King Khalid University
College of Computer Science
Department of Computer Engineering

Experiment # 1 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

Lab Day: _____ Section Number: _____ Serial Number: _____

1446 || 2024

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Experiment # 1

Introduction to MATLAB

Do the following Operations inside the MATLAB Command window and write down the results.

>> x = 3

Question: What is the data type of x? Did you define the datatype? Why
Your Answer:

>> y = x^2

>> a = 3;
>> b = a^3;
Question: Did you get the result? Why? Are the variables a and b available in the workspace?
Your Answer:

>> a

>> b

>> who

Question: What did it display ?
Your Answer:

>> clear x
Question: What happened to variable x?
Your Answer:

>> clear all
Question: What happened to all the variables ? Check the workspace.
Your Answer:

>> clc
Question: What did you notice in the command window?
Your Answer:

```
>> x = pi/3;
```

```
>> sin(x)
```

```
>> cos(x)
```

```
>> tan(x)
```

```
>> y = sin(x)^2 + cos(x)^2
```

```
>> 2*(sin(x)^2) + cos(2*x)
```

```
>> fix(clock)
```

Question: What did you get?
Your Answer:

MATRIX OPERATIONS IN MATLAB

Question: Write the command to enter the following MATRIX

$$A = \begin{bmatrix} 1 & 2 & 0 \\ 2 & 5 & -1 \\ 4 & 10 & -1 \end{bmatrix} \text{ and } B = \begin{bmatrix} 3 & 1 & 2 \\ 6 & 4 & 5 \\ 8 & 9 & 7 \end{bmatrix}$$

>> A = _____
>>

>> B = _____
>>

>> C = A+B
>>

>> D = A-B
>>

Observation: Is matrix C = D? Why?
Answer:

>> E = A*B
>>

>>F= B*A
>>

Observation: Is matrix E = F? Why?
Answer:

>> G = A.*B

>> H = B.*A

Observation: Is Matrix 'G' equal to Matrix 'H' ?
Answer:

>> I = A'

>> J = B'

Observation: What is this operation called as?
Answer:

>> K = inv(B)

Observation: What is this operation called as?
Answer:

>> eig(A) %eigen values of matrix A

>> det(B)

Observation: What is this operation called as?
Answer:
Question : For the matrix equation below, A X = B, determine the vector X.

$$\begin{bmatrix} 4 & -2 & -10 \\ 2 & 10 & -12 \\ -4 & -6 & 16 \end{bmatrix} \begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix} = \begin{bmatrix} -10 \\ 32 \\ -16 \end{bmatrix}$$

>>clc

```
>>clear all
>>close all
>> A = _____
>>

>> B = _____
>>

>> X = inv(A)*B
>>
```

Question : Find the 4X4 Magic Matrix 'M'

```
>> M = _____
```

Question : Display all the elements of the second row of the matrix M

Question : Display all the elements of the thord column of the matrix M

POLYNOMIAL OPERATIONS / VECTOR OPERATIONS

Question : Find the roots of the polynomial $P(x) = x^3 - 2x - 5$

```
>> clc
>> clear all
>> close all
>> p = [1    0    -2    -5]
>>

>> r  = roots(p)
```

Question : Estimate the Polynomial from the above roots 'r'

```
>> p2 = poly(r)   % to get back the polynomial from the roots
>>
```

Question : Find the value of P of the polynomial $P(x) = x^3 - 2x - 5$ at x = 10.

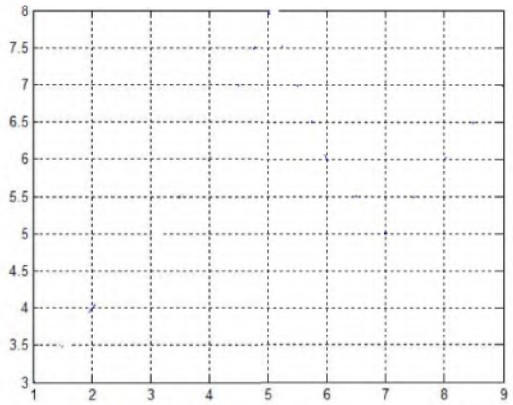
```
>> polyval(p,10)
>>
```

Question : Multiply the two polynomials $a(x) = x^2 + 2x + 3$ and $b(x) = 4x^2 + 5x + 6$

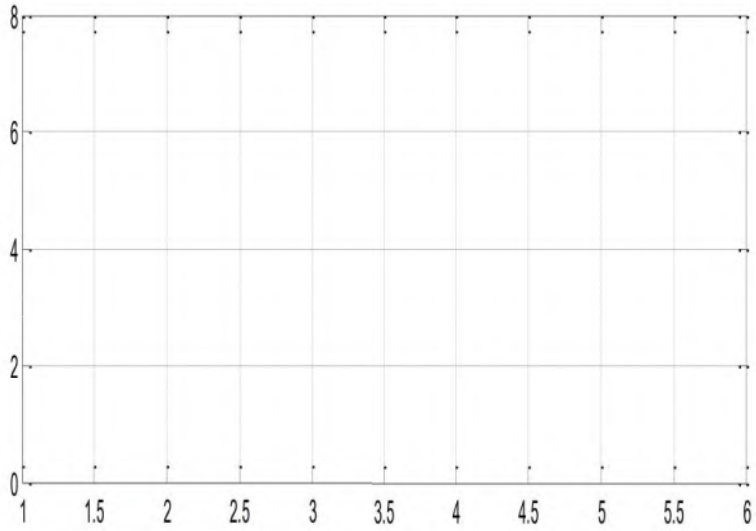
```
>> clc
>> clear all
>> close all
>> a = [1 2 3];
>> b = [4 5 6];
>> c  = conv(a,b)   % to find the multiplication (linear convolution) of two polynomials


>> [d , r1] = deconv (c , a)     % to get back the polynomial b


>> [e , r2] = deconv(c , b)     % to get back the polynomial a
```

VARIOUS PLOTS IN MATLAB

```
>> clc
>> clear all
>> close all
>> A = [1 2 3 4 6 4 3 4 5]


>> B = A + 2


>> plot(B)
```

