ECE216 Lab 2 Student Answer Sheet

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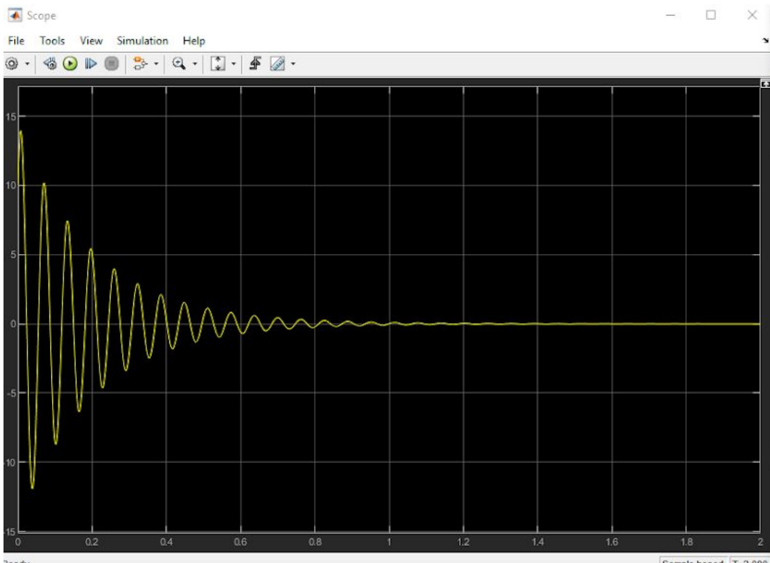
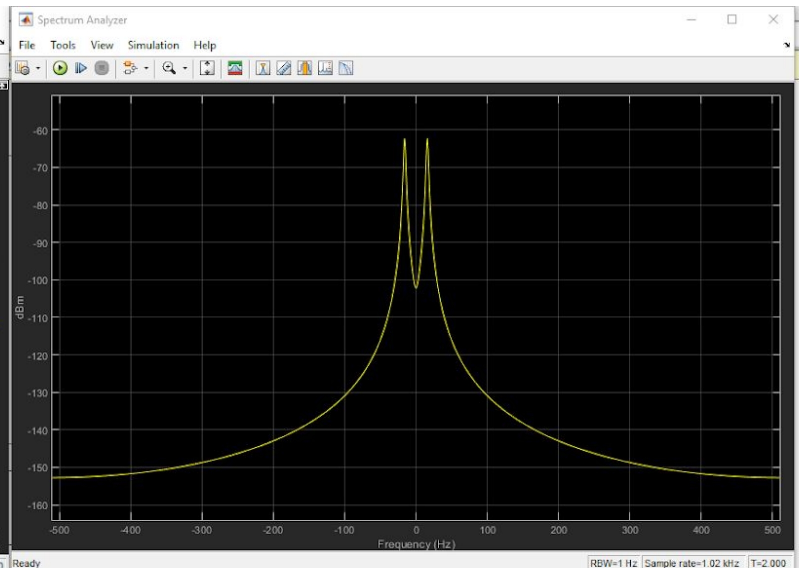
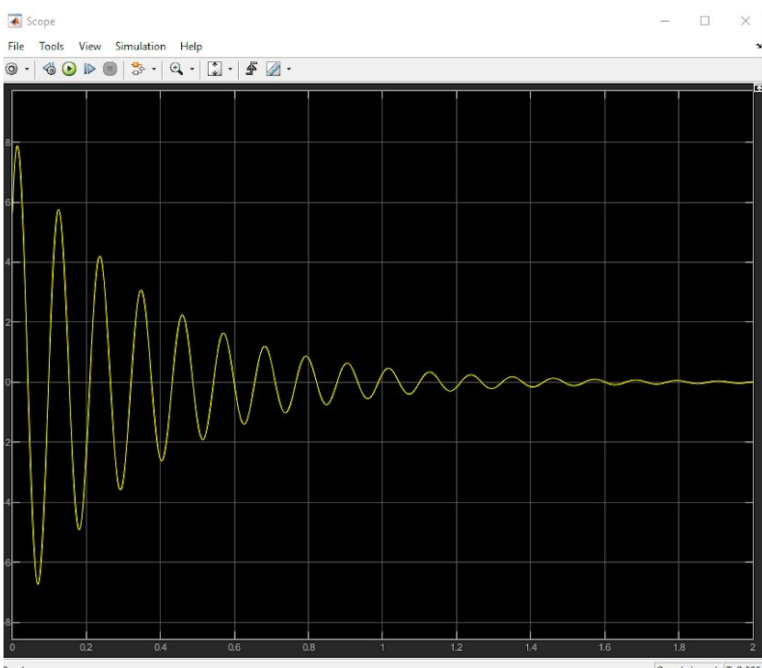
1. **Theta = 1.77**

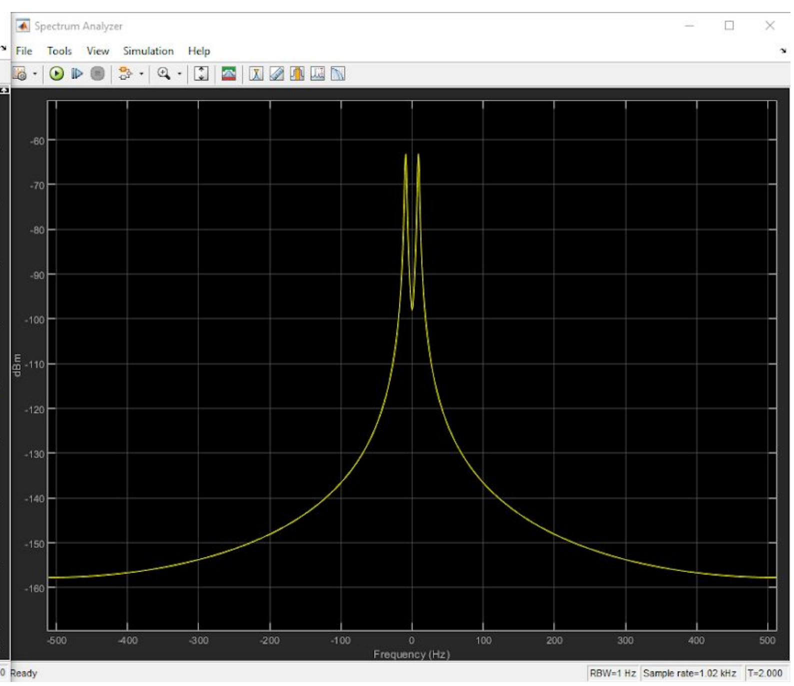
1.1.0
Graph :





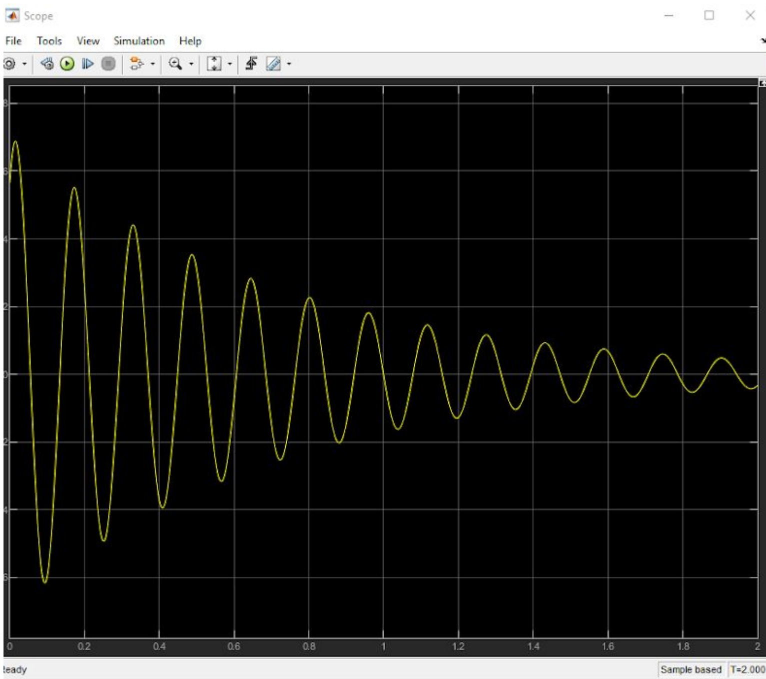
1.1.1
Since theta = 1.77, the new capacitance C = 0.0177, and L = 0.0177, Wn = 56.497

