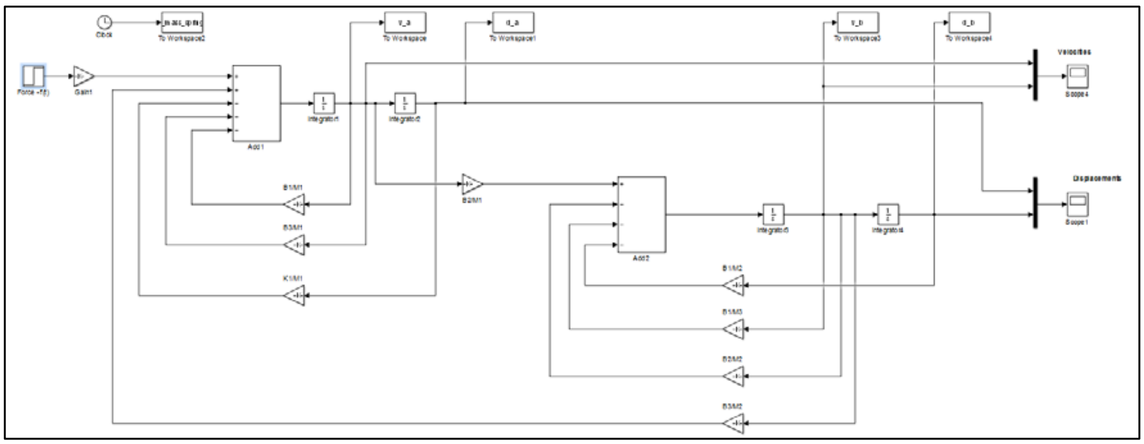

Figure 1: Simulink Model for System 1: Mass-Spring System from Lab Session 03

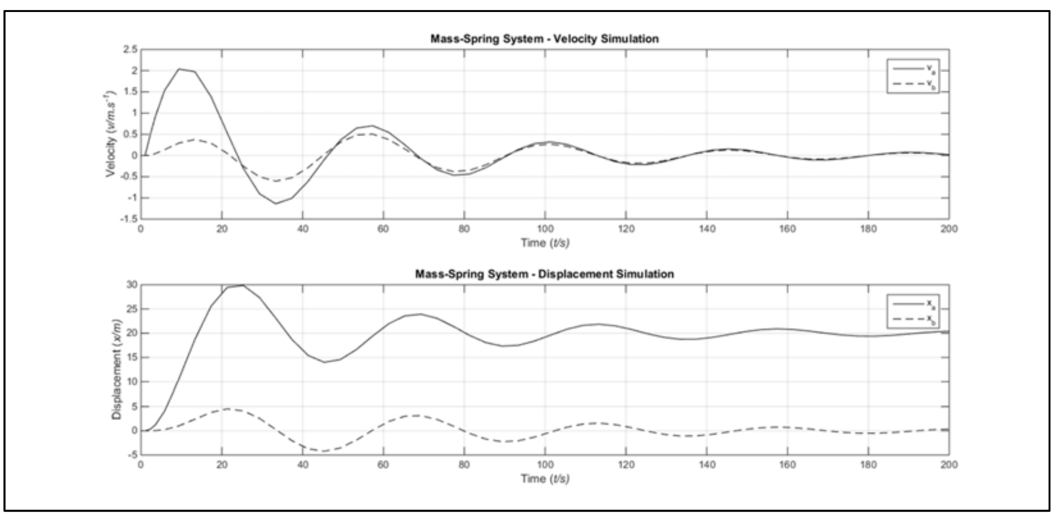

Figure 2: Simulink Model Results for System 1: Mass Spring System from Lab Session 03

Analysis of Results

- The Simulink model results are identical to those from the MATLAB ODE45-based solution derived in Lab Session 03.
- Velocities of both masses oscillate about a mean/steady state value of 0, with the amplitude of oscillations in A's velocity being larger than that of B's.
- Mass A likewise has a larger amplitude of oscillations in displacement and also has a non-zero mean position, just like the results in Lab Session 03.
- Mass B oscillates about a mean position of 0 m and eventually comes to rest at this position as well. This is also in agreement with the simulation from Lab Session 03.
- In both simulations, the peak displacements for Masses A and B are 30 m and 5 m respectively, with peak velocities for the same being 2 m/s and ~0.5 m/s.
- This proves that Simulink model has been designed properly, as it yields the same results for displacement and velocity of both masses as the ODE45 solution.