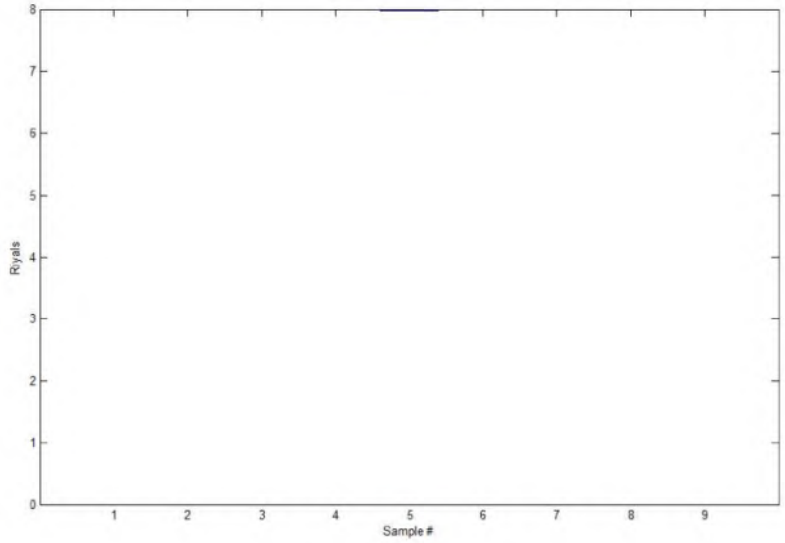


```
>> grid on
>> figure
>> stem (A,B)
 >> grid on
```

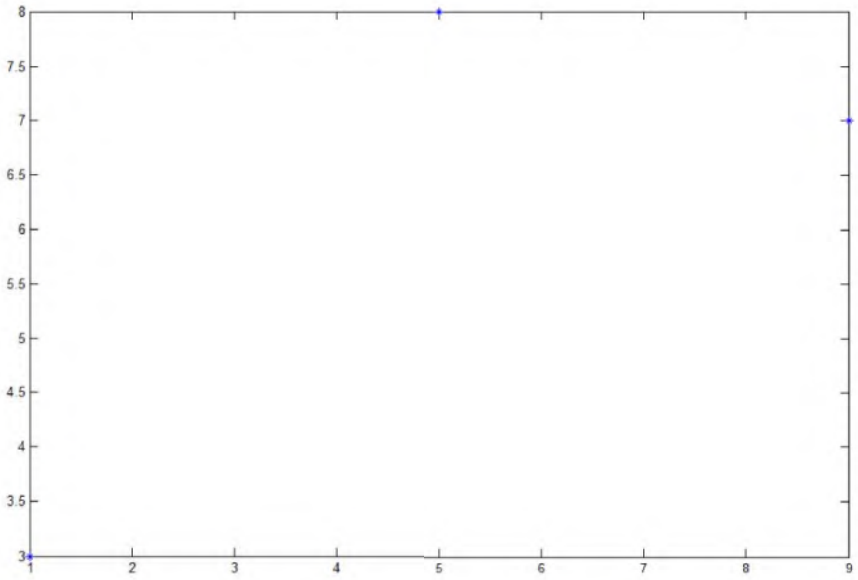


Observation: What is the difference between Plot and Stem?
Answer

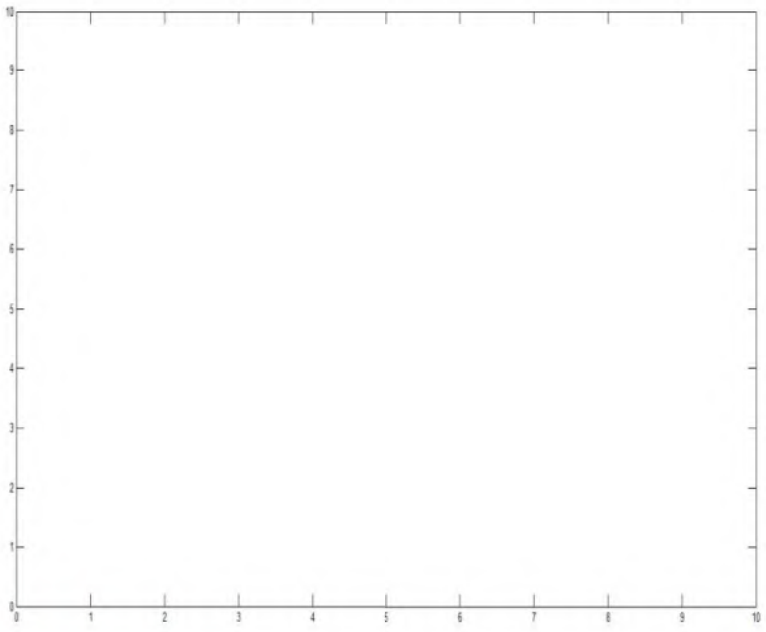
```
>> bar(B)                %bar plot
>> xlabel('Sample #')
>> ylabel('Riyals')
```



>> figure
>>plot(B,'*')



>> axis([0 10 0 10])



Question: What is the use of *'axis'*?

LAB ACTIVITY – EXERCISE

NOW OPEN THE NEW SCRIPT (CTRL +N) AND DO THE FOLLOWING TASKS. SAVE THE FILE AS CNE311_<EXPERIMENTNUMBER>_<QUESTIONNUMBER>
(EXAMPLE: CNE311_EXP1_1)

1. **Write the MATLAB program to find the AREA and CIRCUMFERENCE of the circle. The radius of the circle must be given as input from the command window.**

MATLAB PROGRAM

OUTPUT OF THE PROGRAM : (FROM COMMAND WINDOW)

2. **Write the MATLAB program to find the square of the elements of the vector of any size. Display also the size of the given vector.**

MATLAB PROGRAM

OUTPUT OF THE PROGRAM : (FROM COMMAND WINDOW)

Quewstion 3: Find the Output of the following. Write down your observation for each operation

```
>> A = [-.5 .1 .5];
```

```
>> B = round(A)
```

```
>> C = fix(A)
```

```
>> D = ceil(A)
```

```
>> E = floor(A)
```

```
>> F = sum(A)
```

```
>> G = prod(A)
```

Question 4: Consider the two polynomials $p(s) = s^2 + 2s + 3$ and $q(x) = s + 1$. Using the MATLAB, compute

a) **Product of p(s) and q(s)**

b) **Roots of p(s) and q(s)**

c) **Multiplication of p(-1) and q(6)**

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Experiment # 2 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