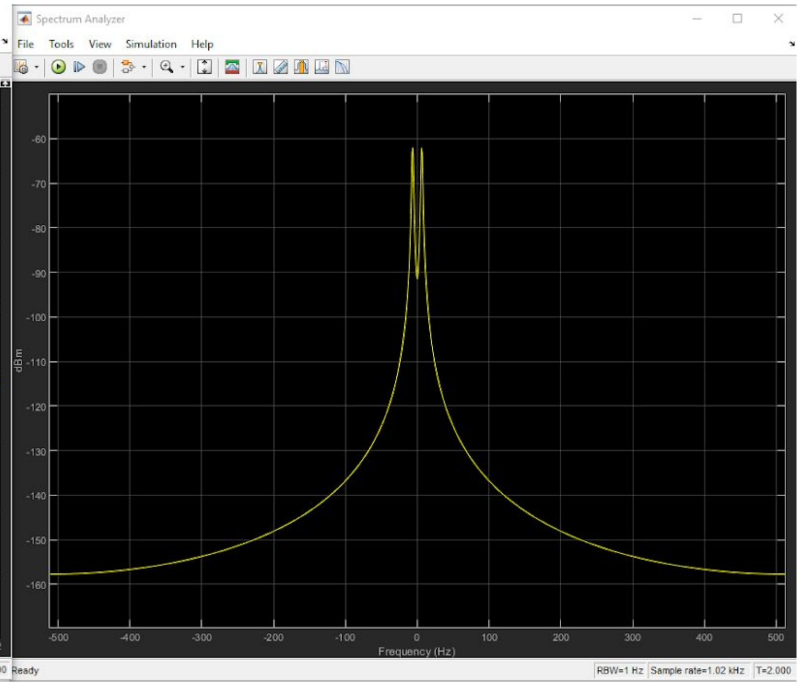




1.1.2

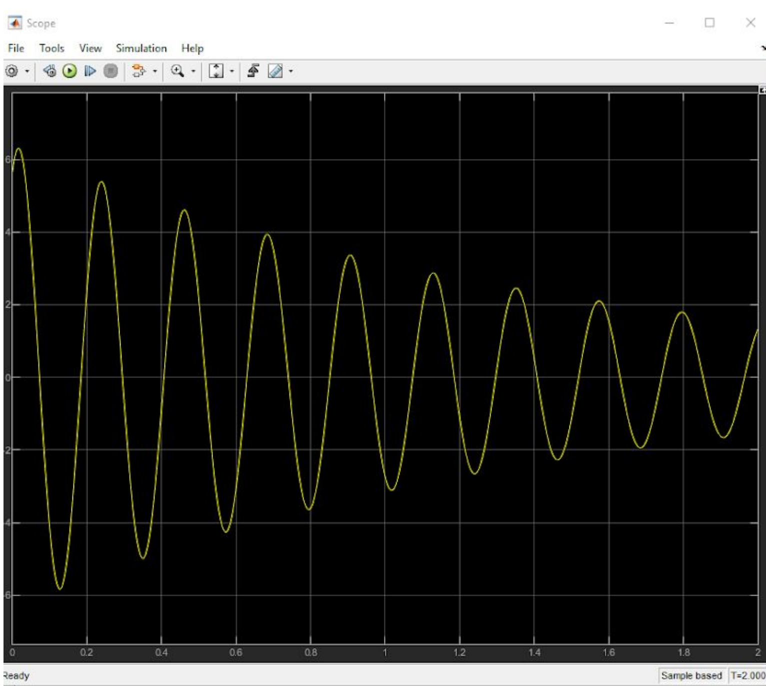
C = 0.0354, L = 0.0177, Wn = 39.949

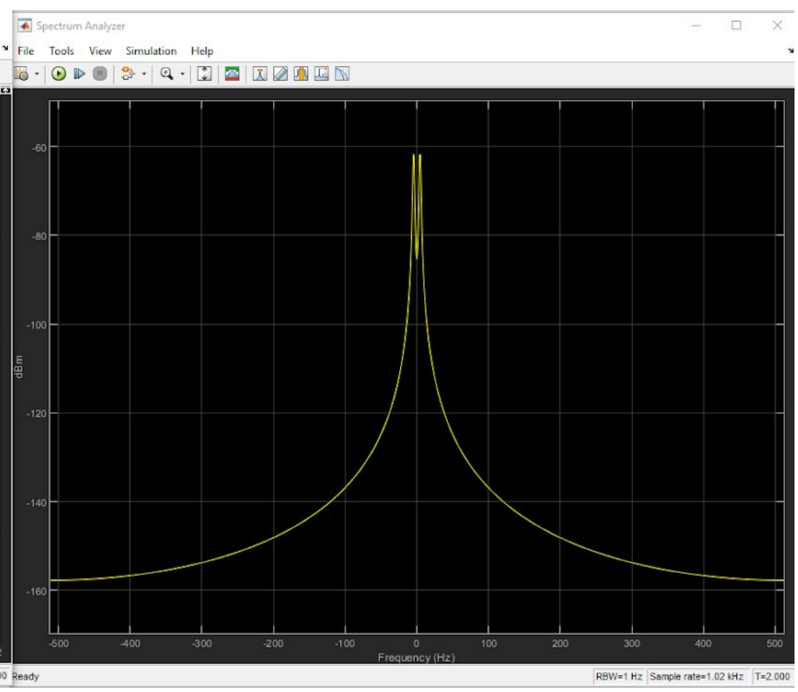




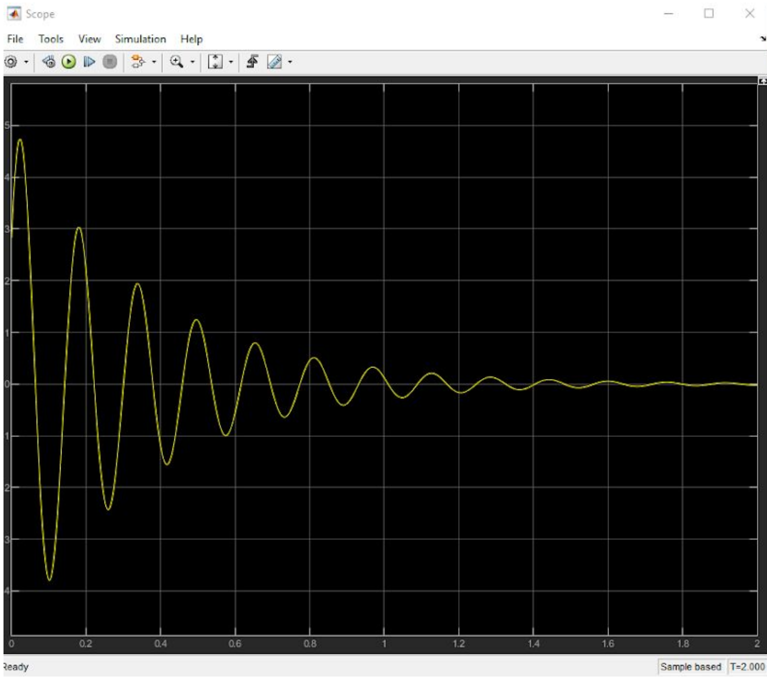
1.1.3

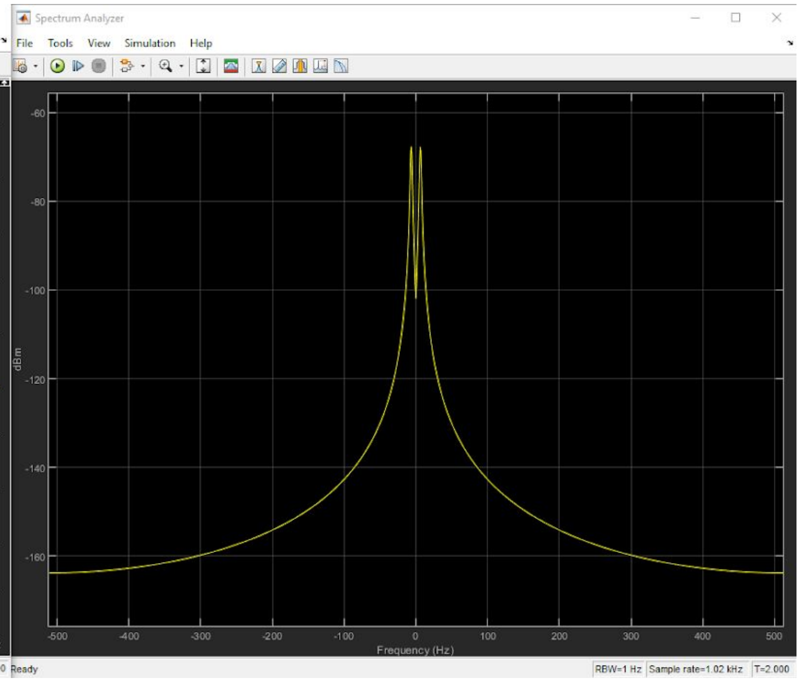
