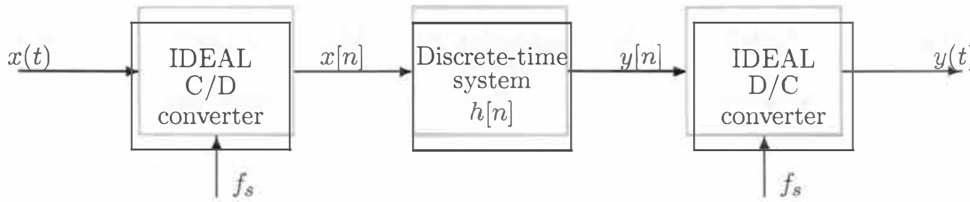
PROBLEM sp-24-FINAL.1:



This problem is related to the above block diagram of an ideal C-to-D converter, a filter, and an ideal D-to-C converter.

(a) **[2 points]** If the output from the ideal C-to-D converter is $x[n] = 3\cos(0.5\pi n)$, and the sampling rate is 2000 samples/sec, then determine one possible value of the input frequency of $x(t)$.

frequency
8000 Hz
4000 Hz
2000 Hz
1600 Hz
1200 Hz
1000 Hz
800 Hz
500 Hz
400 Hz
300 Hz

Pick a number from the list and enter its value in the answer box.

frequency =

(b) [**3 points**] If the input is $x(t) = 2\cos(100\pi t - 0.1\pi) - 7\cos(250\pi t + 0.2\pi)$, and the system is given as $h[n] = \delta[n] - \frac{\sin(0.4\pi n)}{\pi n}$, find the smallest sampling frequency, $f_s = f_{min}$, such that $y(t) = 0$ without aliasing.

Enter the value in the answer box. $\boxed{f_{min} = \quad}$

(c) [**2 points**] Suppose that

$$x(t) = \cos(400\pi t + \pi/2) + \cos(200\pi t + \pi/2).$$

Determine one value of f_s such that $x[n] = 0$.

frequency
8000 Hz
4000 Hz
2000 Hz
1600 Hz
1200 Hz
1000 Hz
800 Hz
500 Hz
400 Hz
300 Hz

Pick a number from the list and enter its value in the answer box.

$f_s =$

(d) [**5 points**] Suppose that $x(t) = \cos(500\pi t)$ and $y(t) = 0.75\cos(200\pi t)$. Also, suppose that the discrete-time IIR system is given by the following difference equation: $y[n] = a_1 y[n-1] + x[n] + b_2 x[n-2]$. Determine a value for f_s that is larger than 200 Samples/s. The same f_s is used at both the Ideal C-to-D converter and the Ideal D-to-C converter.

frequency
750 Hz
700 Hz
650 Hz
600 Hz
550 Hz
500 Hz
450 Hz
400 Hz
350 Hz
300 Hz

[2 points] Pick a number from the list and enter its value in the answer box. $f_s =$

[3 points] Determine the value of a_1 when the value for b_2 is given as $b_1 = 0.25$.

$a_1 =$

(e) [**2 points**] Suppose that the discrete-time LTI system is defined by the following difference equation:

$$y[n] = x[n] + b_1 x[n-1] + x[n-2] + a_1 y[n-1].$$

In this part, let $a_1 = -0.3$. The overall system can be used to null one continuous-time sinusoid. The frequency that is nulled is controlled by the value of b_1. If the sampling rate is $f_s = 8000$ Hz, find the value of b_1 so that the overall system nulls out a sinusoid at 60 Hz.

$b_1 =$

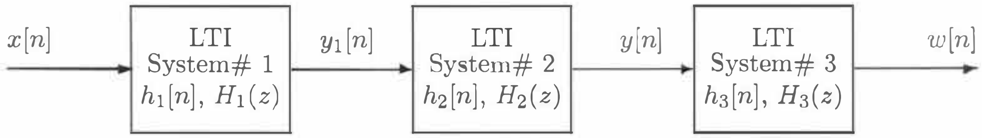
(f) [**2 points**] Suppose that the discrete-time LTI system is defined by the following difference equation:

$$y[n] = x[n] + b_1 x[n-1] + x[n-2] + a_1 y[n-1].$$

In this part, let $a_1 = 0$ and $b_1 = 1$. If the input $x(t) = 1$ for all t, what is $y(t)$ for all t?