RLC Network (Lab Session 04, System 1)

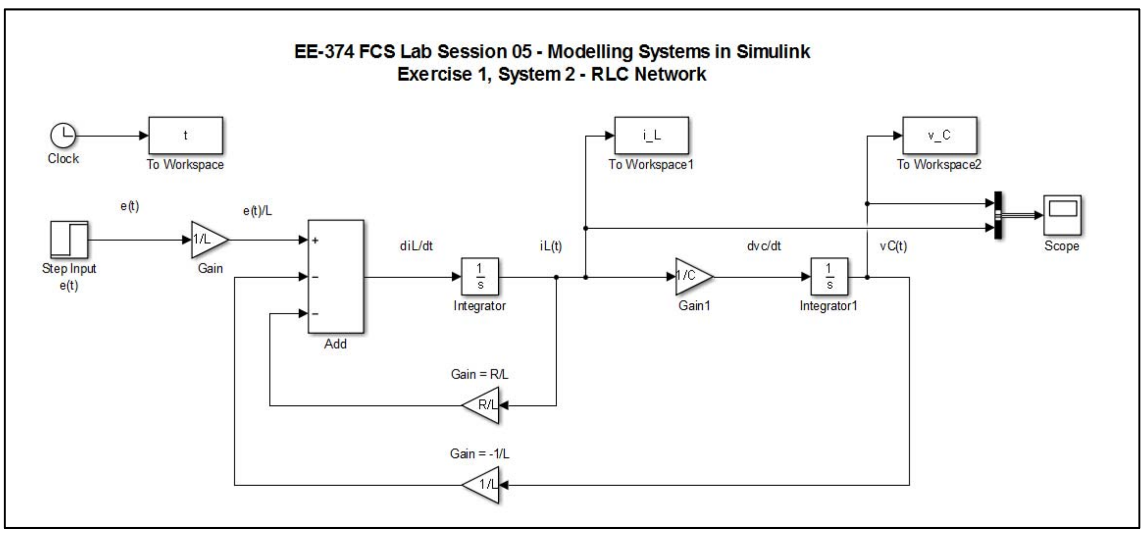

Figure 3: Simulink Model for System 2: First Order RLC System from Lab Session 04

Analysis of Results

- The results from the Simulink simulation of the RLC network are almost identical to the ones from Lab Session 04's MATLAB ODE45 simulation.

- In both cases, the capacitor voltage steadily increases from its initial value of 0 V to a steady state value of e, which was set to 60 V for these simulations.
- Similarly, the inductor current initially rises quickly to the same peak value of 6 A before decaying exponentially to its steady state value of 0 A.
- The data from the Simulink model was stored in the MATLAB workspace in the form of two arrays `v_C` and `i_L`, which were then plotted.