C = 0.0708, L = 0.0177, Wn = 28.248



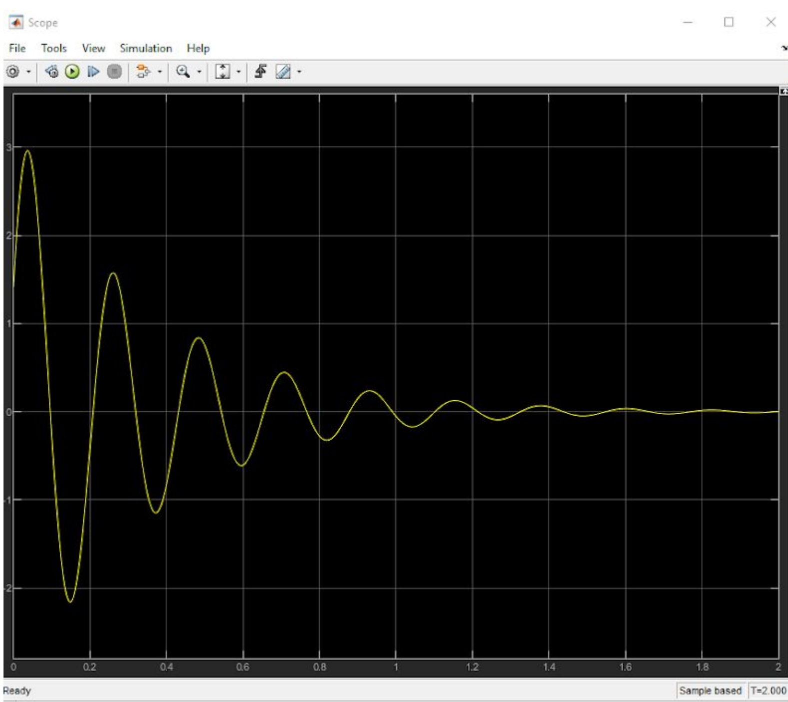


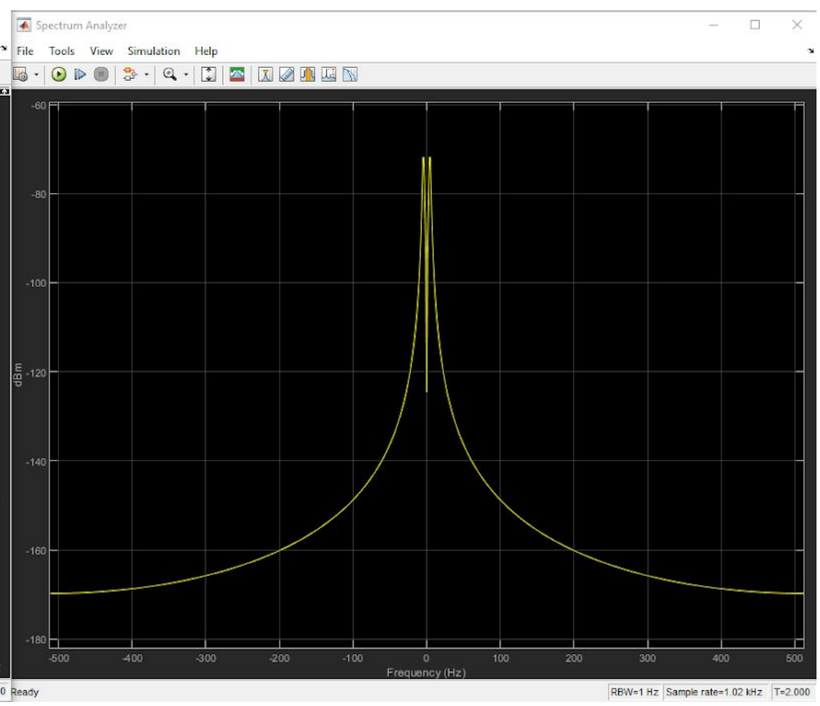
1.1.4
C = 0.0177, L = 0.0354, Wn = 39.949





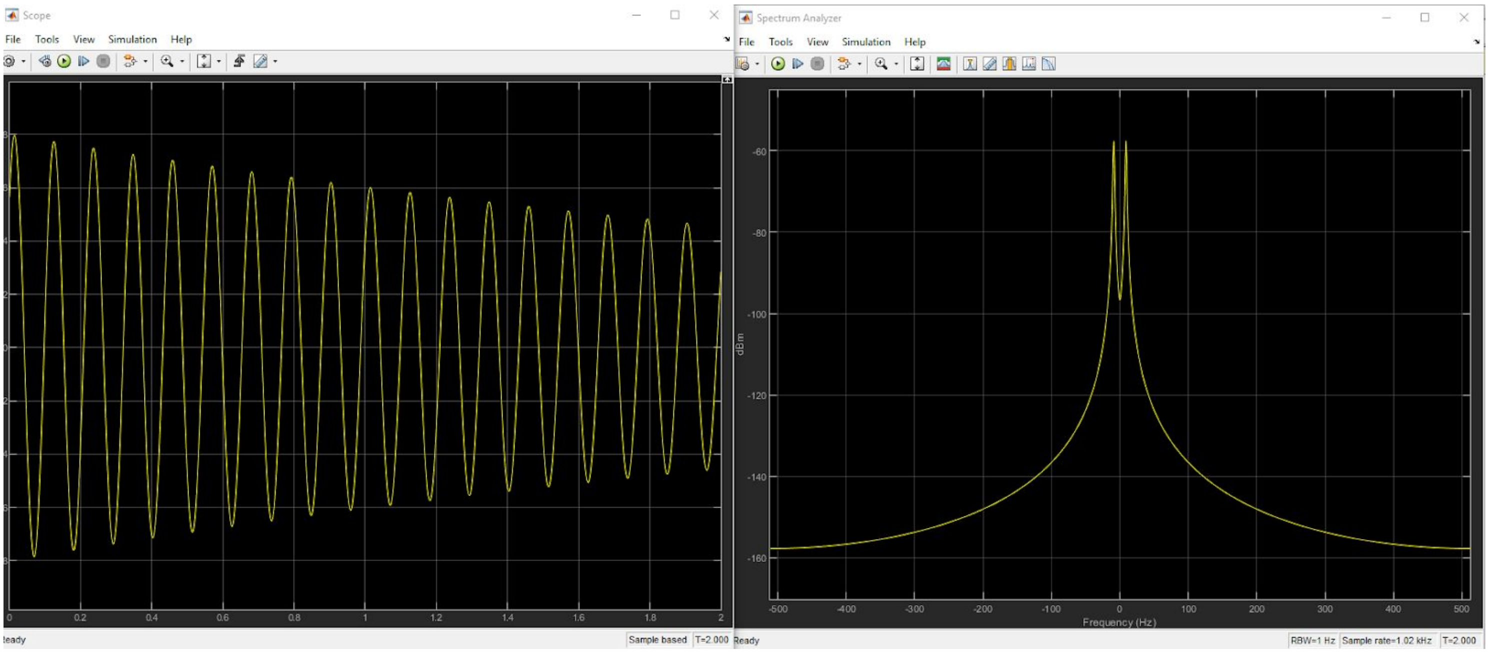
1.1.5
C = 0.0177, L = 0.0708, Wn = 28.248