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Experiment #2

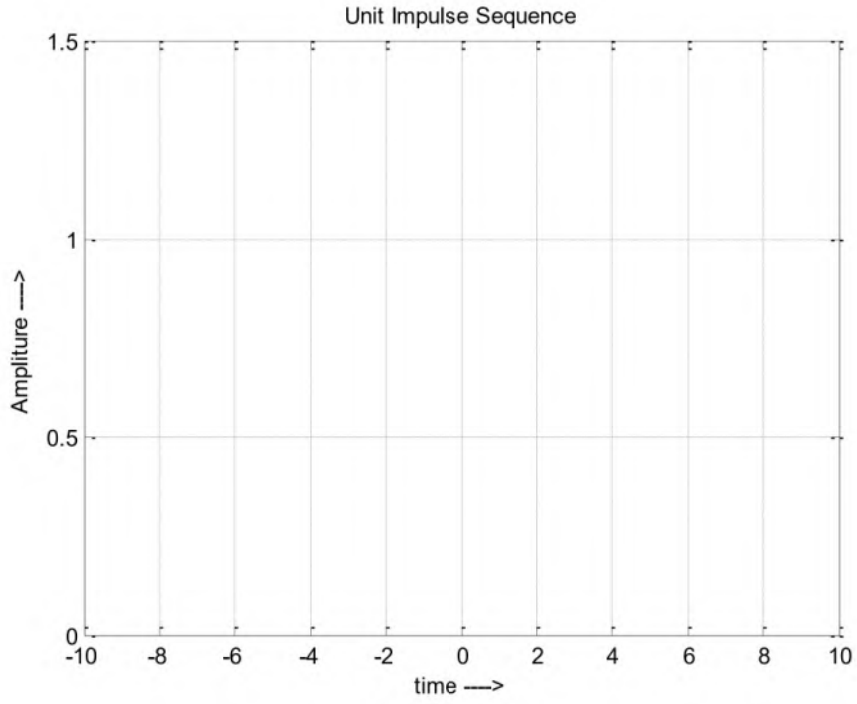
Generation of Sequences

Question 1: Generate a Discrete Unit Impulse Sequence in between the time period n = -10 to 10 using MATLAB. Plot the diagram from -10 to 10 on X-Axis and 0 to 1.5 on Y-Axis.

PROGRAM:

```
clc
clear all
close all
n = -10:10;
y = [zeros(1,10) 1 zeros(1,10)];
% plot the sequence
stem(n,y);
axis([-10 10 0 1.5]);
xlabel('time ---->');
ylabel('Ampliture ---->');
title('Unit Impulse Sequence');
grid on;
```

Output:

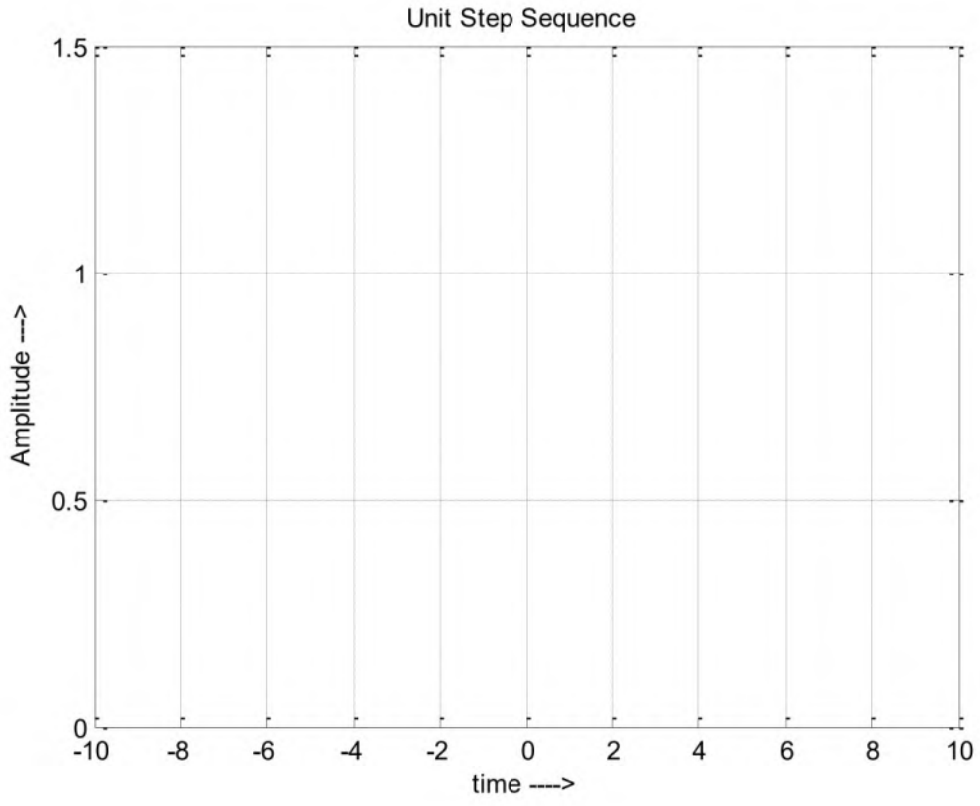


Question 2: Generate a Discrete Unit Step Sequence in between the time period n = -10 to 10 using MATLAB. Plot the diagram from -10 to 10 on X-Axis and 0 to 1.5 on Y-Axis.