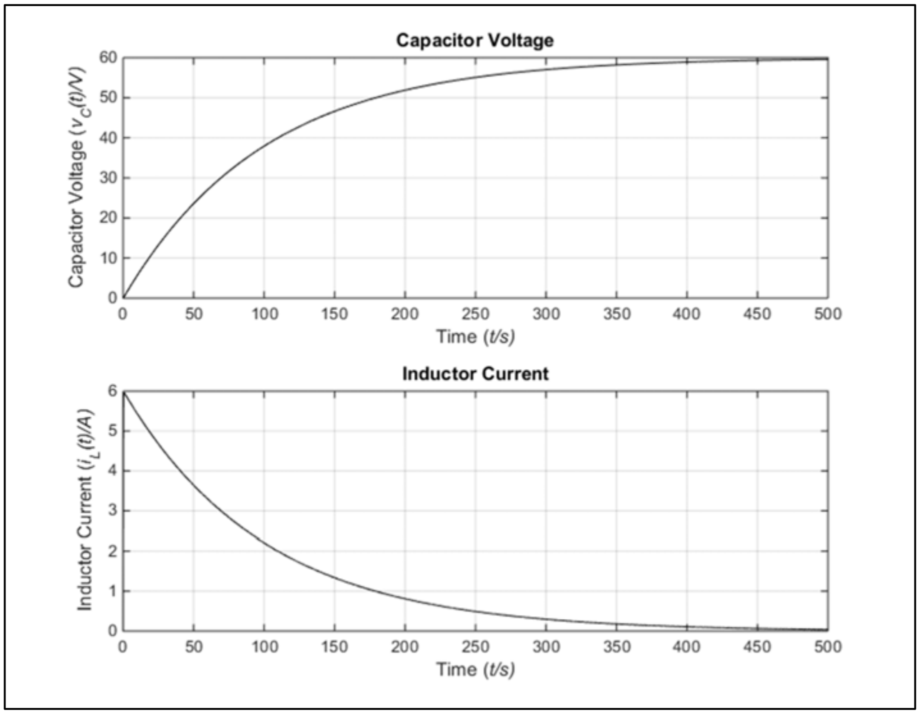

Figure 4: Simulink Model Results for System 2: First Order RLC System from Lab Session 04

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RLC Network (Lab Session 04, System 2)