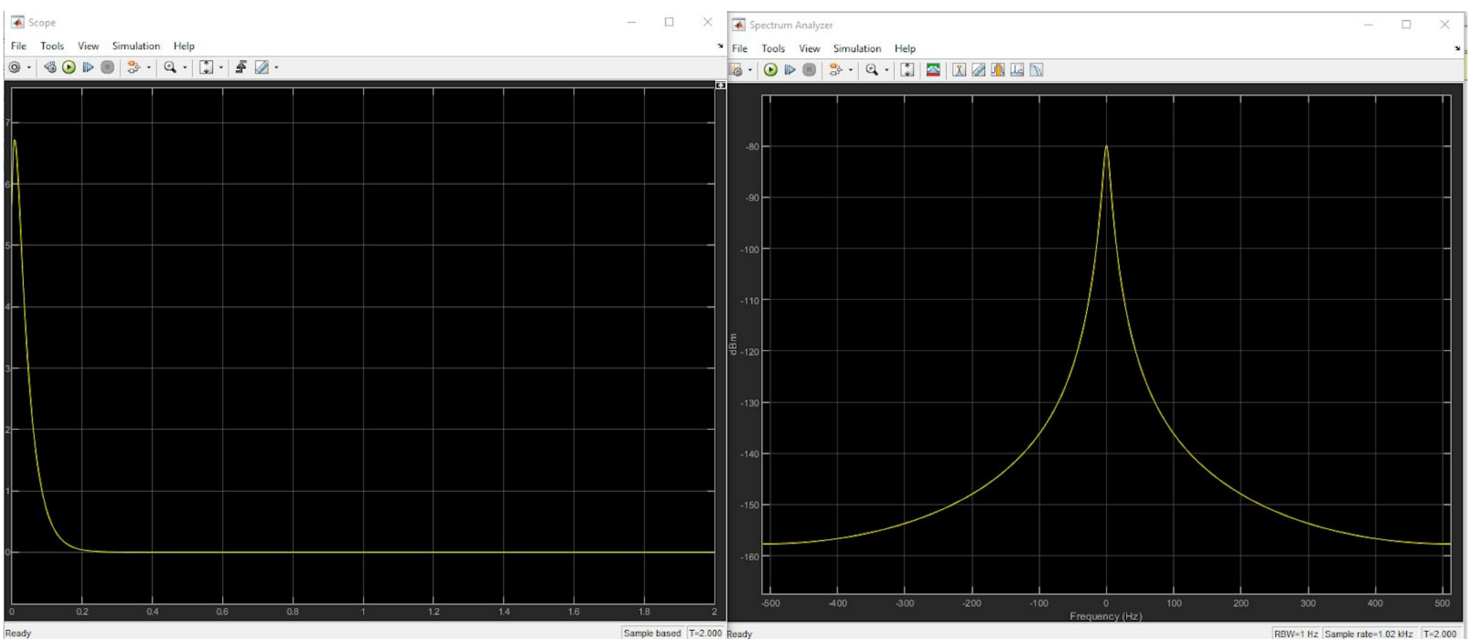


1.2

For a resistor with 0.01Ohms, we get this kind of graph seen below :



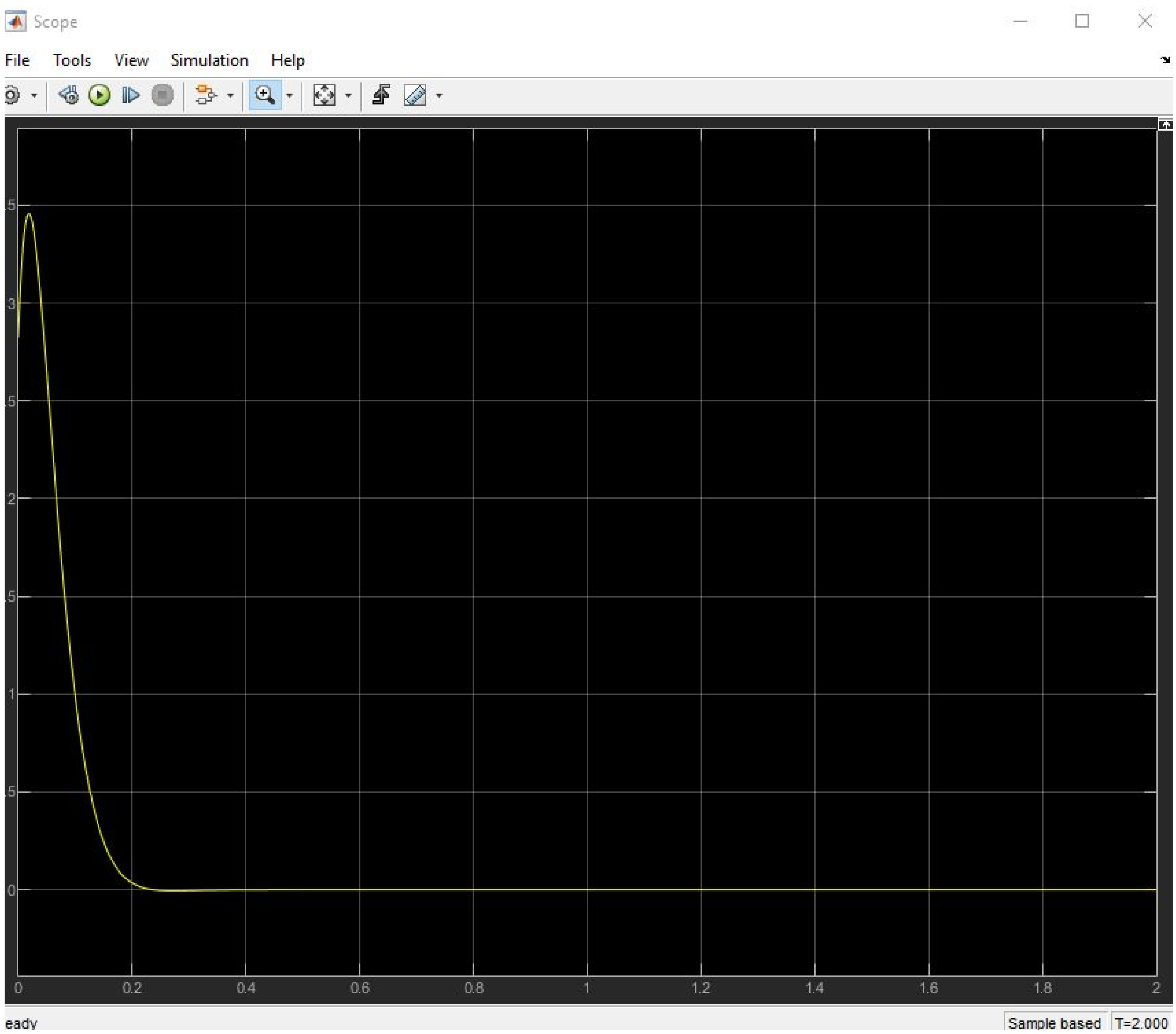
If we increase the resistance, up to a maximum of 2.5, we get the following graph



So clearly, the resistance has a dampening effect on the system.

Finding the critically damped resistance :
By estimation, and checking various values and comparing with the graph, we were able to find the the resistance required to critically damp the system for L = 0.01 * Theta, and C= 0.01*Theta, is ~2.0 Ohms.

For a higher LC value :
We get the following graph of capacitor voltage, what we're able to tell is that increasing the value of the inductance and capacitance will reduce the resistance required to switch from underdamped to overdamped. Below is a graph with resistance = 1.8, which is lower than the 2Ohms seen in the previous part.



