ECE 438 - Laboratory 4a
Sampling and Reconstruction of Continuous-Time Signals

Date:2/2/2023

Section:

Name	Signature	Time spent outside lab
Student Name #1 [Ruixiang Wang]		
Student Name #2 [---%]		

	Below expectations	Lacks in some respect	Meets all expectations
Completeness of the report			
Organization of the report			
Quality of figures: *Correctly labeled with title, x-axis, y-axis, and name(s)*			
Understanding of sampling and reconstruction with an impulse generator (Section 3) (50 pts): *Plots of signals and their frequency spectrum, `explain why` questions*			
Understanding of sampling and reconstruction with sample and hold (Section 1 and 4) (50 pts): *Plots, questions, analytical questions*			

In [2]:
```
import numpy as np
import matplotlib.pyplot as plt
```

In [3]:
```
# make sure the plot is displayed in this notebook
%matplotlib inline
# specify the size of the plot
plt.rcParams['figure.figsize'] = (16, 6)

# for auto-reloading extenrnal modules
%load_ext autoreload
%autoreload 2
```

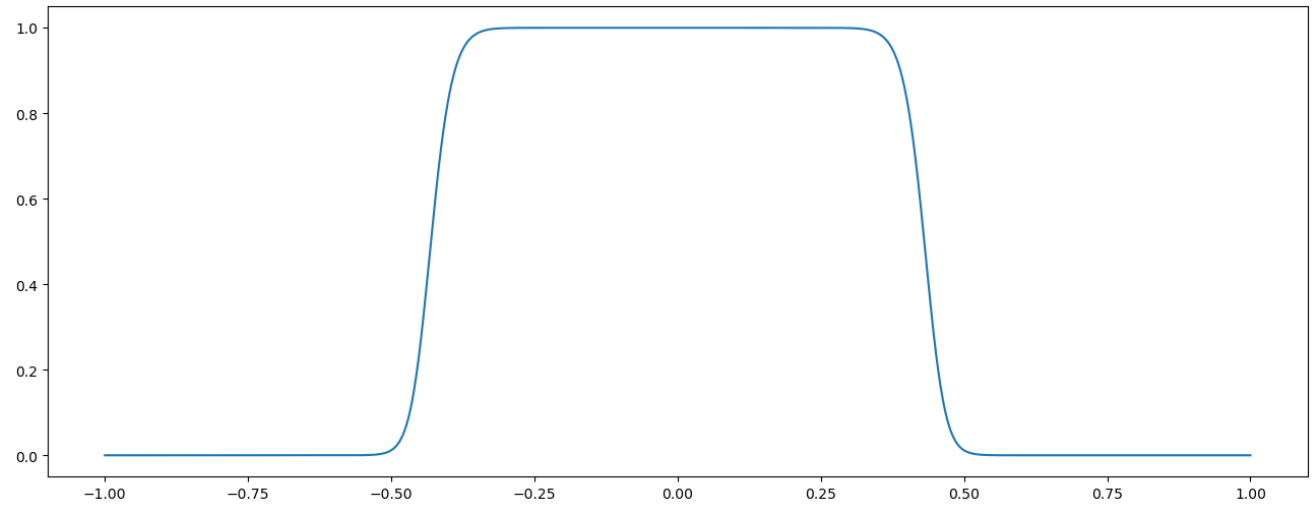
Exercise 1

Let $T_s = 1$ sec, $f_c = 0.45$ Hz, **and** $N = 20$.

1. Compute and plot the magnitude response of the system in Figure 2 without the sample-and-hold device. Let the frequencies be `f = np.linspace(-1, 1, 2001)`.

In [7]:
```
import math

f = np.linspace(-1, 1, 2001)
fc = 0.45
N = 20

def Hb(f,fc,N):
    Y = 1 / (1 + (f / fc)**N)
    return Y

Hf = Hb(f,fc,N) * Hb(f,fc,N)

plt.plot(f,Hf)
```