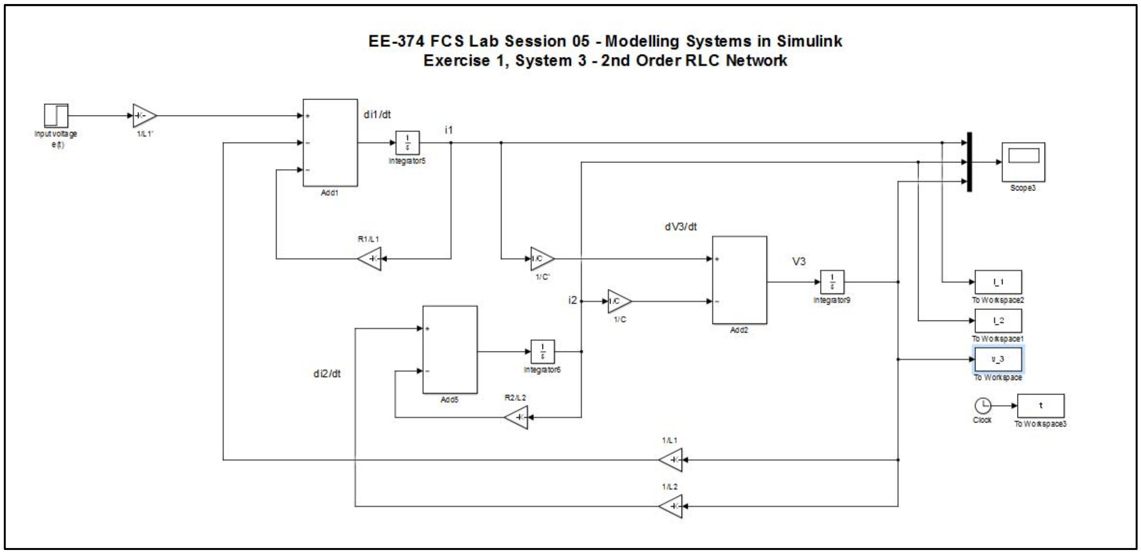


Figure 5: Simulink Model for System 3: 2nd Order RLC System from Lab Session 04

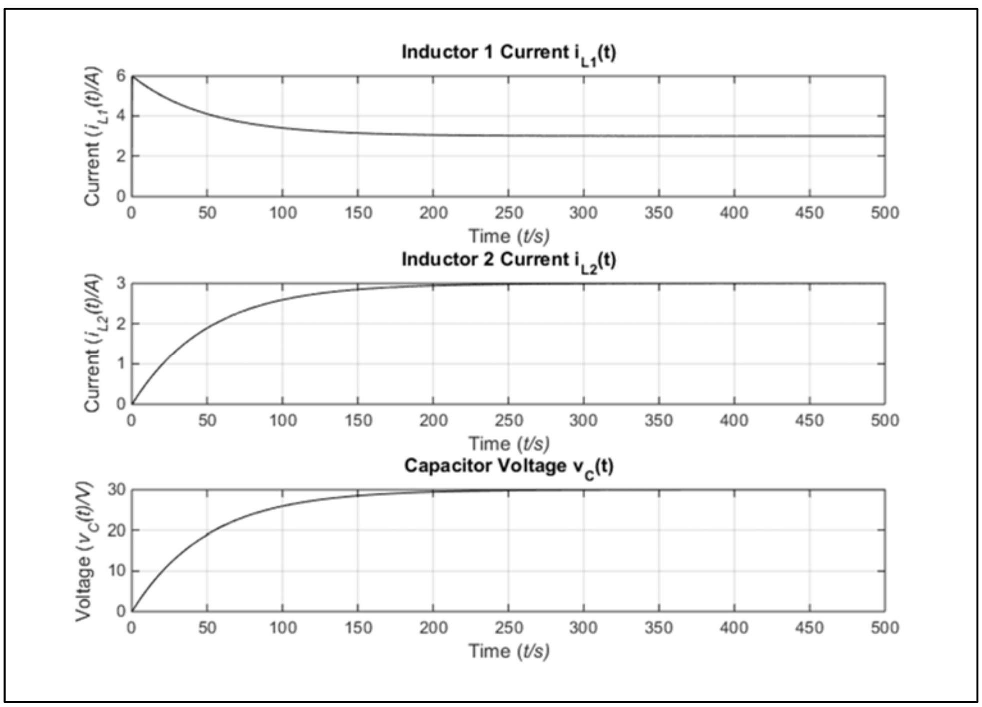
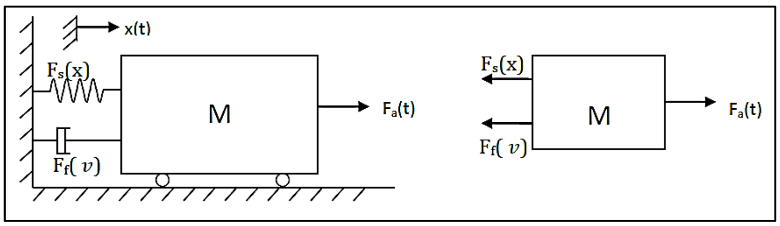


Figure 6: Simulink Model Results for System 3: 2nd Order RLC System from Lab Sessoon 04

Analysis of Results

- Simulink model results are identical to those from Lab Session 04's ODE45 simulation
- The capacitor voltage gradually increases from 0 to its steady state value of 30 V by 200 s in both simulation results.
- Inductor Current $i_{L1}(t)$ rises quickly to the same peak value of 6A before decaying exponentially to its steady state value of 3A by 200s, while $i_{L2}(t)$ also stabilizes at 3A by 200s in both simulations.

Exercise 02 (from Lab Presentation) – Mass-Spring System



$$M\frac{d^2x(t)}{dt^2} + B\frac{dx(t)}{dt} + Kx(t) = F_a(t)$$

A) Construct a Simulink diagram to calculate the response of the Mass-Spring system.