$y(t) =$

PROBLEM sp-24-FINAL.2:



The above block diagram depicts a cascade connection of three LTI systems. Suppose that the system function for system # 1 is given as $H_1(z) = 2 - 2z^{-5}$. Also, suppose that system # 2 is an FIR filter described by the following difference equation: $y[n] = 3y_1[n] + 3y_1[n-5]$.

(a) **[2 points]** Make a pole-zero plot for the first system, system # 1. Account for all poles and zeros.

(b) **[2 points]** If we would like to replace the first two systems, # 1 and # 2, with a single overall system that has an impulse response $h[n]$, determine $h[n]$ as a sum of scaled and shifted delta functions.

$h[n] =$

(c) [**3 points**] What is $y[n]$ when $x[n] = \cos(\pi n + \pi/5)$.

$y[n] =$

(d) [**2 points**] Suppose that $y[n] = 6\delta[n-2] - 6\delta[n-12]$ is the output of system# 2 when $x[n] = \delta[n-B]$, where B is an integer. Determine the value of B.

$B =$

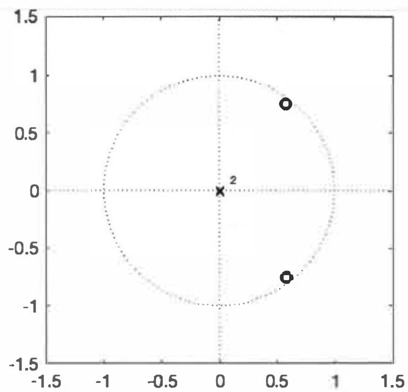
(e) [**4 points**] We would like to design system# 3 such that it inverts the cascade of the first two systems, $H_1(z)$ and $H_2(z)$. Suppose that system# 3 can be defined by the following difference equation: $w[n] = a_1 w[n-1] + a_{10} w[n-10] + b_0 y[n] + b_{10} y[n-10]$.

Determine the values of a_1, a_{10}, b_0, and b_{10}.

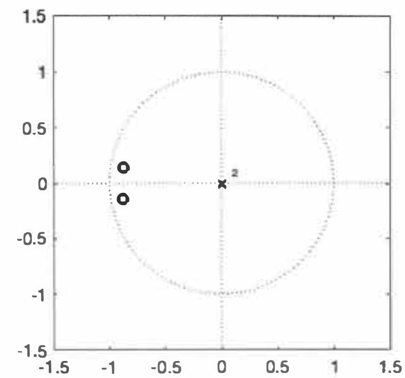
$a_1 =$	$a_{10} =$	$b_0 =$	$b_{10} =$

PROBLEM sp-24-FINAL.3:

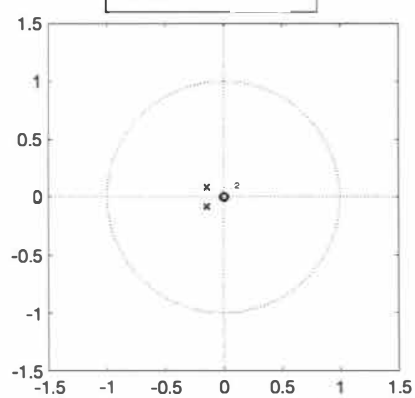
(a) **[2 points Each]** Below are the pole-zero plots of the system functions, H(z), of several discrete-time systems. Also, there are plots of impulse responses, $h[n]$, on the next page. For each pole-zero plot, enter the letters of the matching impulse response. There are more impulse response plots than pole-zero plots.