PROGRAM:

```
clc
clear all
close all
n = -10:10;
u =[zeros(1,10) ones(1,11)];
stem (n,u);
axis([-10 10 0 1.5]);
xlabel(' time ----> ' );
ylabel(' Amplitude --->' );
title('Unit Step Sequence ');
grid on;
```

OUTPUT:

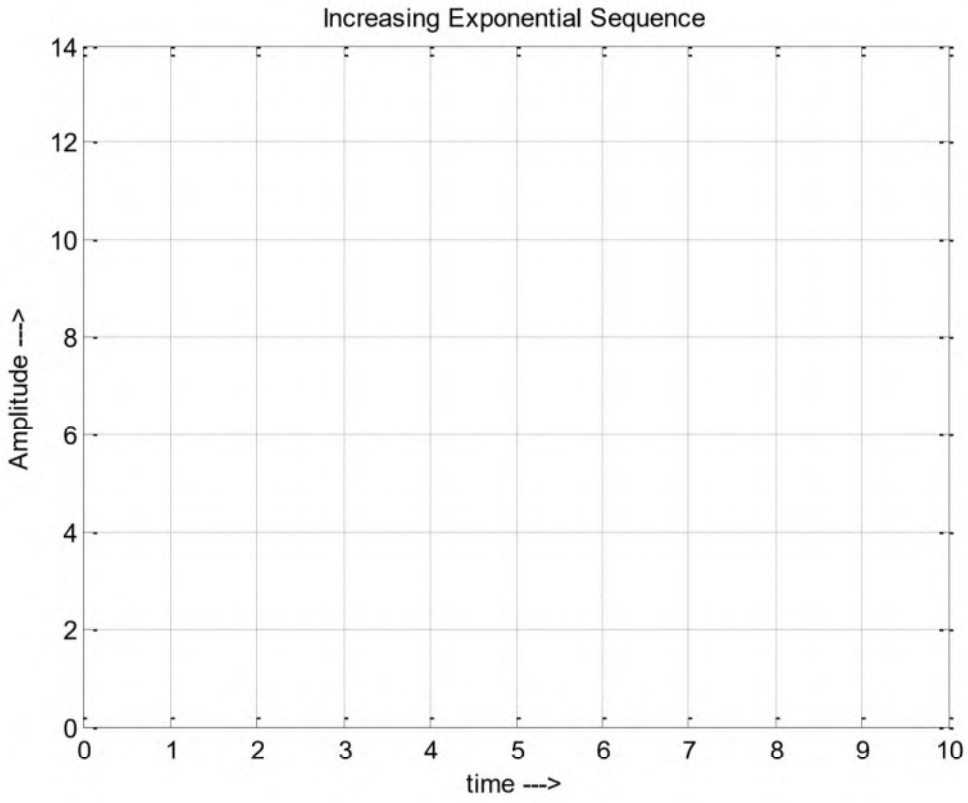


Question 3: Generate a Discrete Increasing Exponential Sequence in between the time period n = 0 to 10 using MATLAB. Plot the diagram from 0 to 10 on X-Axis and 0 to Maz Value on Y-Axis.

PROGRAM:

```
clc
clear all
close all
n=0:1:10;
y = (1.3).^n;
stem (n, y);
xlabel('time --->');
ylabel('Amplitude --->') ;
title('Increasing Exponential Sequence');
grid on;
```

OUTPUT:

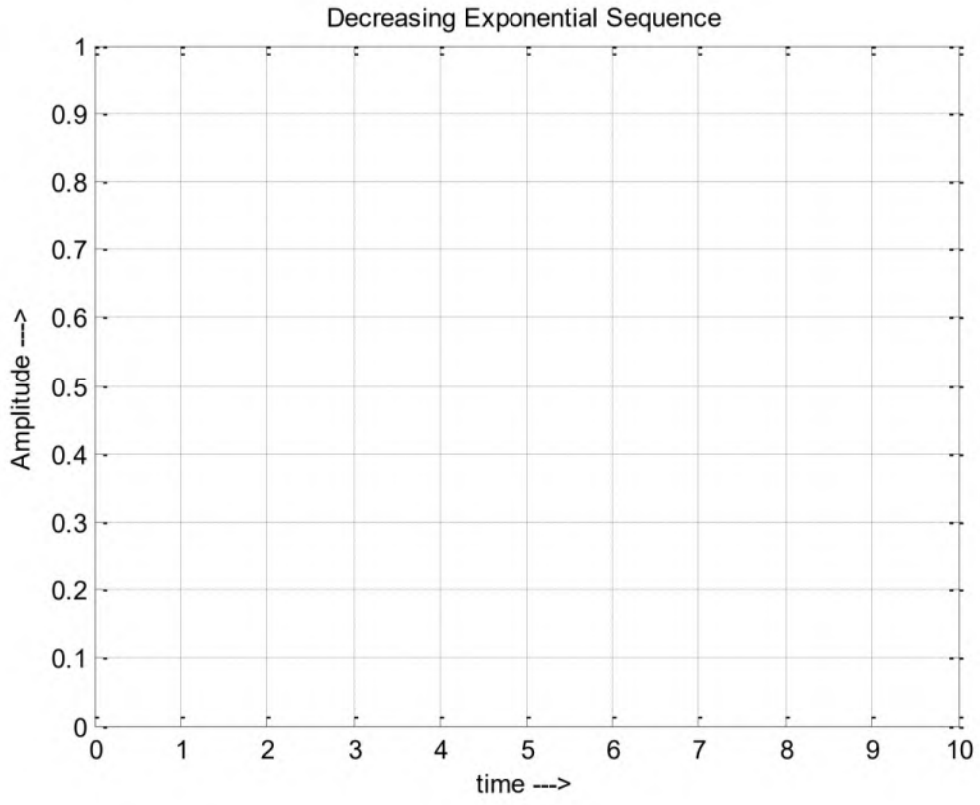


Question 4: Generate a Discrete Decreasing Exponential Sequence in between the time period n = 0 to 10 using MATLAB. Plot the diagram from 0 to 10 on X-Axis and 0 to Maz Value on Y-Axis.

PROGRAM:

```
clc
clear all
close all
n=0:1:10;
y = (0.8).^n;
stem (n, y);
xlabel('n');
ylabel('x(n)') ;
xlabel('time --->')
ylabel('Amplitude --->');
title('Decreasing Exponential Sequence');
grid on;
```

OUTPUT:

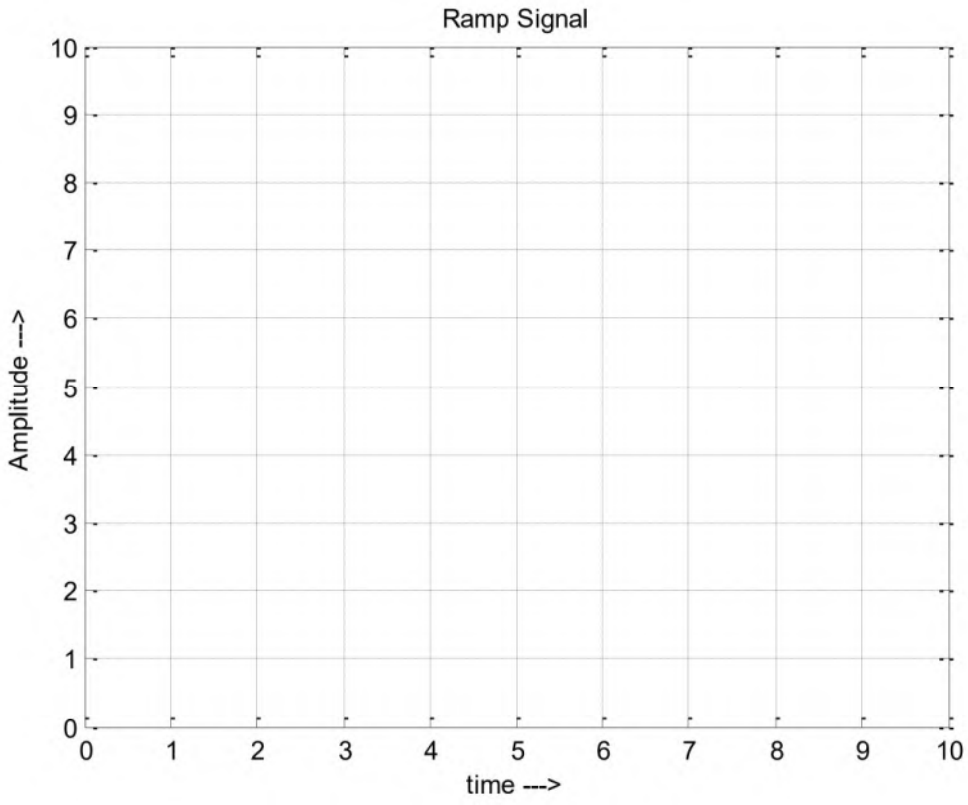


Question 5: Generate a Discrete Ramp Sequence in between the time period 0 to any time given as input in the OUTPUT using MATLAB. Plot it using suitable axis parameters.

PROGRAM:

```
clc
clear all
close all
x=input(' enter the length of ramp sequence');
n = 0:x;
stem(n,n)
axis([0 x 0 x])
xlabel('time --->')
ylabel('Amplitude --->');
title('Ramp Signal')
grid on;
```

OUTPUT:

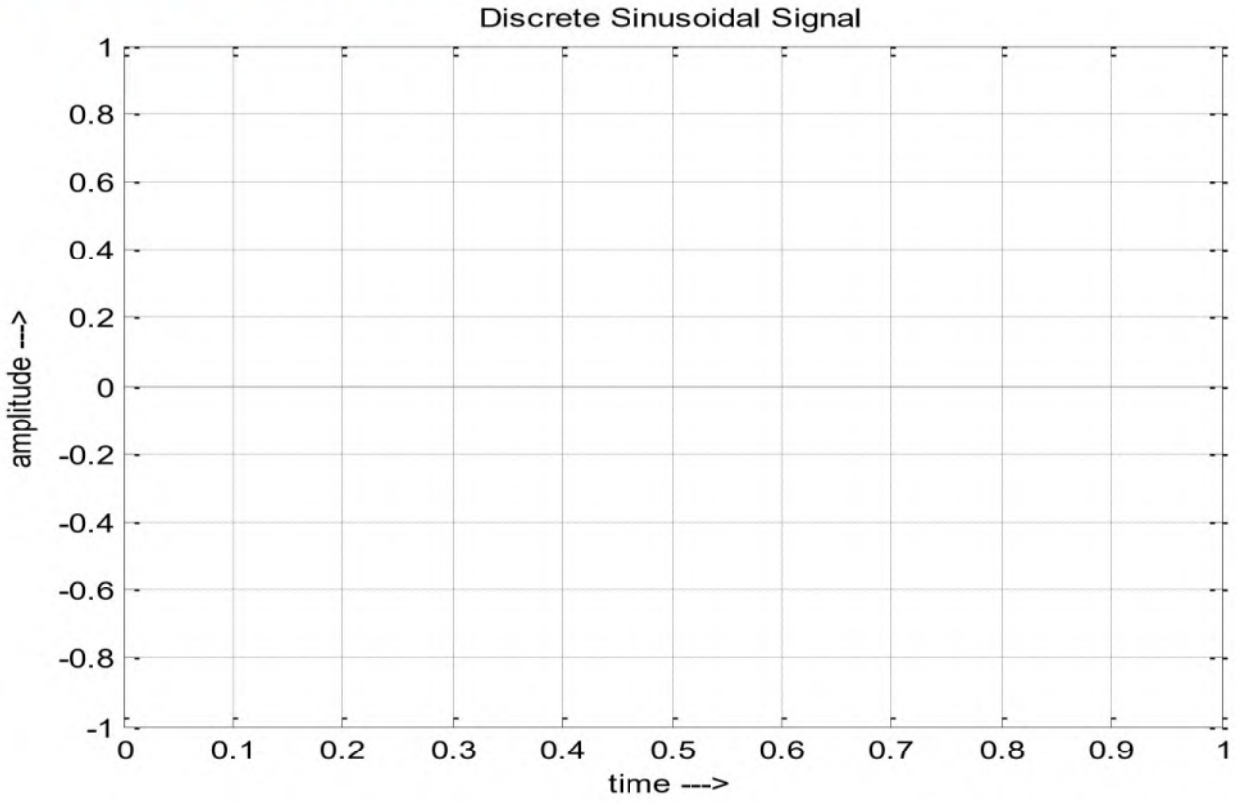


Question 6: Generate a Discrete Periodic Sine Sequence using MATLAB. No. of cycles required should be input from the command window. Plot it using suitable axis parameters.