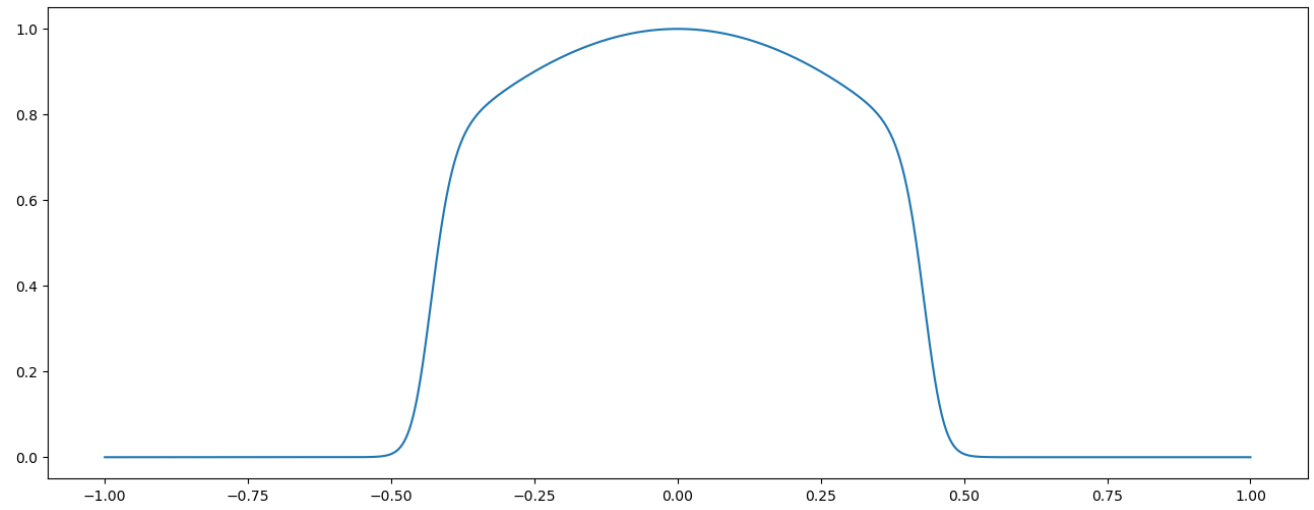
Out[7]: [<matplotlib.lines.Line2D at 0x22d2a1561c0>]



2. Compute and plot the magnitude response of the complete system in Figure 2. Let the frequencies be `f = np.linspace(-1, 1, 2001)`.

In [8]:
```
Ts = 1
fs = 1/Ts

Hf_shs = Hb(f,fc,N) * Hb(f,fc,N) * abs(np.sinc(f/fs))

plt.plot(f,Hf_shs)
```

Out[8]: [<matplotlib.lines.Line2D at 0x22d2a1c10a0>]