<u>Simulink Model</u>

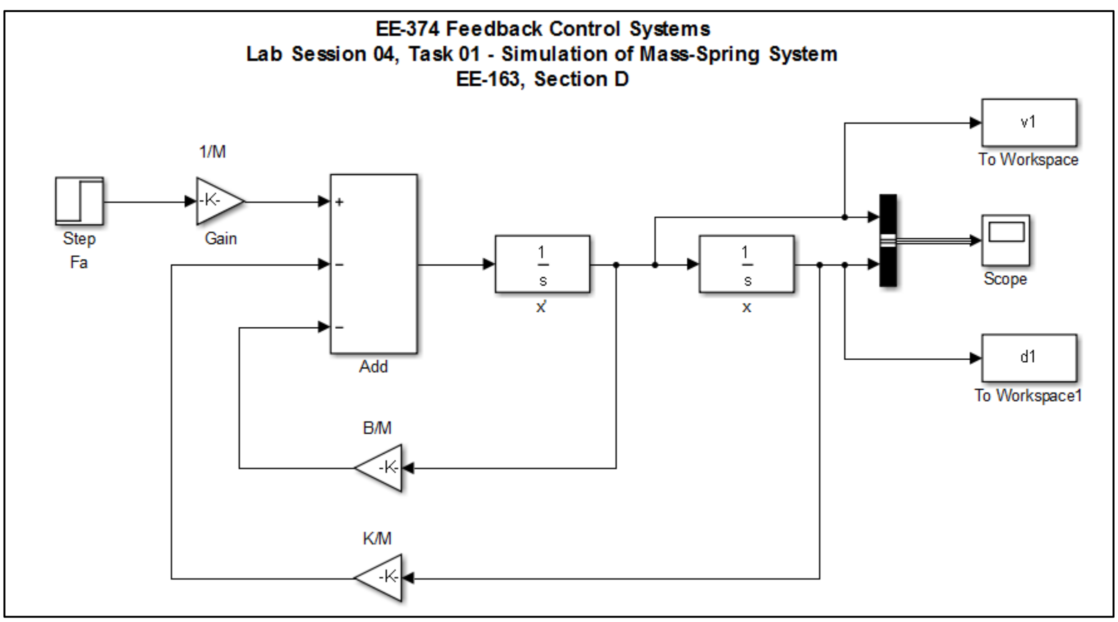


Figure 7: Simulink Model for Mass Spring System

B) Plot the positions and the speeds.

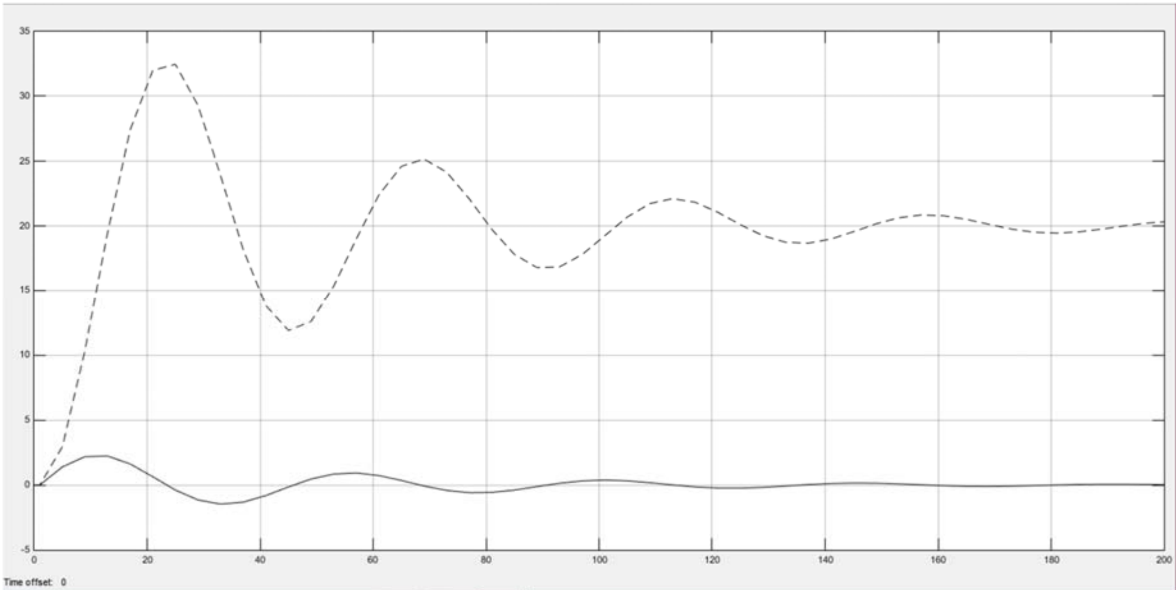


Figure 8: Mass Spring System Response - Position (dotted) an and Speed (Solid)

C) Change the values of each parameters, such as Mass M, Friction coefficients B and Elastic characteristic k. Compare the results and describe the effects.