Part 2

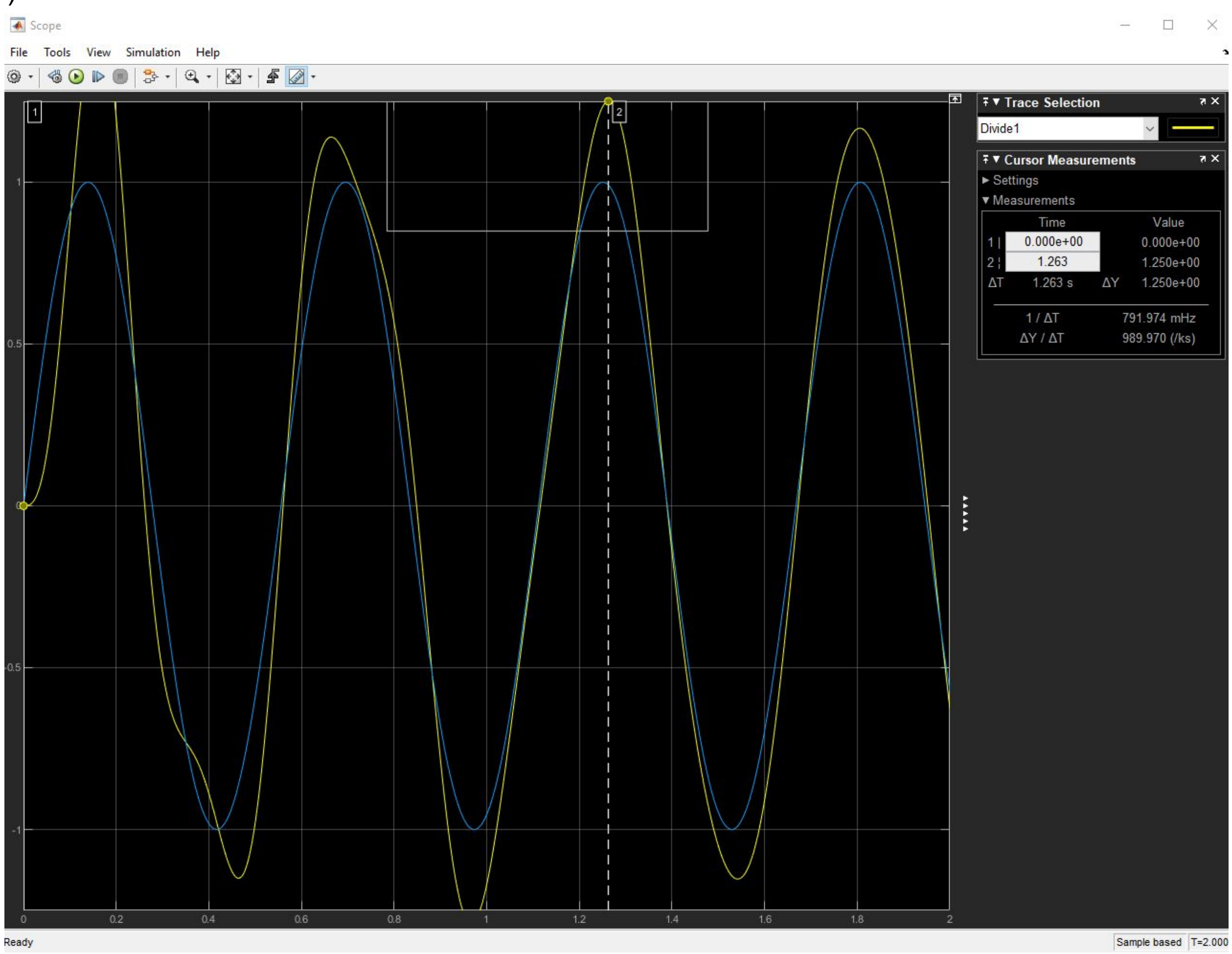
2.1

See graphs for all of these below, also assume all of these amplitudes are at steady state

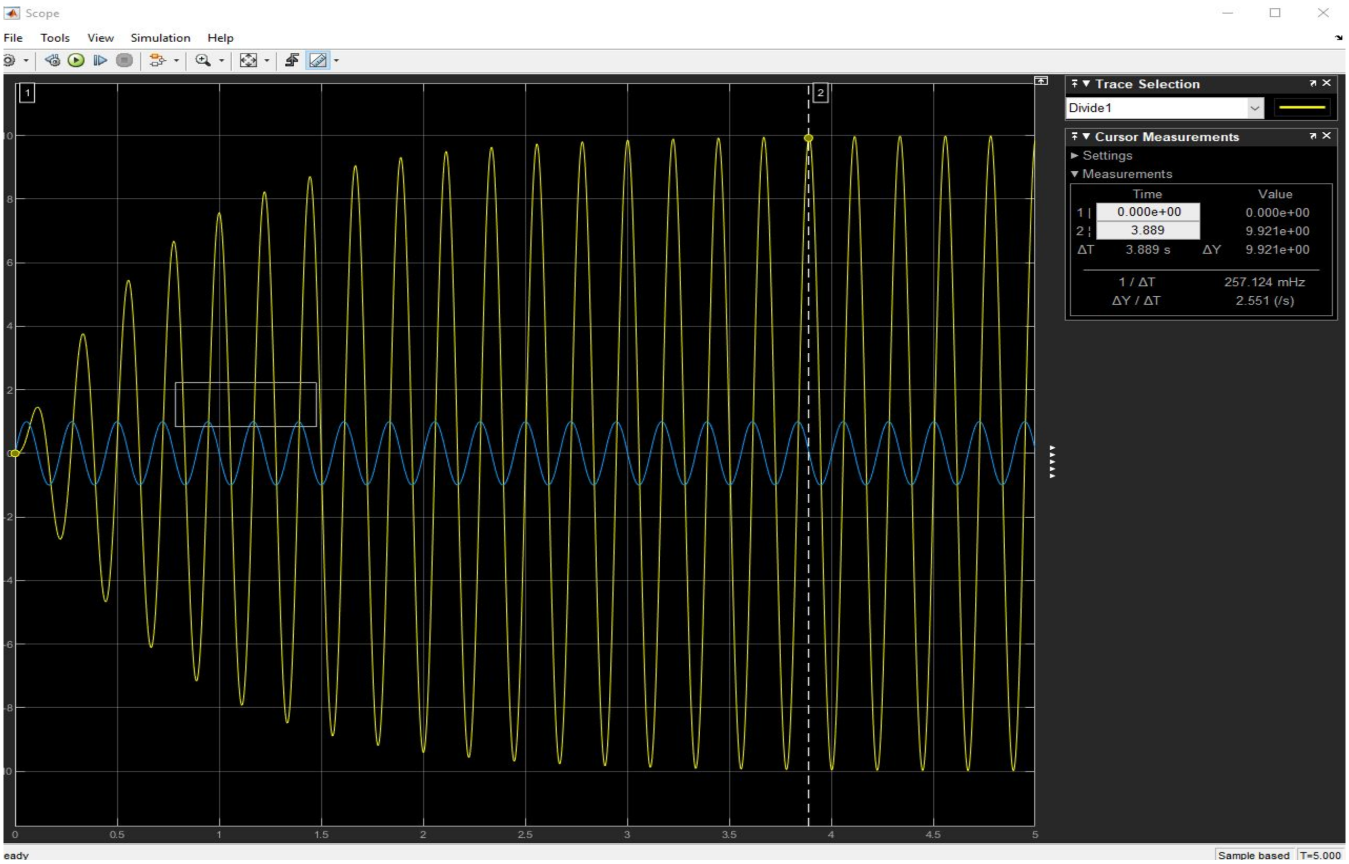
i) Amplitude = 1.25
ii) Amplitude = 9.921
iii) Amplitude = 0.4 early on, ~0.32 at steady state
iv) Amplitude = 0.0734
v) Amplitude = 0.0155

The higher the frequency of the input, the smaller the amplitude is for the output signal. If we lower the frequency of the input, the output more and more matches the input almost looking identical. (as seen below).

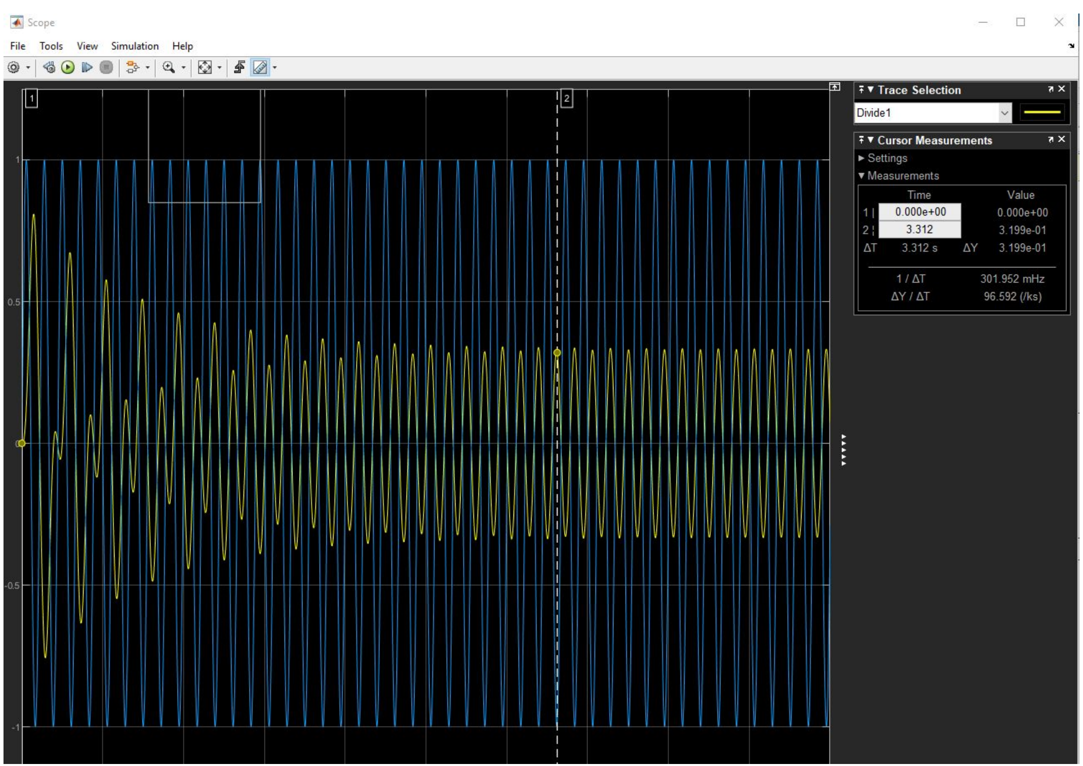
i)