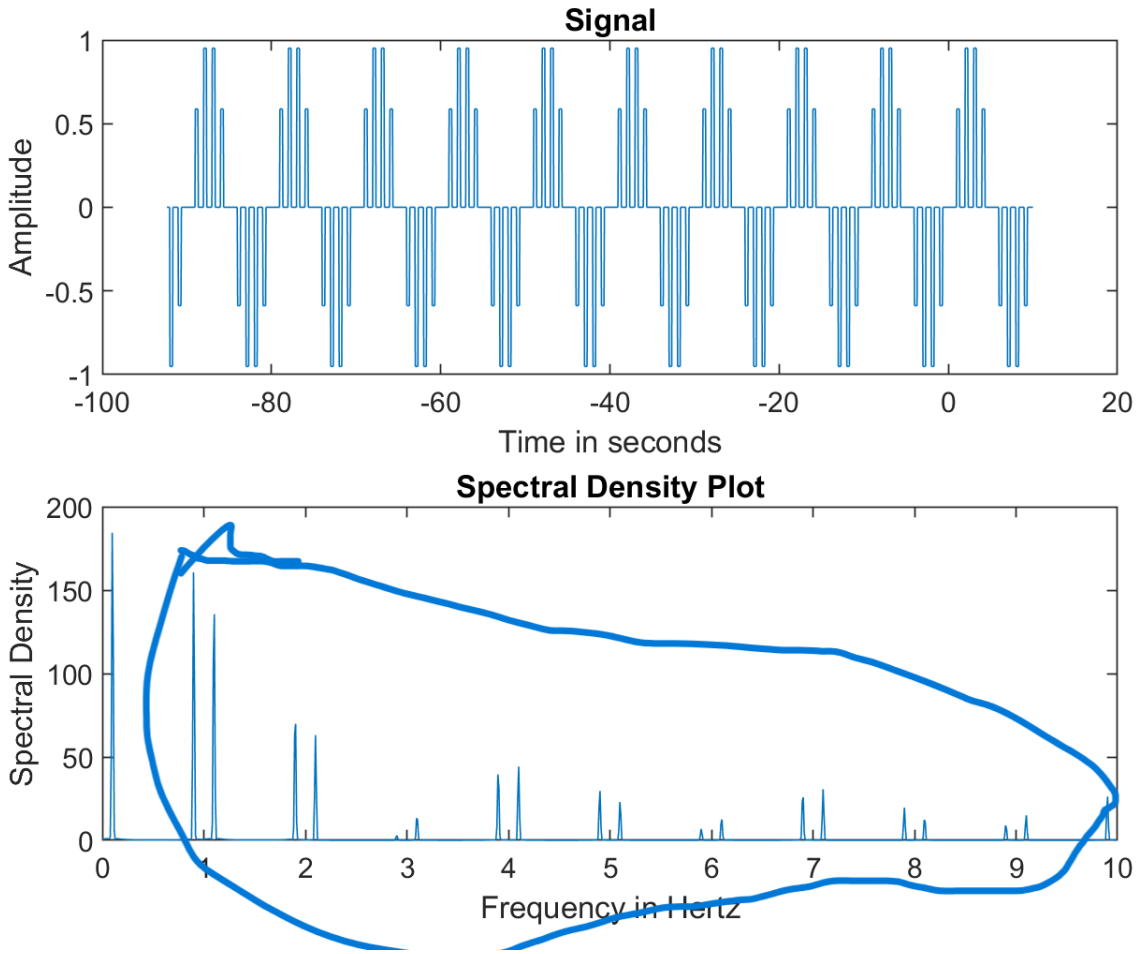


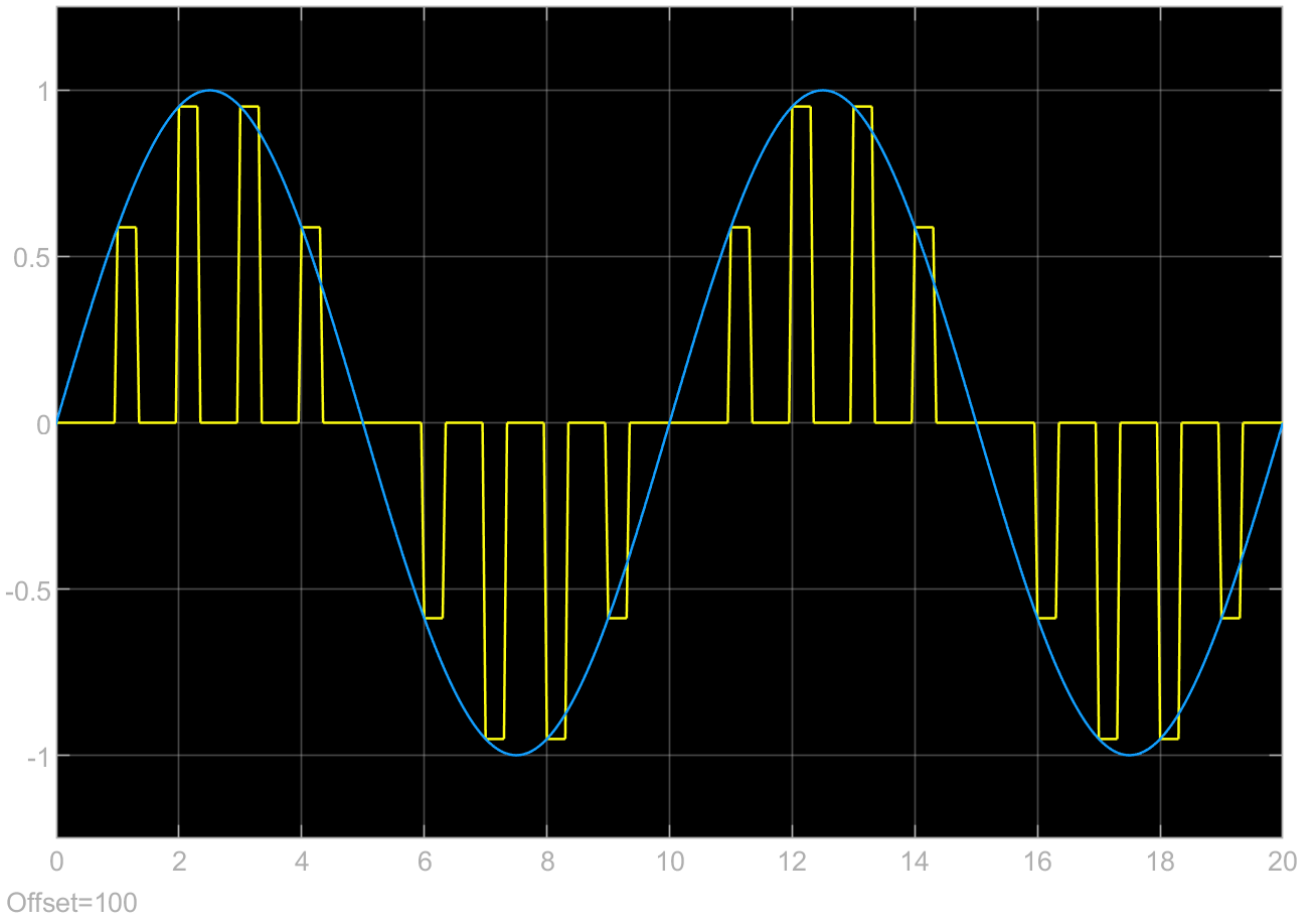
3. Comment on the shape of the two magnitude responses. How might the magnitude response of the sample-and-hold affect the design considerations of a high quality audio CD player?

For a high quality audio the sample-andhold magnitude response is not precise enough