The table below shows the different values that were used for each of the parameters M, B, and K.

Parameter	**Value 1**	**Value 2**	**Value 3**
Mass (M)/kg	100	500	750
Coefficient of Viscous Friction (B)/N.s.m^{-1}	3	30	300
Elastic Coefficient (K)/N.m^{-1}	1.5	15	150

The results of the simulation were plotted with MATLAB are as follows

Varying Mass

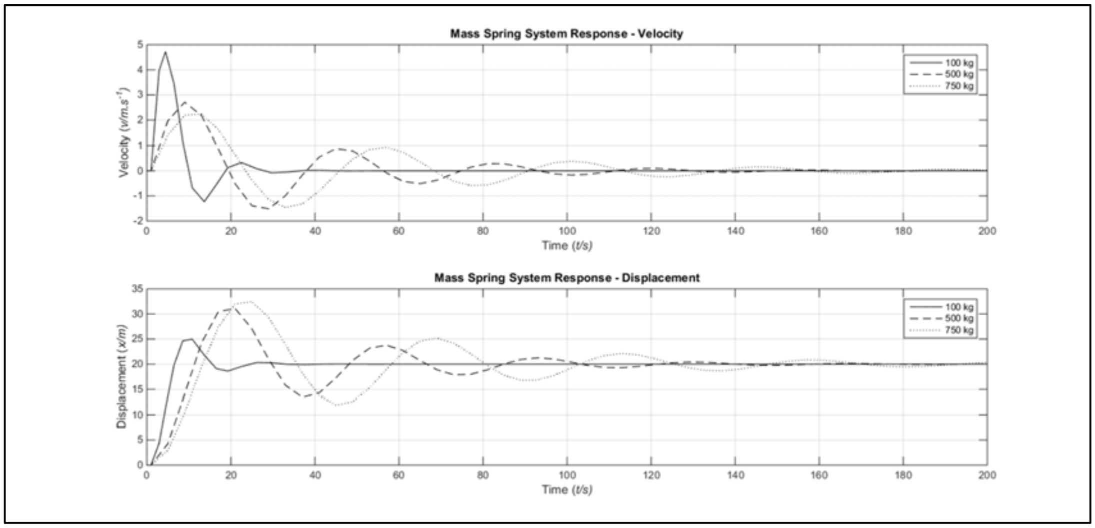


Figure 9: Variation of System Response with Mass

Varying Coefficient of Viscous Friction

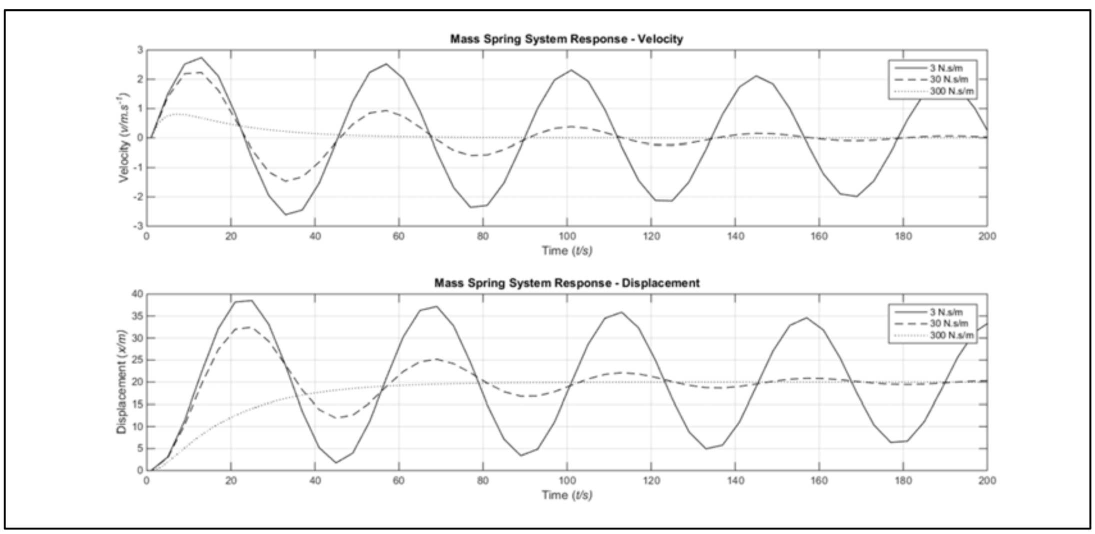


Figure 10: Variation of System Response with Coefficient of Viscous Friction

Varying Elastic Coefficient

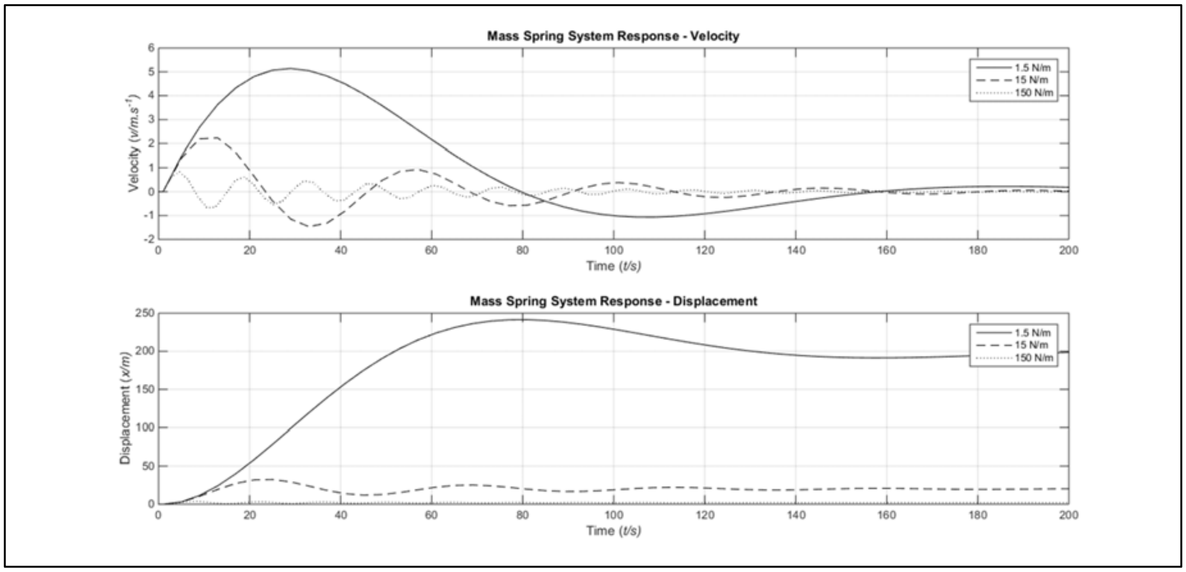


Figure 11: Variation of System Response with Elastic Coefficient

Analysis of Results

- As the mass increases, the amplitude of the oscillations in velocity decreases while that of displacement increase. In both cases, the duration of the transient response/oscillations increases with mass.
- The ideal coefficient of friction for M = 750 kg, F = 300N, and K = 15 N/m seems to be 300 N.s/m, as both the displacement and the velocity steadily increase and decrease respectively to their steady state values, with little to no oscillations.
- A friction coefficient of 3 N.s/m is clearly insufficient and shows evidence of underdamping, as oscillations in displacement and velocity have large, slowly decaying amplitudes. The rate of decay increases with increasing coefficient of friction.
- There is a significant difference in the steady state displacement when the spring constant is 1.5 N/m compared to those with spring constants of 15 and 150 N/m.
- The transient velocity response dies out almost instantly when the spring constant is 150 N/m, and takes only slightly longer in the case of the displacement.
- Increasing the value of spring constants decreases transient amplitude and duration.