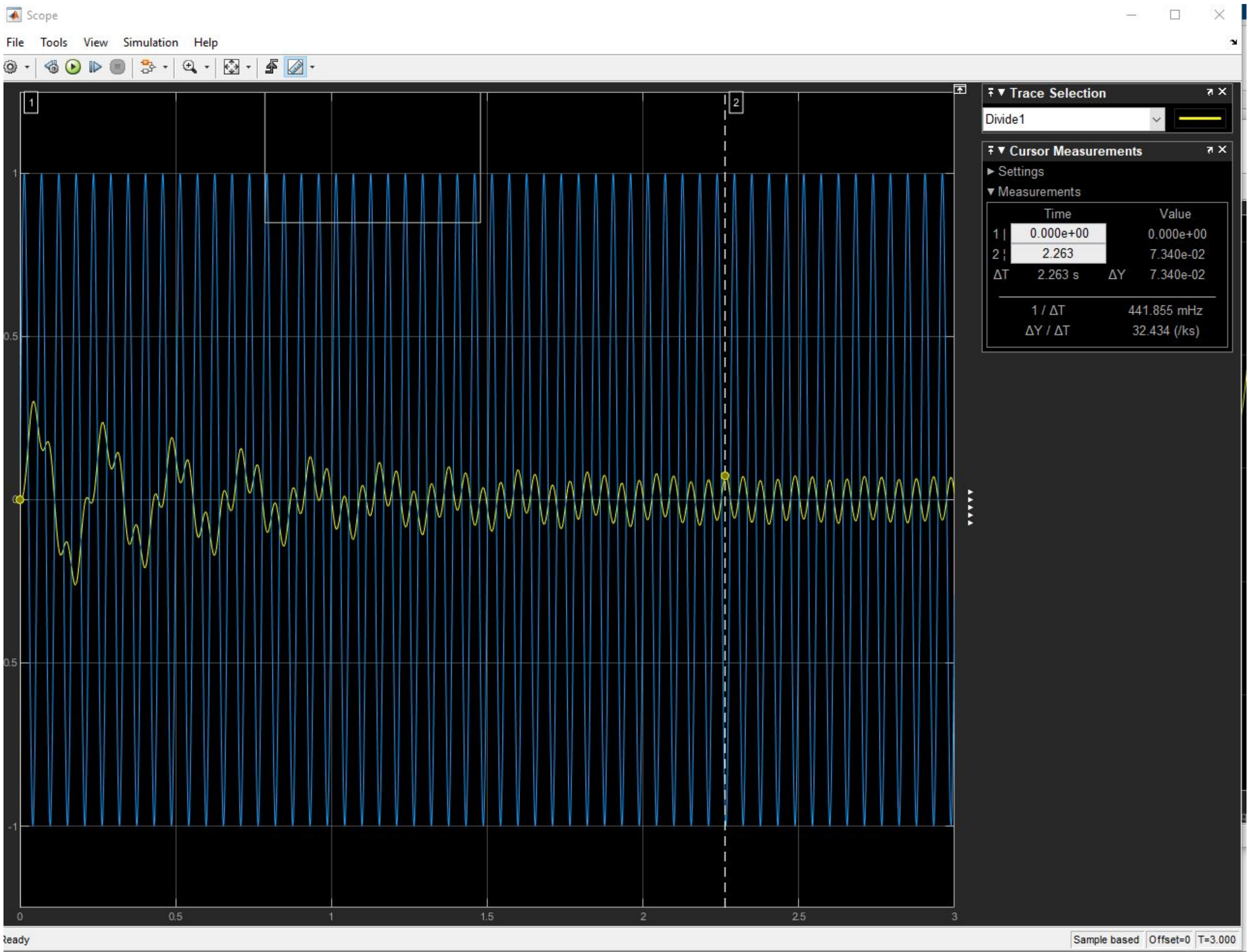
ii)


Scope
File Tools View Simulation Help
Trace Selection
Divide1
Cursor Measurements
Settings
Measurements
Time Value
1 0.000e+00 0.000e+00
2 3.889 9.921e+00
ΔT 3.889 s ΔY 9.921e+00
1 / ΔT 257.124 mHz
ΔY / ΔT 2.551 (/s)
eady
Sample based T=5.000

iii)

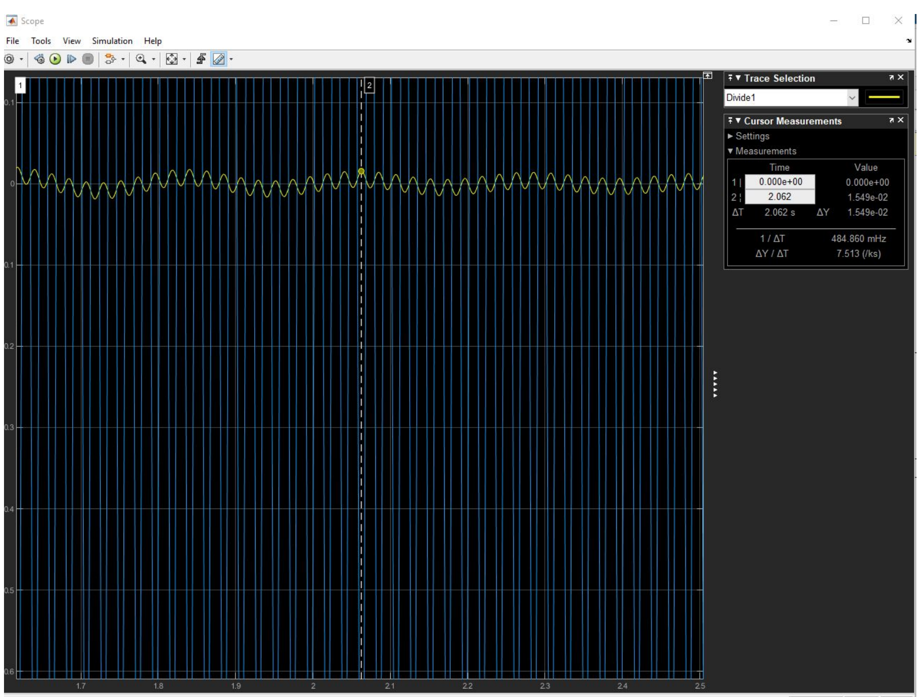

Scope
File Tools View Simulation Help
Trace Selection
Divide1
Cursor Measurements
Settings
Measurements
Time Value
1 0.000e+00 0.000e+00
2 3.312 3.199e-01
ΔT 3.312 s ΔY 3.199e-01
1 / ΔT 301.952 mHz
ΔY / ΔT 96.592 (/ks)

iv)



Scope
File Tools View Simulation Help
Trace Selection
Divide1
Cursor Measurements
Settings
Measurements
Time
Value
1 0.000e+00 0.000e+00
2 2.263 7.340e-02
ΔT 2.263 s ΔY 7.340e-02
1 / ΔT 441.855 mHz
ΔY / ΔT 32.434 (/ks)
Ready
Sample based
Offset=0
T=3.000

v)

