Assignment 6b

R Sumedhan

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1 Overview

This assignment is all about looking and analysing *Linear Time-Invariant* or *LTI* systems. We are given a certain set of equations in continuous-time domain and are told to find their Laplace Transforms using the signal toolbox.
The different commands in numpy for creating the polynomials are

- poly1d : Defines polynomials
- polyadd : Adds polynomials
- polymul : Multiplies polynomials

The different commands in scipy for running the simulations are

- lti : Defines a transfer function
- impulse : Finds the impulse response of the system
- step : Finds the step response of the system
- lsim : Simulates the convolution of two systems

2 Spring Responses

The spring equation is given as

$$\ddot{x} + 2.25x = f(t)$$

where f(t) is a damped input whose laplace transform is

$$F(s) = \frac{s + 0.5}{(s + 0.5)^2 + 2.25}$$

We then change the input by changing the damping coefficient, giving us a different laplace transform. The approach is to solve the laplace transform using `impulse` to find its impulse response and plot it.

We then change the frequency of the cosine function in a for loop and simulate the spring using `lsim` and make the impulse plots for each of the sinusoid frequency, keeping the natural frequency of the spring the same.

We find that the shape of the output sinusoid is almost the same except for a minor lateral shift on the time scale. This lateral shift is only due to the change in the frequency, which could be considered as error.

We also have a coupled spring response whose equations are given by

$$\ddot{x} + (x - y) = 0$$
$$\ddot{y} + 2(y - x) = 0$$

3 RLC Two-port Network

We are asked to find the magnitude and phase response of a steady state transfer function of a two-port RLC network. We are then given an input to find its output in the two-port network using `lsim`. The input is as follows

$$v_i(t) = cos(10^3 t)u(t) - cos(10^6 t)u(t)$$

We find the short-term and the long term responses separately by defining different time scales. We see that short-term, the input keeps increasing in a ladder-like fashion and is more steeper than the normal sinusoidal steep. In the long term, we see the frequency of the output decrease. These differences could be explained based on which cosine function dominates in a time scale. The higher frequency dominates in the short-term whereas the opposite is true in the long-term.

4 Plots

Spring Responses

The first plots are the spring responses for the two damped sinusoidal inputs.
The next plot is the varied spring responses for varied frequencies.
The plot for the coupled spring responses is as below

RLC network

The magnitude and phase plots for the RLC transfer function are
The next two plots are the output for the short-term and long-term w.r.t time

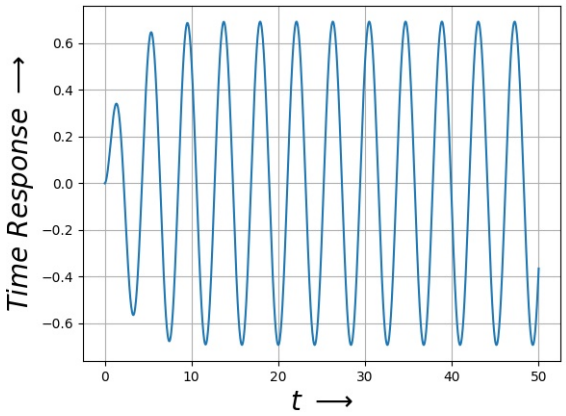

Figure 1: Spring response for a larger decay

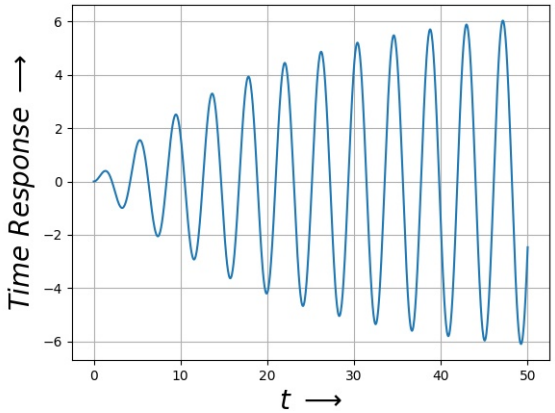

Figure 2: Spring response for a smaller decay

5 Conclusion

The code for the assignment can be referred in the other file.