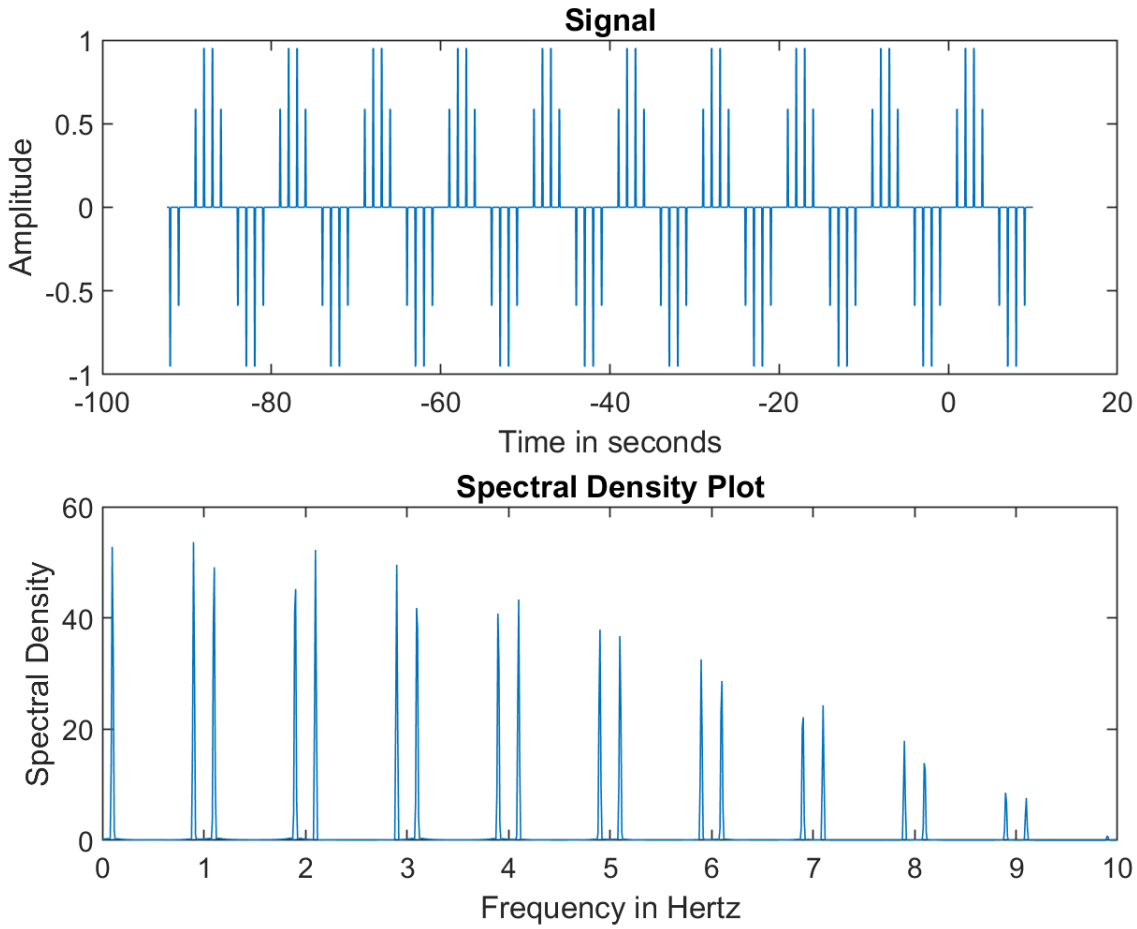
Exercise 3

1.Submit the plot of the input/output signals and the plot of the output signal and its frequency spectrum. On the plot of the spectrum of the reconstructed signal, circle the aliases, i.e. the components that do NOT correspond to the input sine wave.