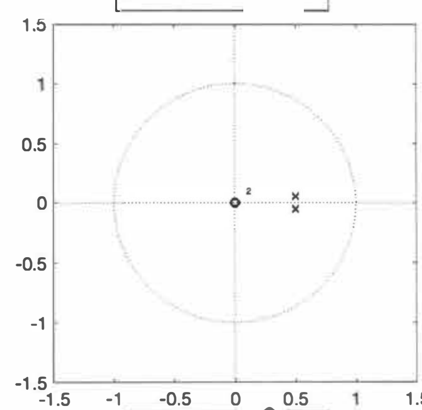
ANS =



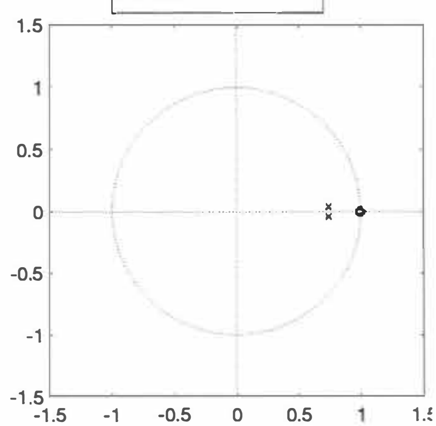
ANS =



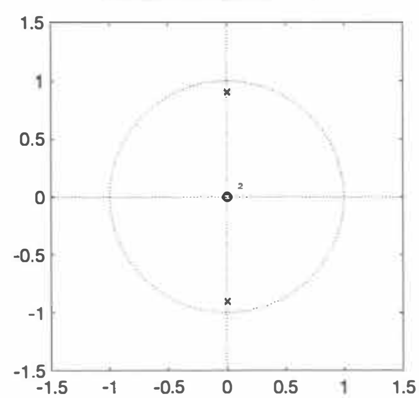
ANS =



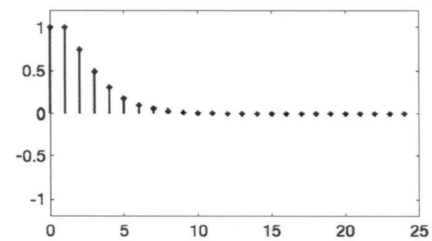
ANS =



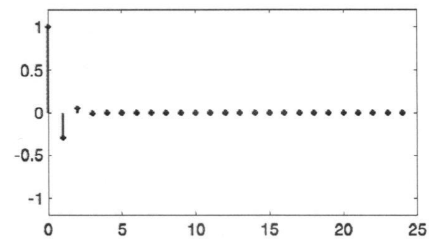
ANS =



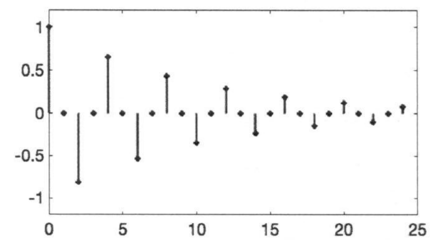
ANS =


1
0.5
0
-0.5
-1
0 5 10 15 20 25

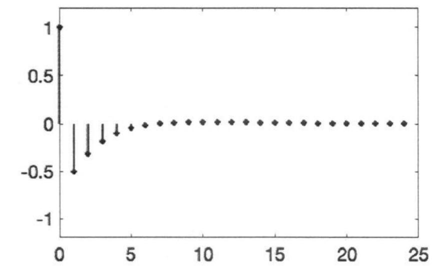
A


1
0.5
0
-0.5
-1
0 5 10 15 20 25

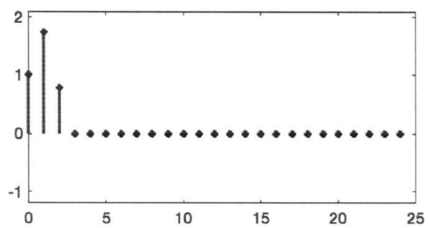
B


1
0.5
0
-0.5
-1
0 5 10 15 20 25

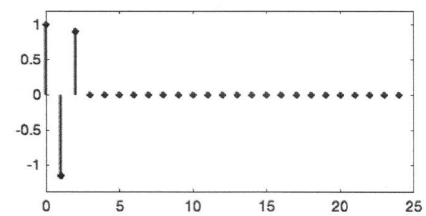
C


1
0.5
0
-0.5
-1
0 5 10 15 20 25

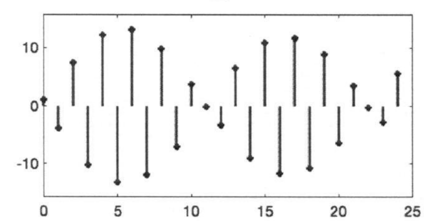
D


2
1
0
-1
0 5 10 15 20 25

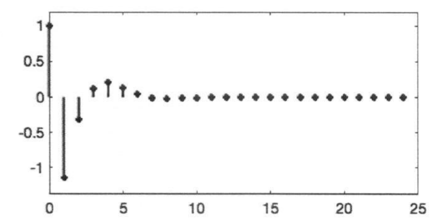