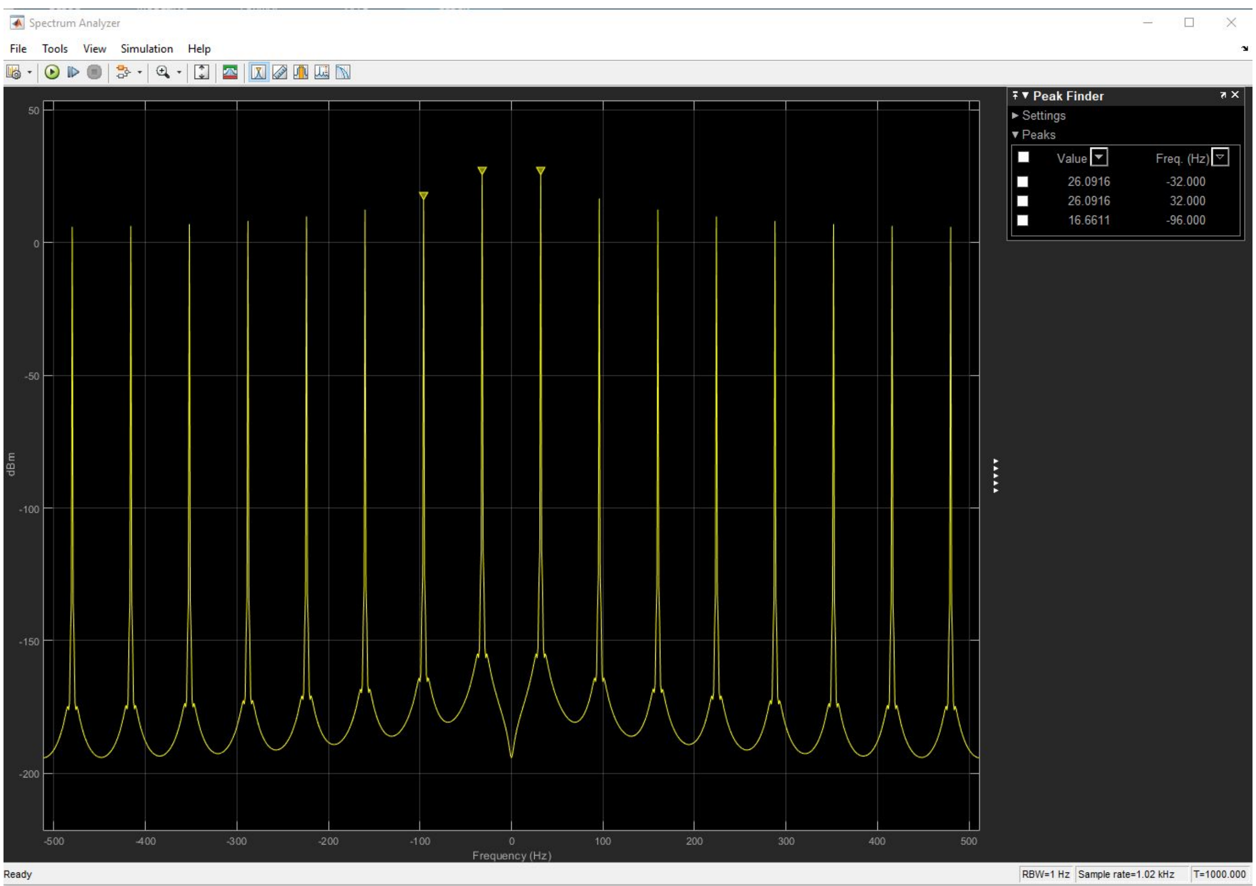


Scope
File Tools View Simulation Help
Trace Selection
Divide1
Cursor Measurements
Settings
Measurements
Time
Value
1 0.000e+00 0.000e+00
2 2.062 1.549e-02
ΔT 2.062 s ΔY 1.549e-02
1 / ΔT 484.860 mHz
ΔY / ΔT 7.513 (/ks)
Ready
Sample based
Offset=0
T=3.000

2.2 Square Wave with Simulink

Here is our graph below, the fundamental frequency can be seen to be 32hz, which corresponds exactly with what we'd expect it to be.

According to the fourier series for a square wave (seen in part 3 of the handout), the square wave consists entirely of sine waves, each of which has a frequency of f = n * f0 (calculated by hand), where f0 is the fundamental frequency of 32Hz. This means that on the graph, we should expect that the only frequencies that show up are integer multiples of 32Hz. That is exactly what is seen below. The first spike (the fundamental frequency) is at 32Hz, the following ones are 96Hz and 160Hz, which are both integer multiples of 32. Also, since the alphaK term in the fourier series is 1/n, we should expect that the peaks progressively get smaller, and this can be verified in the graph below.



Part 3 - Fourier Series Approximations

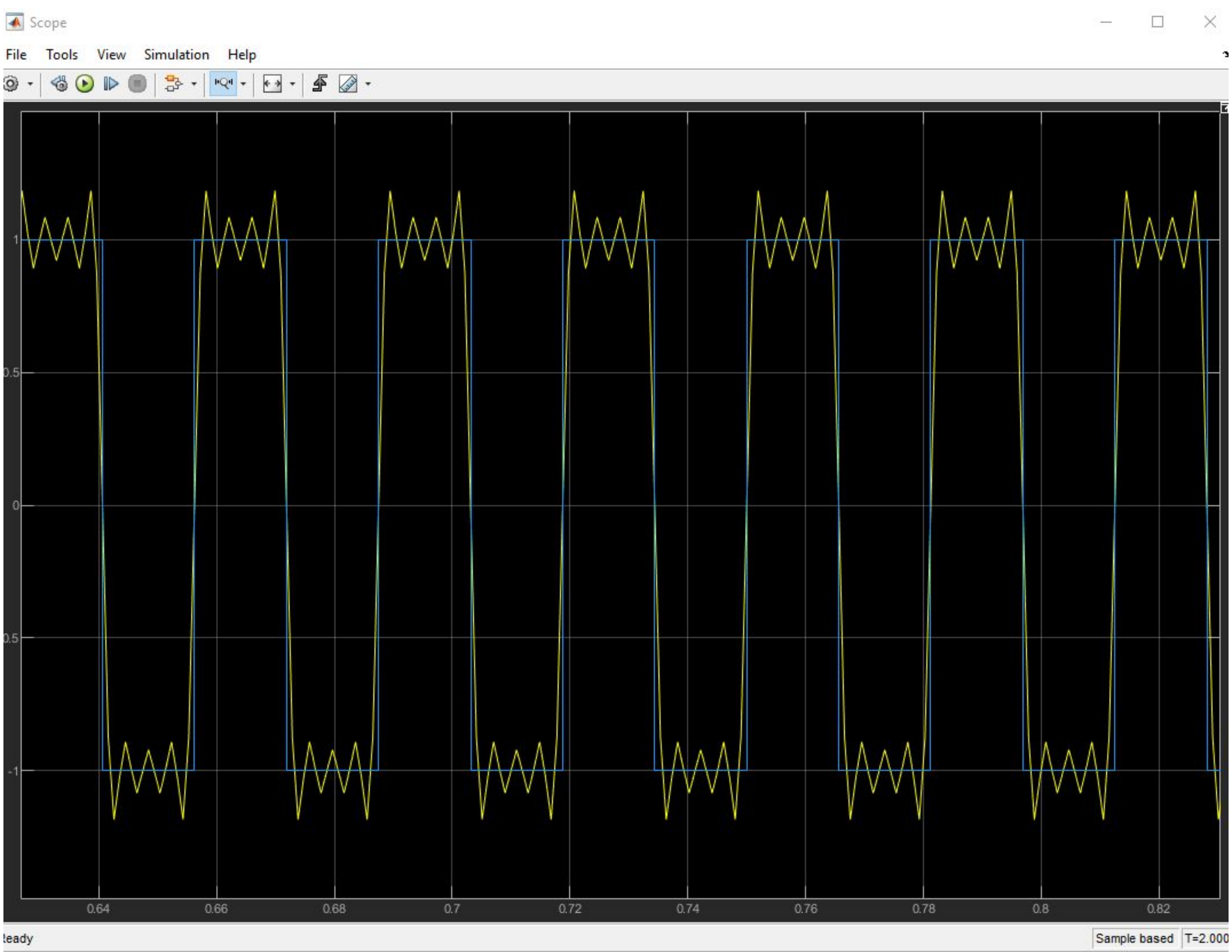
3.1

The first four frequencies that can be seen on the chart are 32Hz, 96Hz, 160Hz, 224Hz, all of which are visible on the graph above, and are integer multiples of 32.

Based on the hand calculation from above, it was already found that the nth frequency, fn = n * f0, where f0 is 32Hz. Looking at the first four terms of the fourier series, we get the following coefficients, n = 1, 3, 5 and 7. If we compare the frequencies, the calculated values are : 32Hz, 96Hz, 160Hz, and 224Hz, so the calculated values align perfectly with the observed values on the graph.