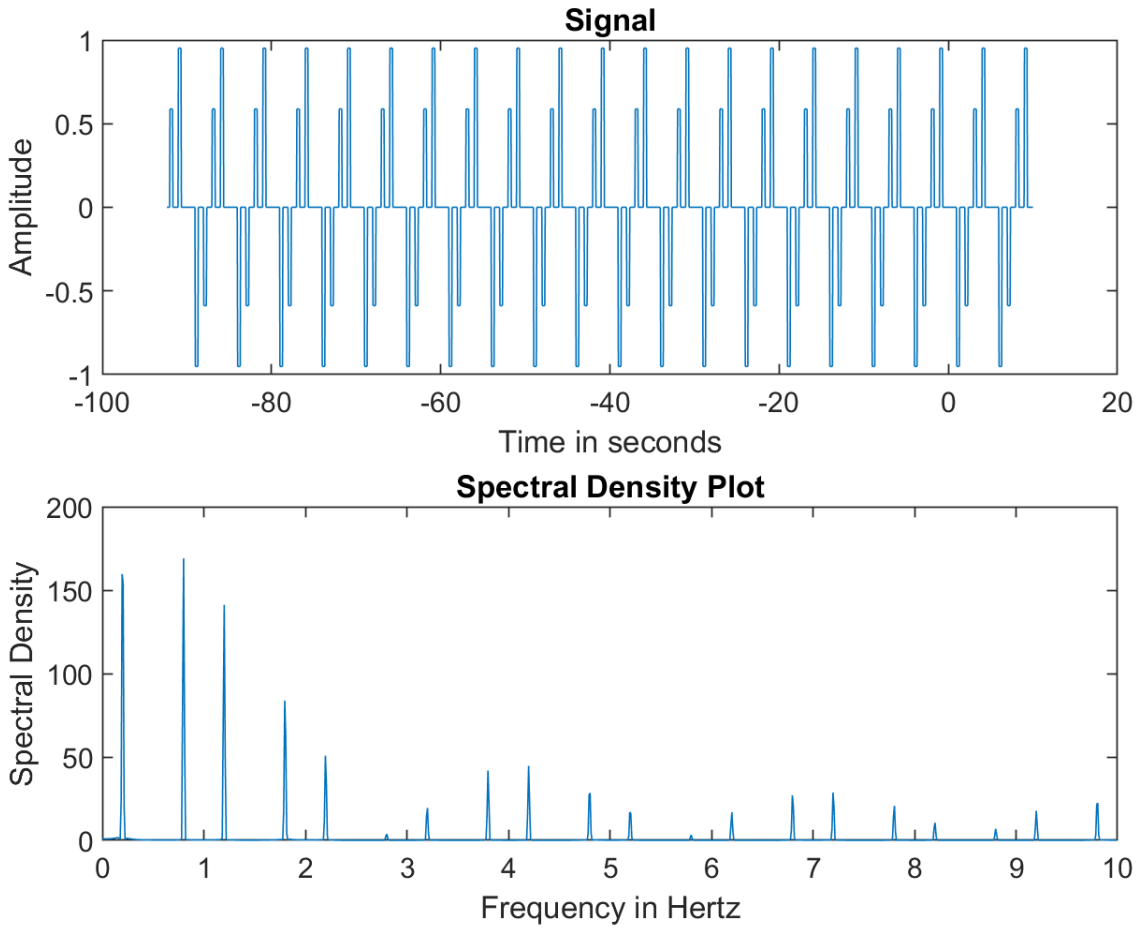


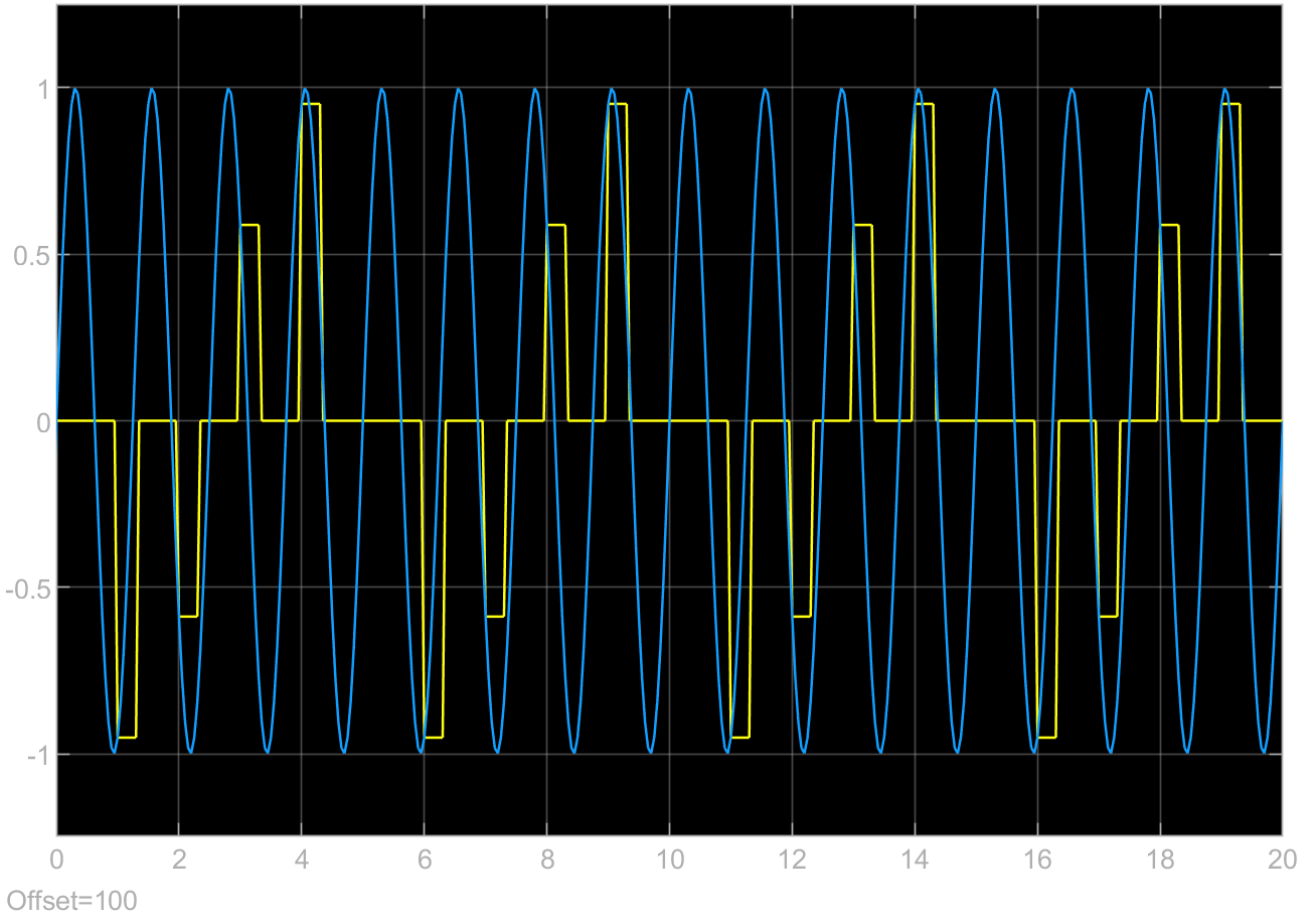


2.Submit the plot of the output frequency spectrum for a pulse width of 0.1 sec. Indicate on your plot what has changed and explain why.