PROGRAM:

```
clc;
clear all;
close all;
N = input('Enter the number of time periods =  ' );
t = 0:0.05:N;
x = sin(2*pi*t);
stem(t,x);
xlabel('time --->' );
ylabel('amplitude --->' );
title('Discrete Sinusoidal Signal' );
grid on;
```

OUTPUT: (For N=1 timeperiod)

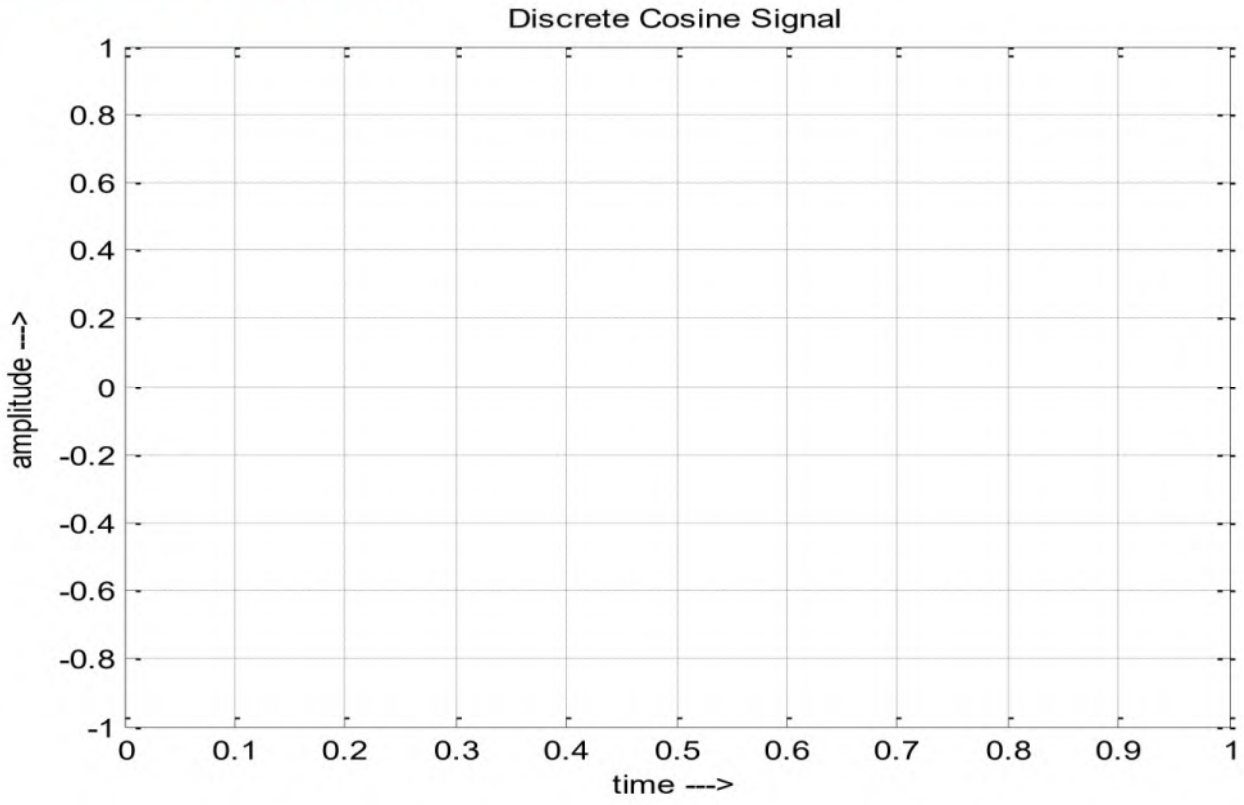


Question 7: Generate a Discrete Periodic Sine Sequence using MATLAB. No. of cycles required should be input from the command window. Plot it using suitable axis parameters.

PROGRAM:

```
clc;
clear all;
close all;
N = input('Enter the number of time periods....' );
t = 0:0.05:N;
x =cos(2*pi*t);
stem(t,x);
xlabel('time --->' );
ylabel('amplitude --->' );
title('Discrete Cosine Signal' );
grid on;
```

OUTPUT: (For N=1 time periods)

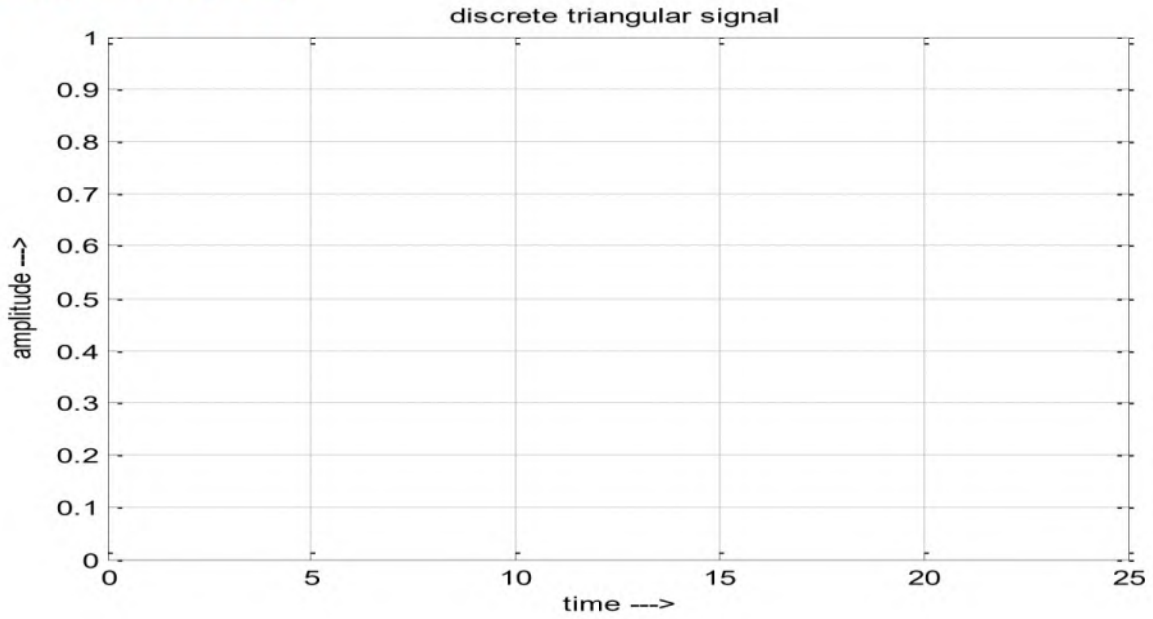


EXERCISE

QUESTION 1: Generate a discrete TRIANGULAR Waveform using MATLAB. No. of time periods required should be input from the command window. Plot it using suitable axis parameters.