E


1
0.5
0
-0.5
-1
0 5 10 15 20 25

F


10
0
-10
0 5 10 15 20 25

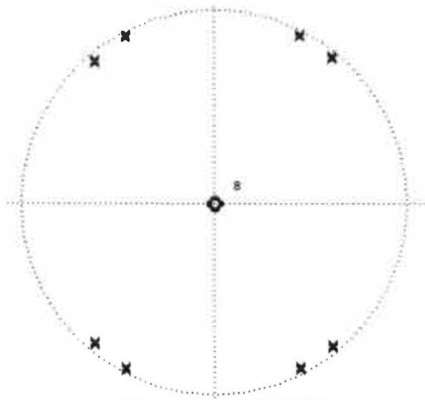
G


1
0.5
0
-0.5
-1
0 5 10 15 20 25

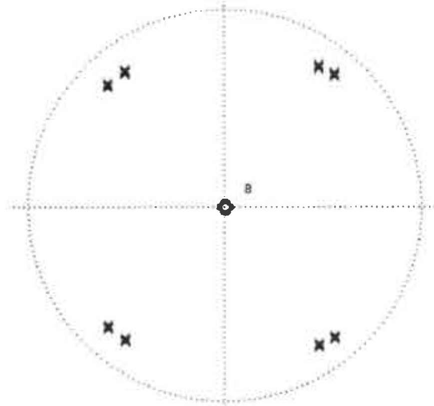
H

This page is left blank so that you can use it as work space.

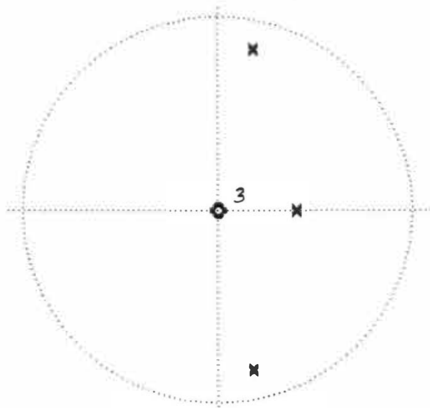
(b) **[2 points Each]** Below are the pole-zero plots of the system functions, H(z), of several discrete-time systems. Also, there are plots of frequency responses, $H(e^{j\omega})$, on the next page. For each pole-zero plot, enter the letters of the matching frequency response. There are more frequency response plots than pole-zero plots.