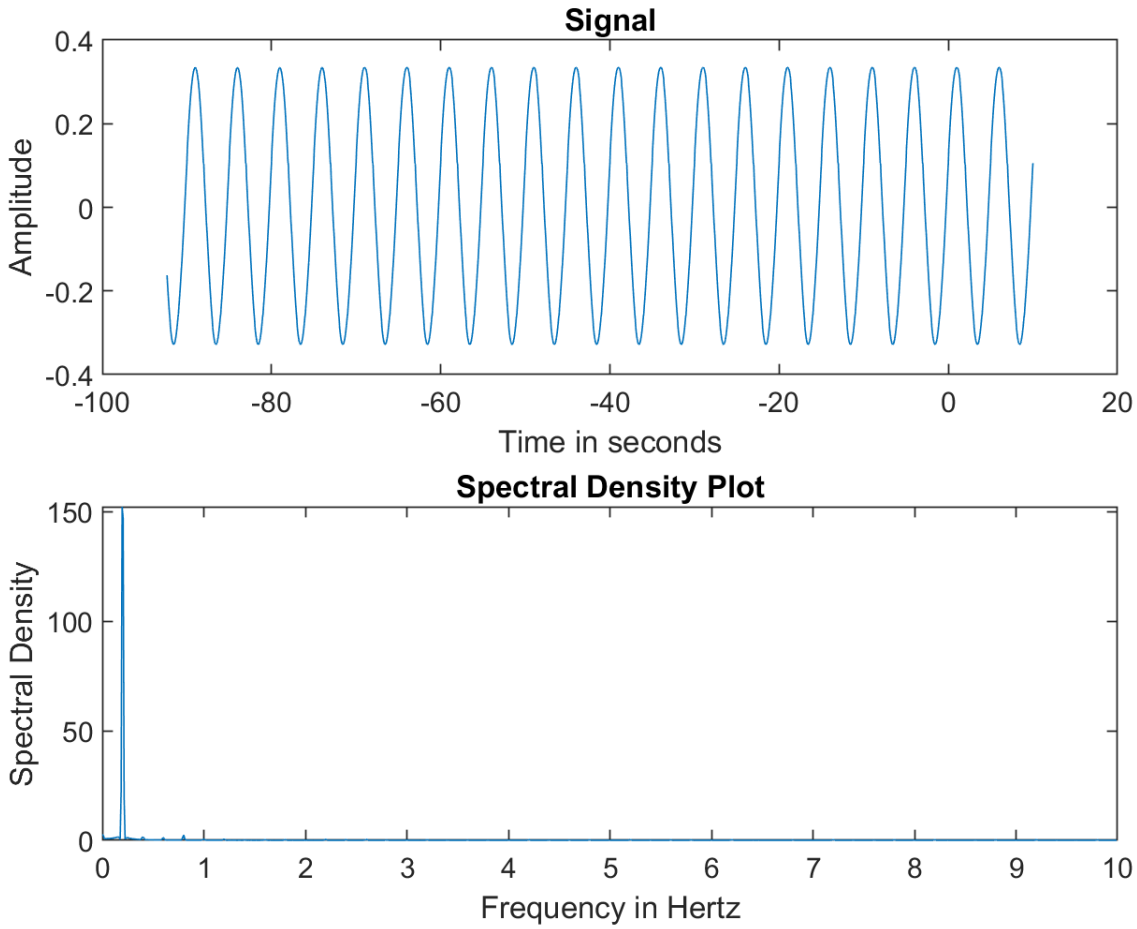
3.Submit the plot of the input/output signals and the plot of the output signal and its frequency spectrum. On the frequency plot, label the frequency peak that corresponds to the lowest frequency (the fundamental component) of the output signal. Explain why the lowest frequency is no longer the same as the frequency of the input sinusoid.