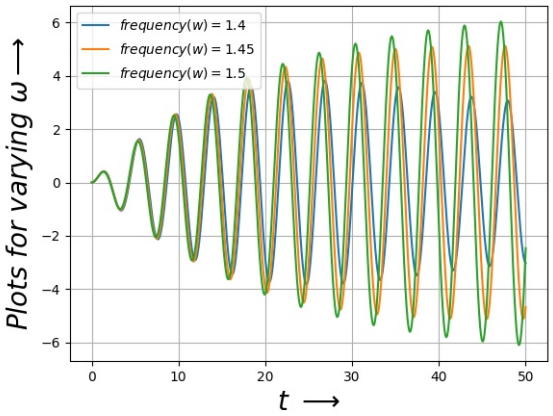

Figure 3: Spring response for varied frequencies

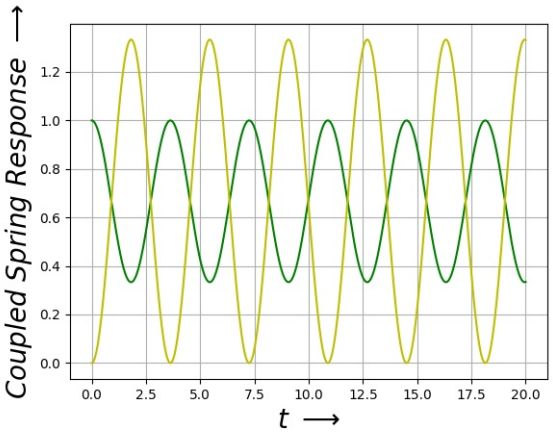

Figure 4: Coupled spring response

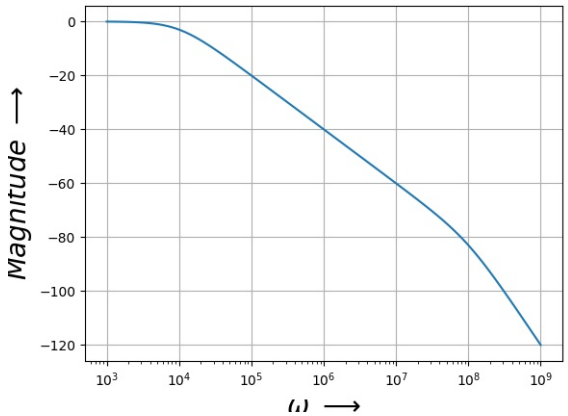

Figure 5: Magnitude response for RLC network

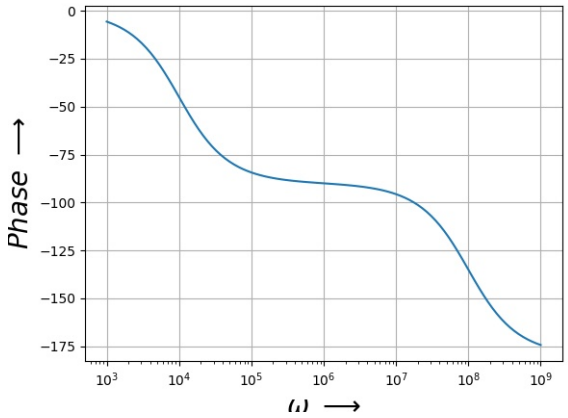

Figure 6: Phase response for RLC network

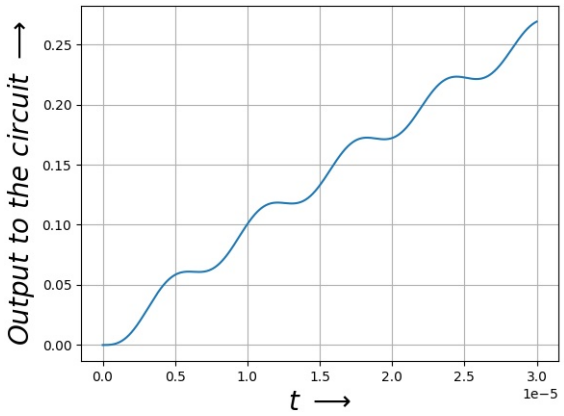

Figure 7: Output for RLC network in the short-term

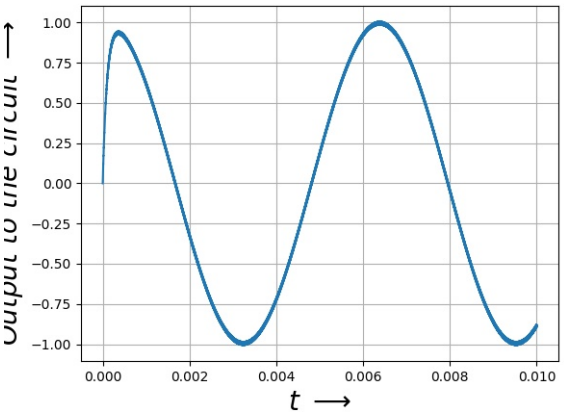

Figure 8: Output for RLC network in the long-term