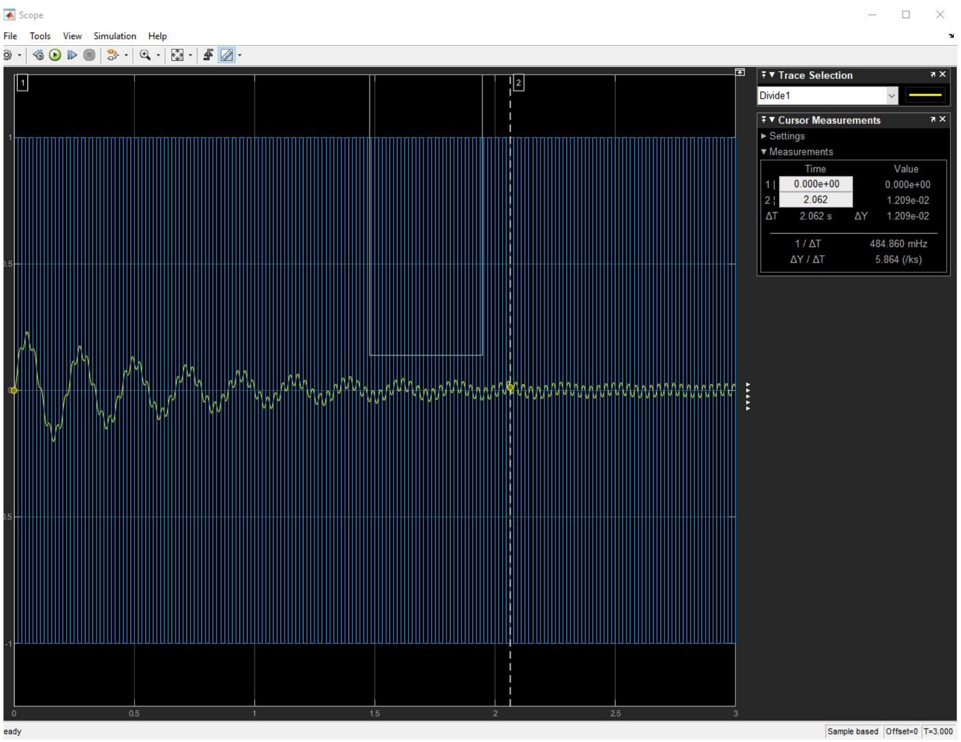
As for the magnitude, the magnitudes for the first four are 4/(pi), 4/(pi*3), 4/(pi*5), 4/(pi*7).

The first four terms of the fourier series graphed alongside the square wave can be seen below:

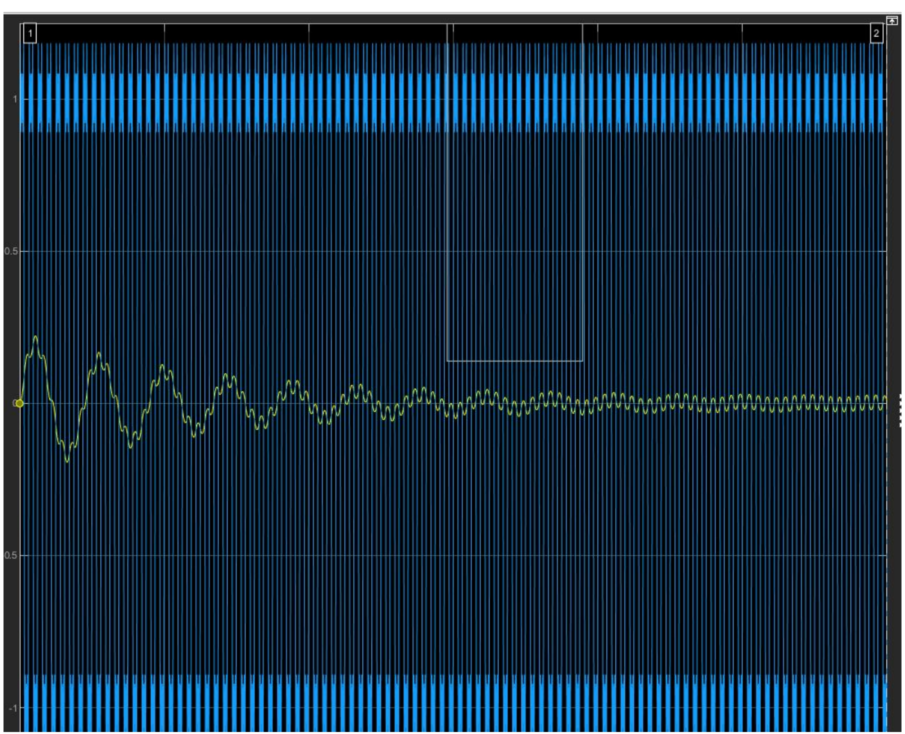


3.2

With the square wave as input to our RLC circuit, we generated this graph, NOTE: Blue is the input square wave, and the yellow wave is the capacitor voltage.



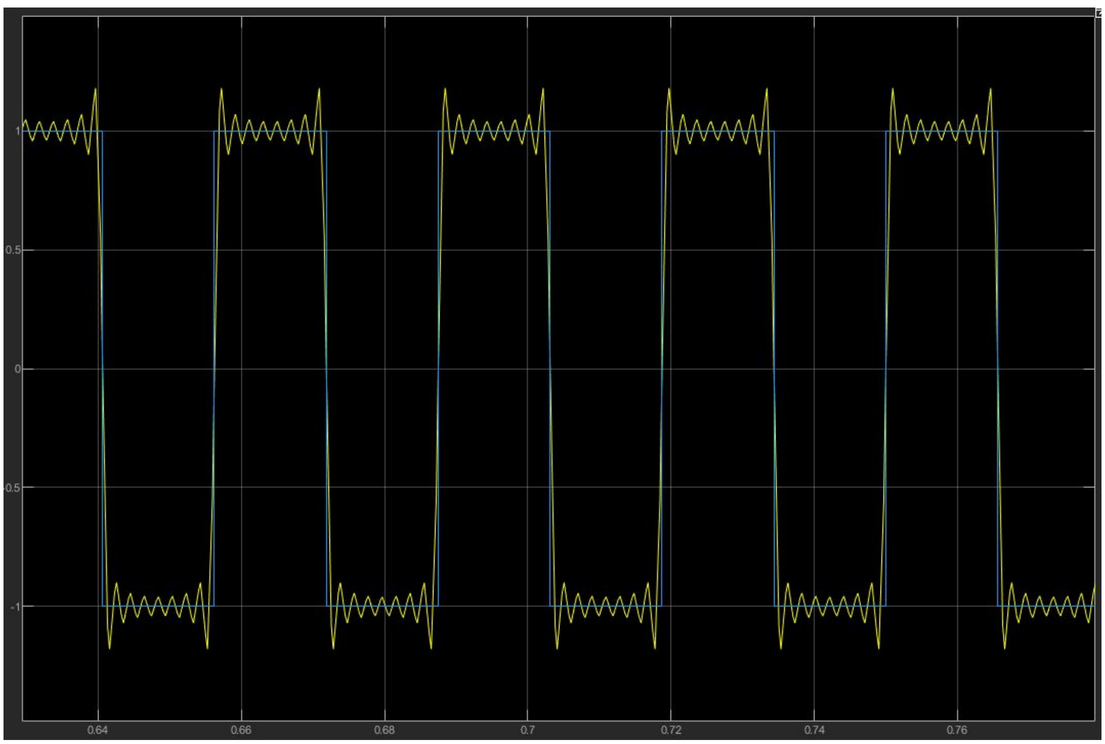
Below here, we used the first four terms of the fourier series as an approximation and here is the graph that was generated. The key similarly is the shape of the output graph.



3.3

We continue the calculation for 8 terms now, the frequencies from the first to the eighth are : 32Hz, 96Hz, 160Hz, 224 Hz, 288Hz, 352Hz, 416Hz, 480Hz. All of these frequencies can be seen on the graph from part 3.1. To answer the question about improvement, it appears that there is much less of an improvement adding another 4 terms. This is likely due to the 1/n term in the Fourier Series, meaning adding more terms (and therefore increasing the value of n), has less and less of an impact on the graph, although it does approximate it better. There are several sharp edges on the 8-term approximation that cannot be removed by adding further terms.

Here is the graph of the square wave, and the first 8 terms of the fourier series approximation graphed side by side :



And below is the graph of the RLC input and output, the graph presented is the 8 first terms, not the square wave, to see how the square wave looks, see the graph from 3.2.