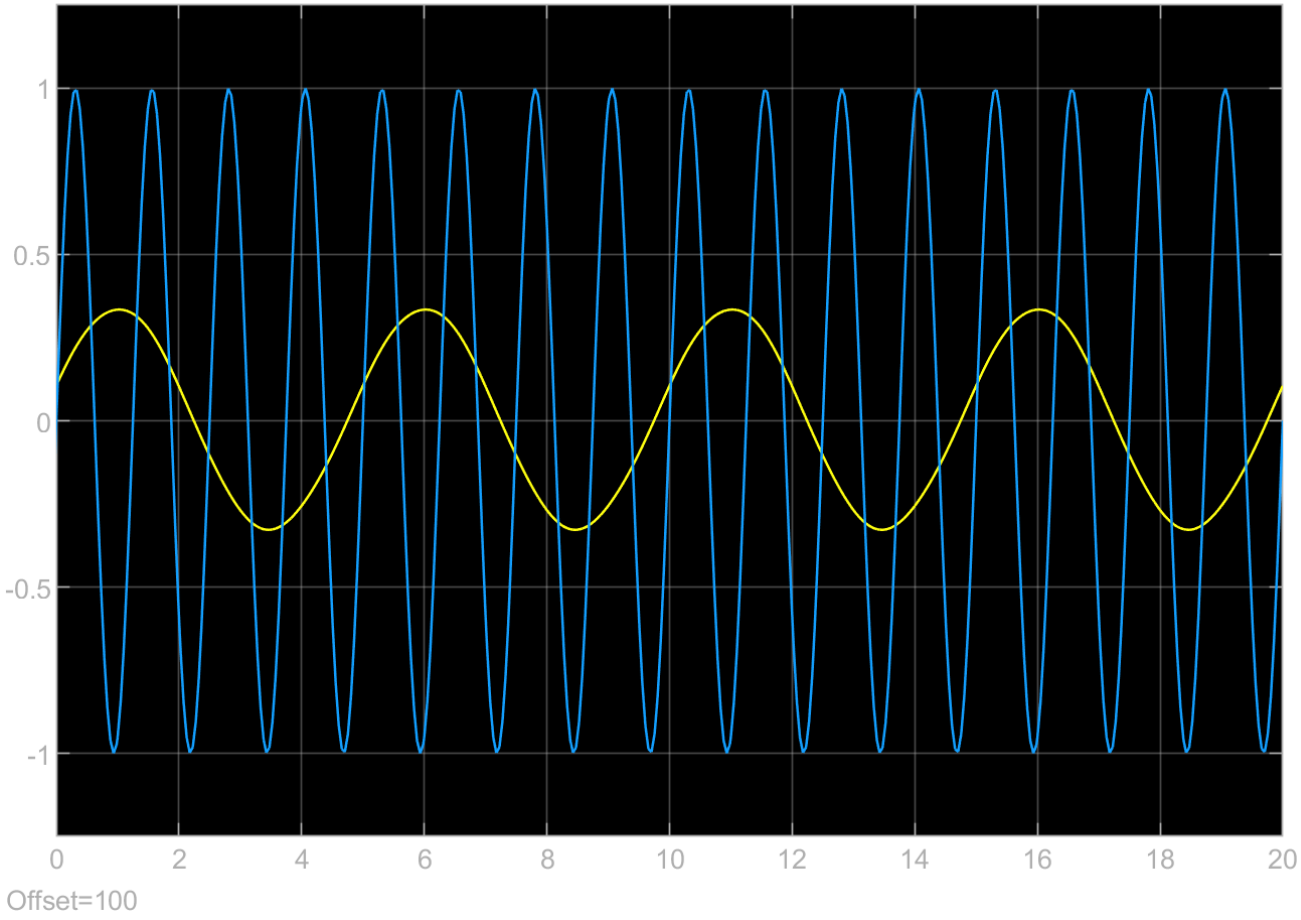

Signal
Amplitude
Time in seconds
Spectral Density Plot
Spectral Density
Frequency in Hertz




```
The sampling frequency is bigger than the signal frequency. It didn't captured the peak.
```

4.Submit the plot of the input/output signals and the plot of the output signal and its frequency spectrum. Explain why the output signal has the observed frequency spectrum.