PROGRAM:

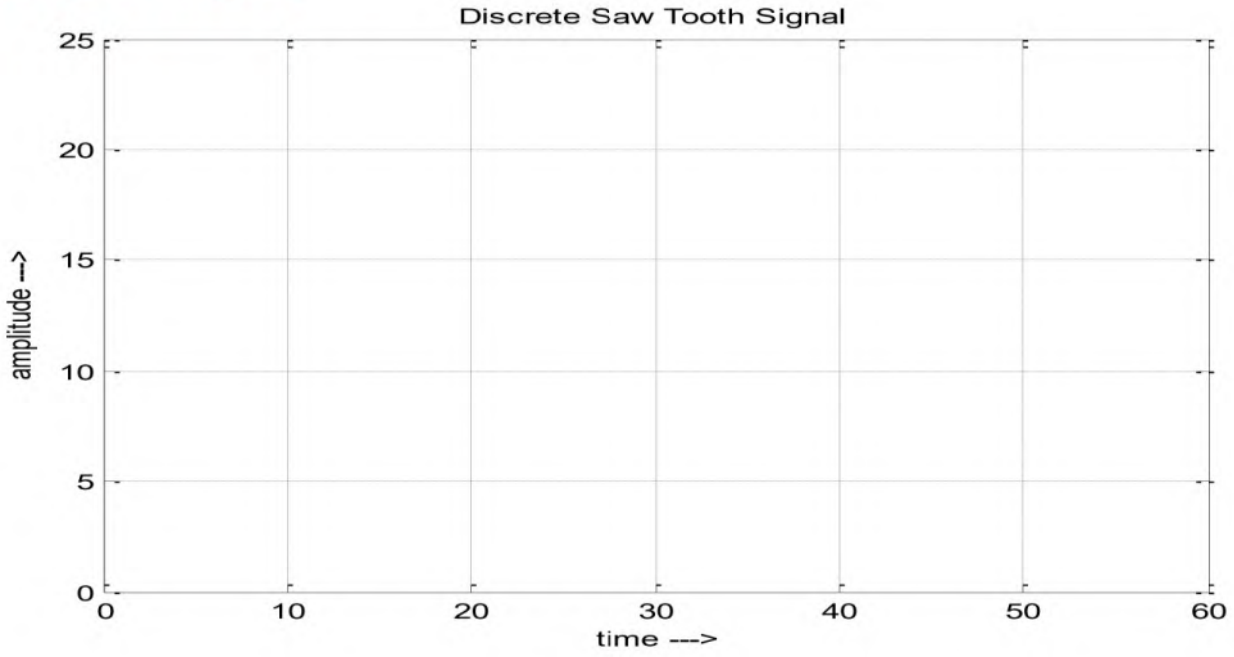
OUTPUT: (For N=1 cycles)



QUESTION 2: Generate a discrete SAWTOOTH Waveform using MATLAB. No. of time periods required should be input from the command window. Plot it using suitable axis parameters.

PROGRAM:

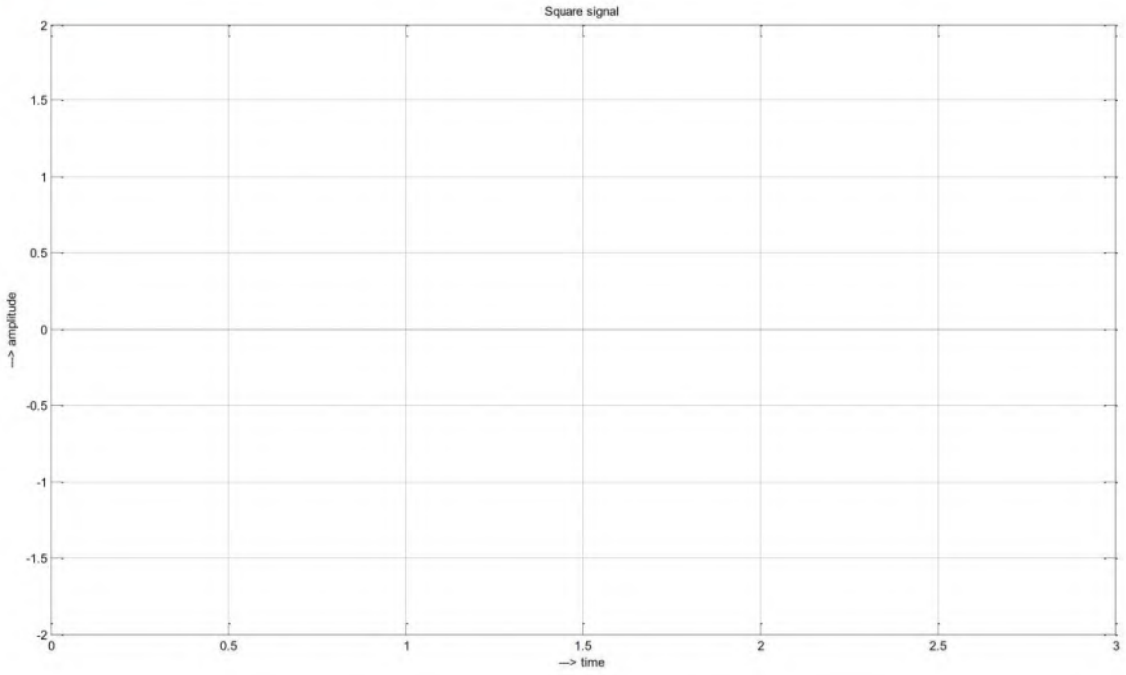
OUTPUT: (For N=2 cycles)



QUESTION 3: Generate a discrete SQUARE Waveform using MATLAB. The time period in seconds should be input from the command window. Plot it using suitable axis parameters.