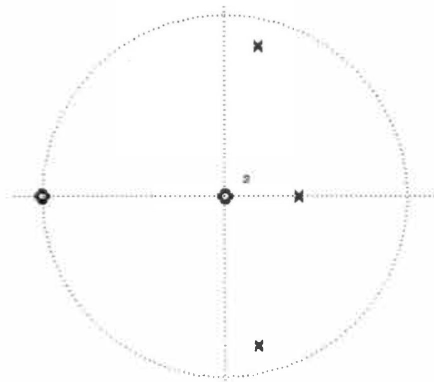
ANS =



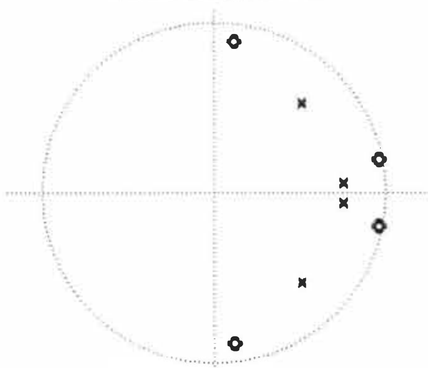
ANS =



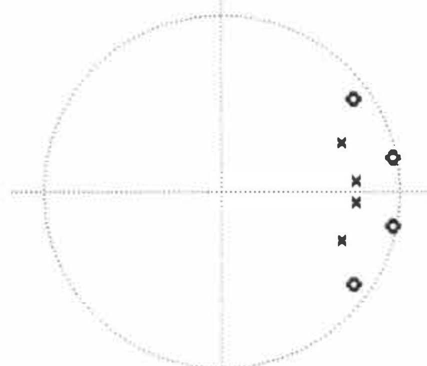
ANS =



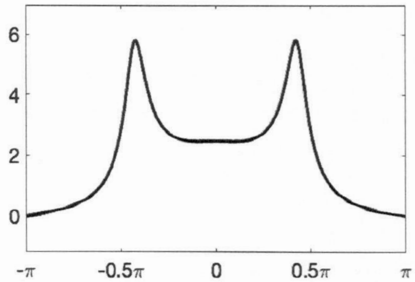
ANS =



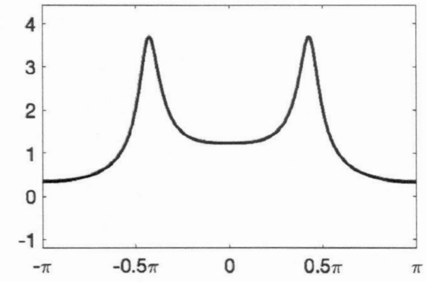
ANS =



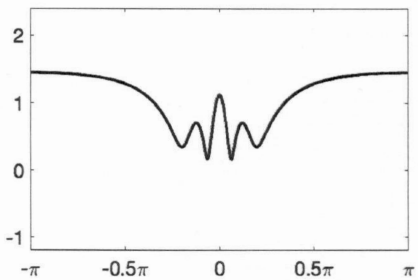
ANS =


6
4
2
0
-π -0.5π 0 0.5π π

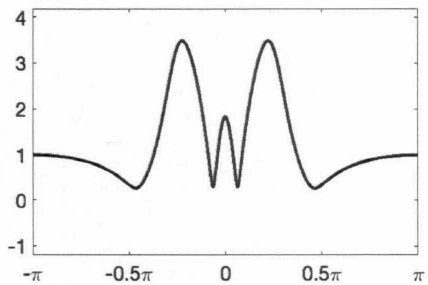
A


4
3
2
1
0
-1
-π -0.5π 0 0.5π π

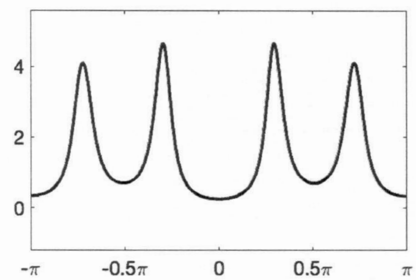
B


2
1
0
-1
-π -0.5π 0 0.5π π

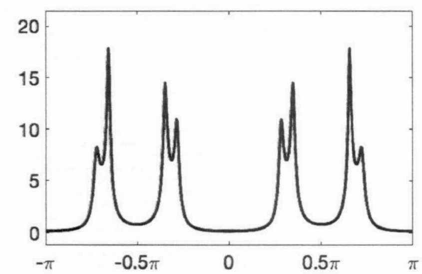
C


4
3
2
1
0
-1
-π -0.5π 0 0.5π π

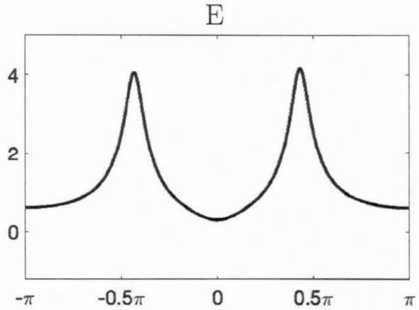
D


4
2
0
-π -0.5π 0 0.5π π

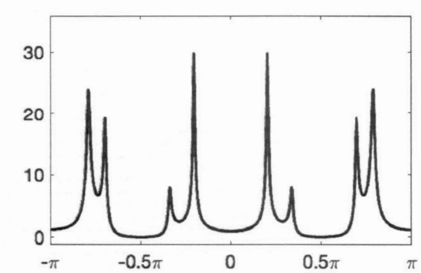
E


20
15
10
5
0
-π -0.5π 0 0.5π π

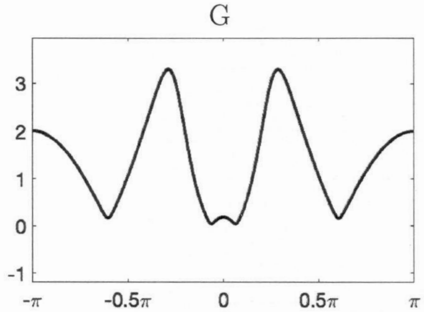
F


4
2
0
-π -0.5π 0 0.5π π

G


30
20
10
0
-π -0.5π 0 0.5π π

H


3
2
1
0
-1
-π -0.5π 0 0.5π π

I

This page is left blank so that you can use it as work space.