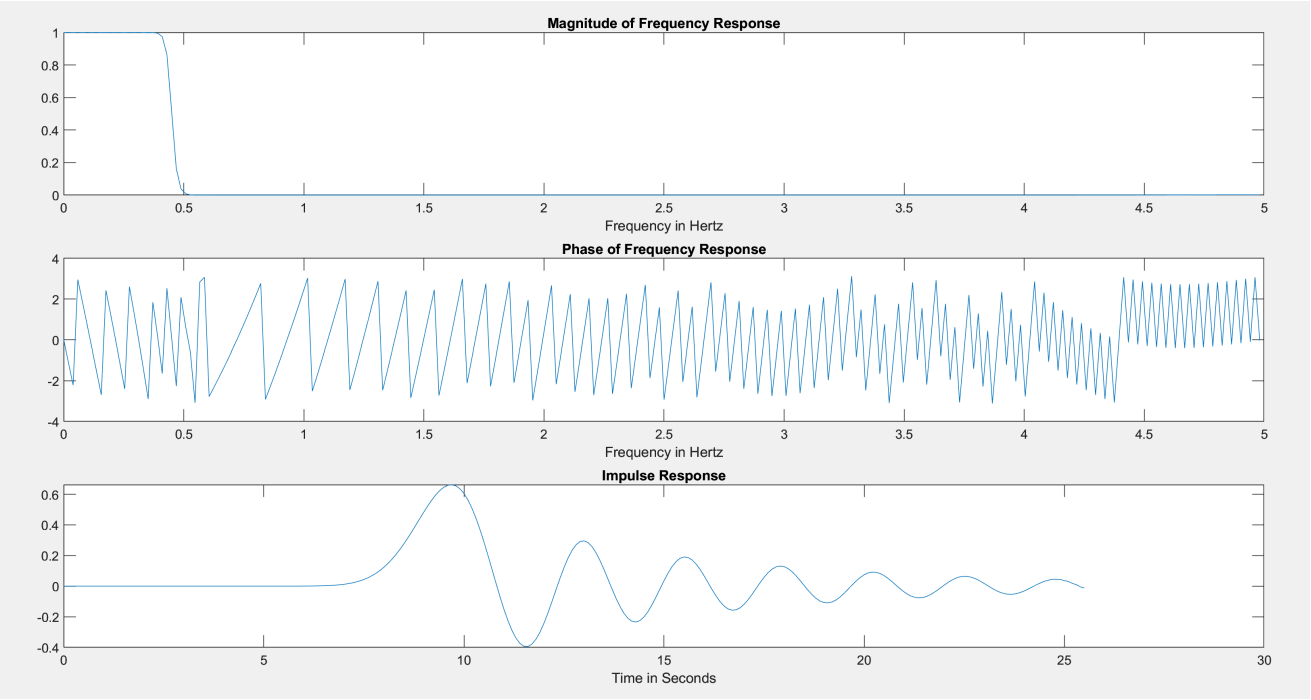

Signal
Amplitude
0.4
0.2
0
-0.2
-0.4
-100
-80
-60
-40
-20
0
20
Time in seconds
Spectral Density Plot
Spectral Density
150
100
50
0
0
1
2
3
4
5
6
7
8
9
10
Frequency in Hertz



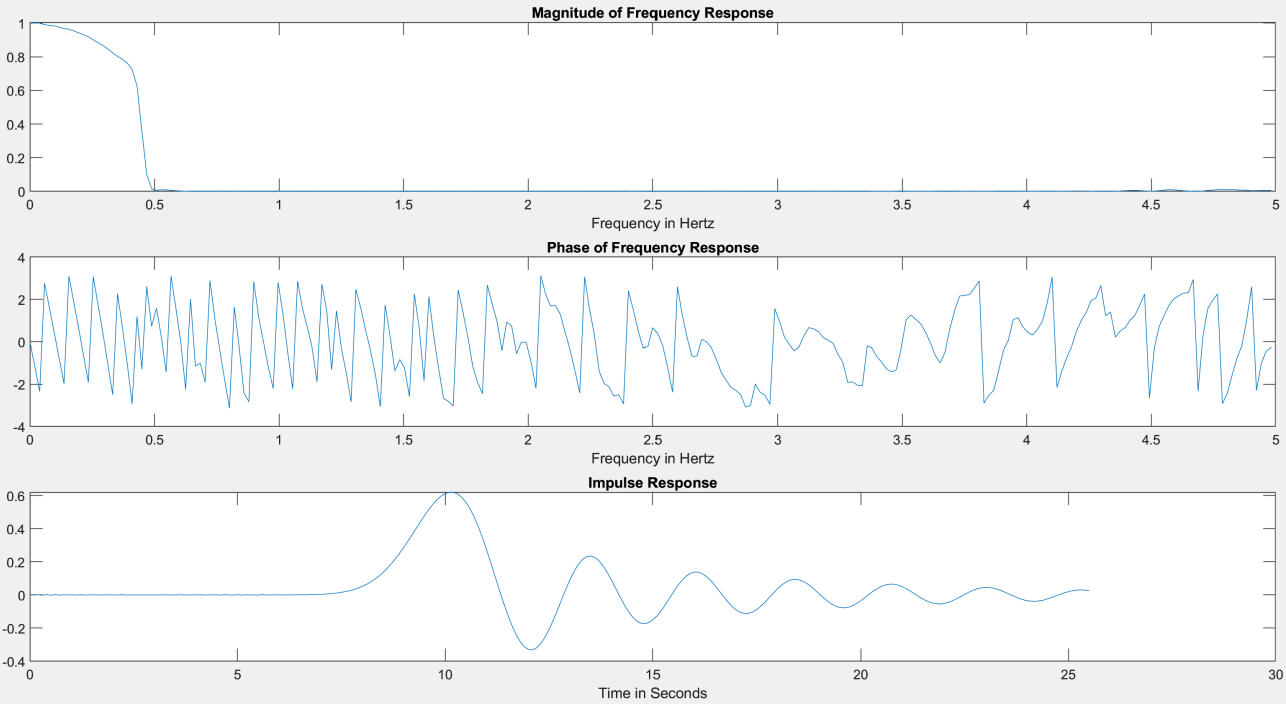
Because the aliases are filtered out

Exercise 4

1.Submit the figure containing plots of the magnitude response, the phase response, and the impulse response of this system. Use the tall mode to obtain a larger printout by typing `orient('tall')` directly before you print.



2.Submit the figure containing plots of the magnitude response, the phase response, and the impulse response of this system. Explain the reason for the difference in the shape of this magnitude response versus the previous magnitude response. Give an analytical expression for the behavior of the magnitude plot for frequencies below 0.45 Hz.



The new magintude response pass through a sinc signal, thus this behavior. Frequencies below 0.45 Hz will follow a sinc signal behavior.