# Lab 1: System Modeling in Maple

We are going to do some virtual experiments by simulating a parallel RLC circuit using Maple. This system is shown in the figure below.

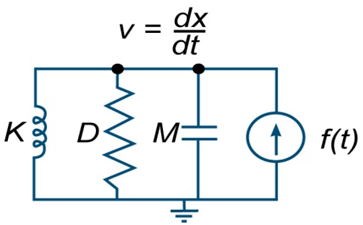


Figure 1: A Parallel RLC Circuit

We will choose a capacitance c = 1 *f* so the transfer function model is

1. Manually derive the general transfer function for the system by hand.
2. Compare the effects of a unit response and unit impulse function to disturb the system:
   1. Using *c* = 1, *k* = 2, and *c* = 3 derive the time domain equations for both inputs and plot your results. Comment on the results.
   2. Using *c* = 1, *k* = 2, and *c* = 2 derive the time domain equations for both and plot your results. Comment on the results.
3. Compare and contrast on the system response to the two inputs. What effect does the damping coefficient play on the system? What effect would a damping coefficient of zero have on the system?

# Lab 2: System Modeling in MapleSim

We are going to do some virtual experiments by simulating a mass-spring-damper system using Maple and MapleSim. This system is shown in the figure below and we assume that the friction between the surface and mass can be ignored.

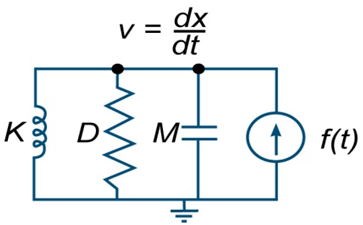


Figure : A Parallel RLC Circuit

We will choose a mass m=1kg so the transfer function model is

1. Manually derive the general transfer function for the system by hand.
2. Construct the model in MapleSim and extract the equations for the system. Use a step signal with a height of 1 for the force input. Compare the results to your hand calculations.
3. Clearly, the original transfer function model is parameterized by *c* and *k*. Can you convert it into a transfer function model that is parameterized by *ζ* (damping ratio) and *ωn* (natural frequency)? Analyze the relationship between *c, k* and *ζ, ωn­*. What is your opinion on how c and k affect the damping and natural frequency?
4. Suppose that we have the following spring and damping values:

|  |  |
| --- | --- |
| *k* = 1, 4, 9, 16, 25 | *c* = 0.5, 1.0, 1.5, 2.0, 2.5 |

1. Using a spring constant of *k* = 1 obtain the results of a 10 second simulation of a unit-step response *x(t)* to *f(t)* for dampers with *c* = 0.5, 1.0, 1.5, 2.0, 2.5 , respectively.
2. Using a damping ratio of *c* =1 obtain the results of a 10 second simulation of a unit-step response *x(t)* to *f(t)* for springs with *k* = 1, 4, 9, 16, 25 , respectively.
3. Analyze the plots obtained in step 2.
4. If you are required to improve the system’s damping ratio or natural frequency using springs and dampers, discuss possible solutions.

# Lab 3: PID Control in Maple and MapleSim

We are going to do some virtual experiments by simulating a mass-spring-damper system using Maple and MapleSim. This system is shown in the figure below and we assume that the friction between the surface and mass can be ignored.

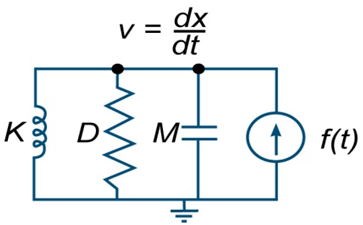


Figure : A Parallel RLC Circuit

We will choose a mass m=1kg so the transfer function model is

1. Manually derive the general transfer function for the system by hand.
2. Construct the model in MapleSim and extract the equations for the system. Use a step signal with a height of 1 for the force input. Compare the results to your hand calculations.
3. Clearly, the original transfer function model is parameterized by *c* and *k*. Can you convert it into a transfer function model that is parameterized by *ζ* (damping ratio) and *ωn* (natural frequency)? Analyze the relationship between *c, k* and *ζ, ωn­*. What is your opinion on how c and k affect the damping and natural frequency?
4. Suppose that we have the following spring and damping values:

|  |  |
| --- | --- |
| *k* = 1, 4, 9, 16, 25 | *c* = 0.5, 1.0, 1.5, 2.0, 2.5 |

1. Using a spring constant of *k* = 1 obtain the results of a 10 second simulation of a unit-step response *x(t)* to *f(t)* for dampers with *c* = 0.5, 1.0, 1.5, 2.0, 2.5 , respectively.
2. Using a damping ratio of *c* =1 obtain the results of a 10 second simulation of a unit-step response *x(t)* to *f(t)* for springs with *k* = 1, 4, 9, 16, 25 , respectively.
3. Analyze the plots obtained in step 2.
4. If you are required to improve the system’s damping ratio or natural frequency using springs and dampers, discuss possible solutions.