PROBLEM sp-24-FINAL.4:

[3 points Each] Pick the correct frequency response characteristic and enter the number in the answer box. Each frequency response is used only once. There are more items on the right-hand list than on the left-hand list.

(a) $h[n] = \left(-\frac{1}{2}\right)^n u[n]$

(b) $H(z) = 1 + z^{-1} + z^{-2} + z^{-3} + z^{-4}$

(c) `yn = filter([1,1],1,xn)`

(d) $h[n] = \sum_{k=0}^{3} \delta[n-k]$

(e) $y[n] = x[n-1] + 2x[n-3] + x[n-5]$

(f) $y[n] = \frac{1}{2}y[n-1] + x[n]$

1. $H(e^{j\hat{\omega}}) = \frac{1}{1-0.5e^{-j\hat{\omega}}}$

2. $H(e^{j\hat{\omega}}) = \frac{1}{1+0.5e^{-j\hat{\omega}}}$

3. $H(e^{j\hat{\omega}}) = 2e^{-j2\hat{\omega}}(0.5 + \cos(\hat{\omega}) + \cos(2\hat{\omega}))$

4. $H(e^{j\hat{\omega}}) = \frac{1}{1-e^{-j0.5\hat{\omega}}}$

5. $|H(e^{j\hat{\omega}})| = 2\cos(\hat{\omega}/2)$

6. $H(e^{j\hat{\omega}}) = \frac{\sin(2\hat{\omega})}{\sin(0.5\hat{\omega})}e^{-j1.5\hat{\omega}}$

7. $\angle H(e^{j\hat{\omega}}) = -3\hat{\omega}$

8. $|H(e^{j\hat{\omega}})| = 0.5\cos(2\hat{\omega})$

This page is left blank so that you can use it as work space.

PROBLEM sp-24-FINAL.5:

The parts in this problem are independent from each other.

(a) **[6 points]** Two periodic sequences are given as follows:

n	...	0	1	2	3	4	5	6	7	8	9	10	11	12	...
$x_1[n]$	...	1	0.5	-0.5	-1	-0.5	0.5	1	0.5	-.5	-1	-0.5	0.5	1	...
$x_2[n]$	...	0	2	0	-2	0	2	0	-2	0	2	0	-2	0	...

Note that the two signals have different periodicity. Suppose that we add the two signals to have a new periodic signal $x[n] = x_1[n] + x_2[n]$. For the sequence $x[n], n = 0, ..., 11$, determine the 12-point DFT sequence and write the values in the following table.

Hint: Write $x_1[n]$ and $x_2[n]$ as simple sinusoids.

k	0	1	2	3	4	5
$X[k]$						

k	6	7	8	9	10	11
$X[k]$						

(b) **[2 points]** Suppose the DFT, $X[k]$, of a sequence $x[n]$ shown below, is real. That is, $X^*[k] = X[k]$ for $k = 0, ..., 7$. Can the unknown values of $x[n]$ be determined? If yes, give the missing values. If no, then justify your answer.

$$\{1, 7, ?, ?, 1, 6, 5, 7\}$$

circle one **YES** (give the missing values below) or **NO** (justify)

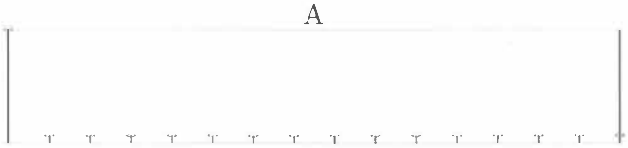
(c) [**1 point Each**] Shown below are different outcomes that result from executing the following MATLABcode:

```
stem(abs(fft(ones(1,L),N));
```

s Match each plot with the corresponding values for the variables N nd L by writing a letter (A through I) in each answer box.

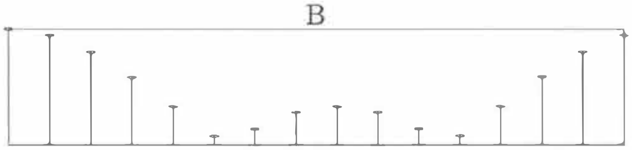
A

`L = 2, N = 16` ANS =



B

`L = 2, N = 64` ANS =

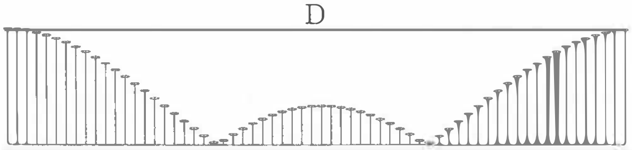


C

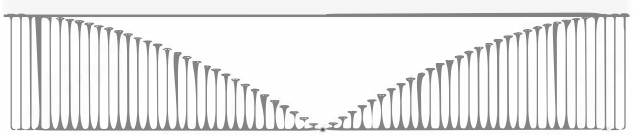
`L = 3, N = 16` ANS =

D

`L = 3, N = 64` ANS =

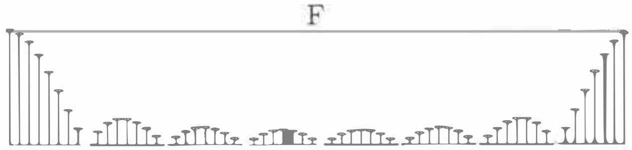


`L = 8, N = 16` ANS =

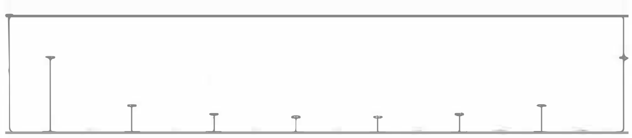


F

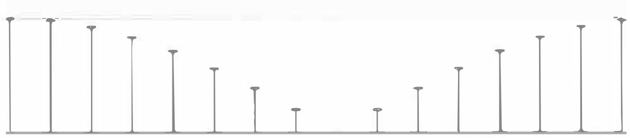
`L = 8, N = 64` ANS =



`L = 15, N = 16` ANS =



`L = 15, N = 64` ANS =



I

`L = 16, N = 16` ANS =

PROBLEM sp-24-FINAL.6:

The parts in this problem are independent from each other.

(a) [**4 points**] Simplify the following expression of $x[n]$ with a single term.

$$x[n] = \sum_{k=-\infty}^{\infty} \left(\frac{\sin(0.7\pi k)}{\pi k}\right) \cdot \left(\frac{\sin(0.85\pi(n-k))}{\pi(n-k)}\right)$$

$x[n] =$

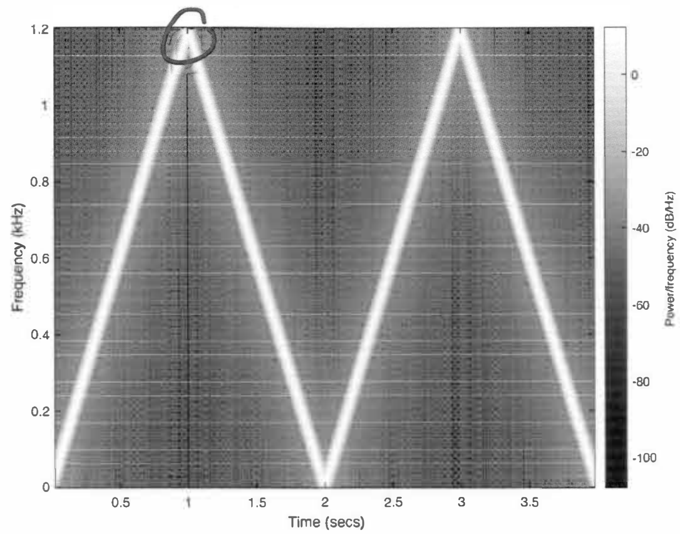
(b) [**4 points**] Determine the fundamental frequency of the signal

$$x(t) = \cos(40\pi t)\cos(24\pi t) + \cos(60\pi t)$$

$f_0 =$	Hz

(c) [**4 points**] Running the following MATLAB code produces the plot below, for a specific value of the parameter W.

```
fsamp = 2400;
tmax = 4;
tt = 0:(1/fsamp):tmax;
xx = real((20+15*j)*exp(j*2*pi*W*(tt.^2)));
spectrogram(xx,128,120,512,fsamp,'yaxis')
```



Note that the y-axis is in kHz, i.e., the highest frequency shown is 1200 Hz.

Determine the numerical value of the parameter W in the MATLAB code.

W =