PROGRAM:

OUTPUT:



King Khalid University
College of Computer Science
Department of Computer Engineering

Experiment # 3 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

Lab Day: _____ Section Number: _____ Serial Number: _____

Experiment #3

Operation on Sequences

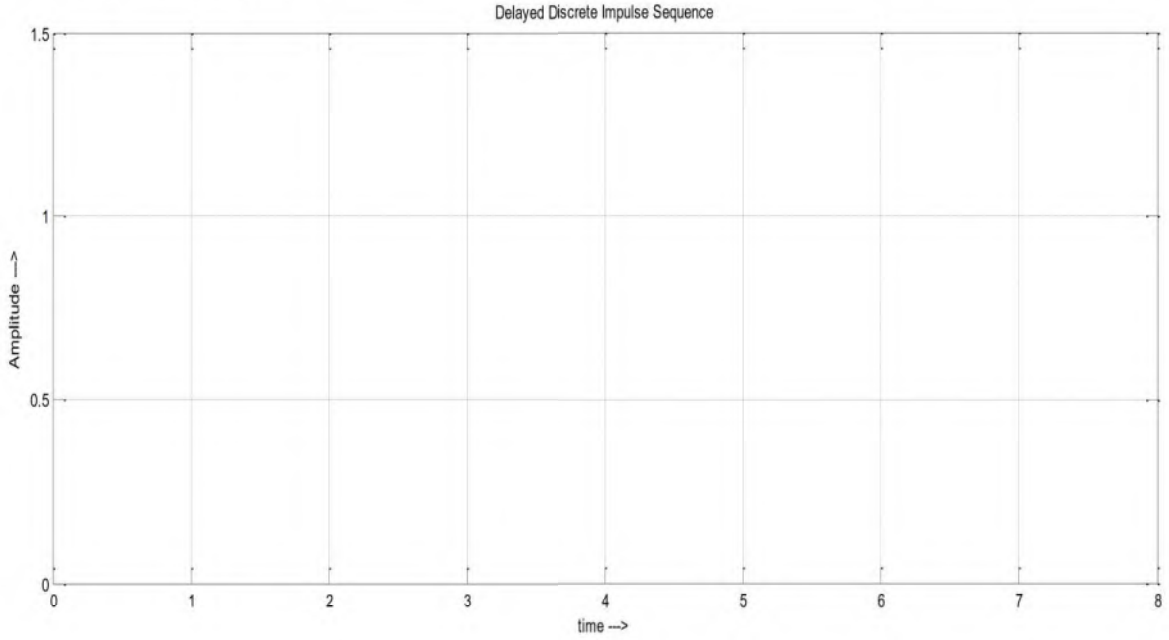
Question 1: Generate a time-delayed Discrete Unit Impulse Sequence using MATLAB. The time delay should be input from the command window. Plot the diagram using suitable azes parameters.

PROGRAM:

```
% delay in impulse signal

clc;    clear all;  close all;
d = input('Enter the time delay = ');
x1 = [zeros(1,d) 1 zeros(1,5)]
n = length(x1);
stem(0:n-1, x1)
axis([0 n-1 0 1.5])
xlabel('time --->')
ylabel('Amplitude --->')
title('Delayed Discrete Impulse Sequence')
grid on;
```

Output: Enter the time delay = 3

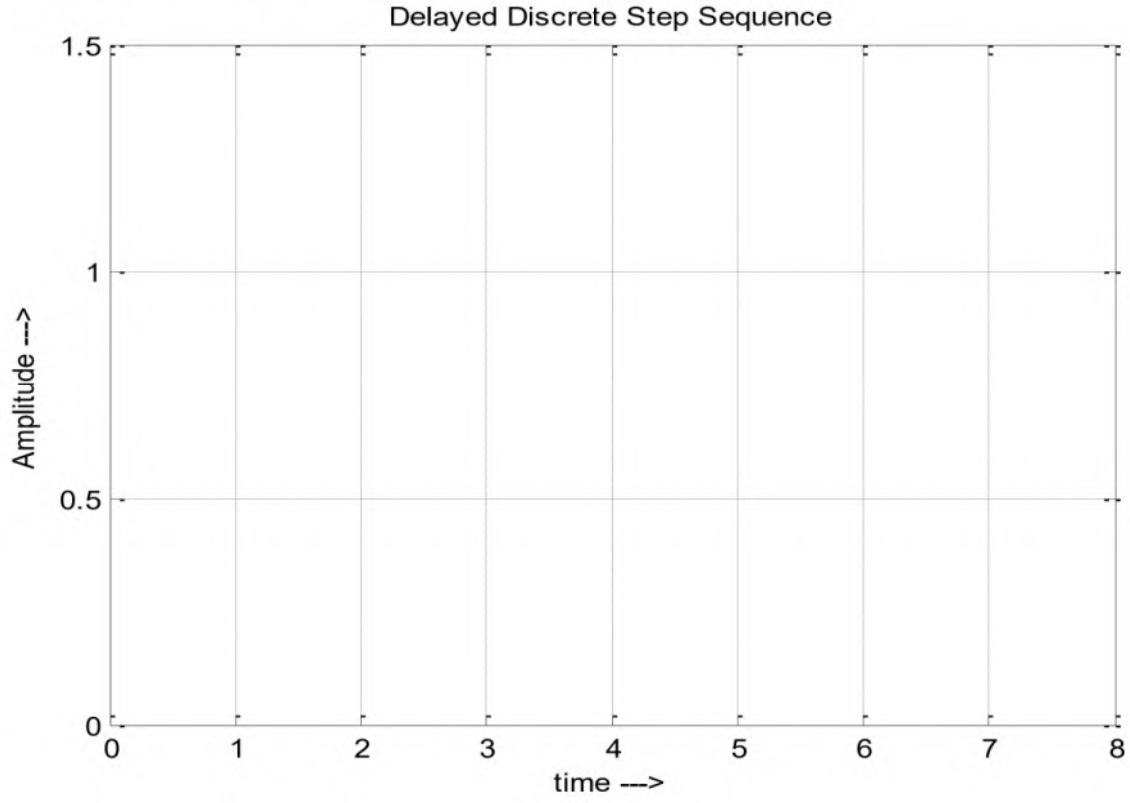


Question 2: Generate a time-delayed Discrete Unit Step Sequence using MATLAB. The time delay should be input from the command window. Plot the diagram using suitable azes parameters.

PROGRAM:

```
% delay in step signal
clc;    clear all;  close all;
d = input('Enter the time delay = ');
x1 = [zeros(1,d) ones(1,6)]
n = length(x1);
stem(0:n-1, x1)
axis([0 n-1 0 1.5])
xlabel('time --->')
ylabel('Amplitude --->')
title('Delayed Discrete Step Sequence')
grid on;
```

OUTPUT: (Enter the time delay = 3)

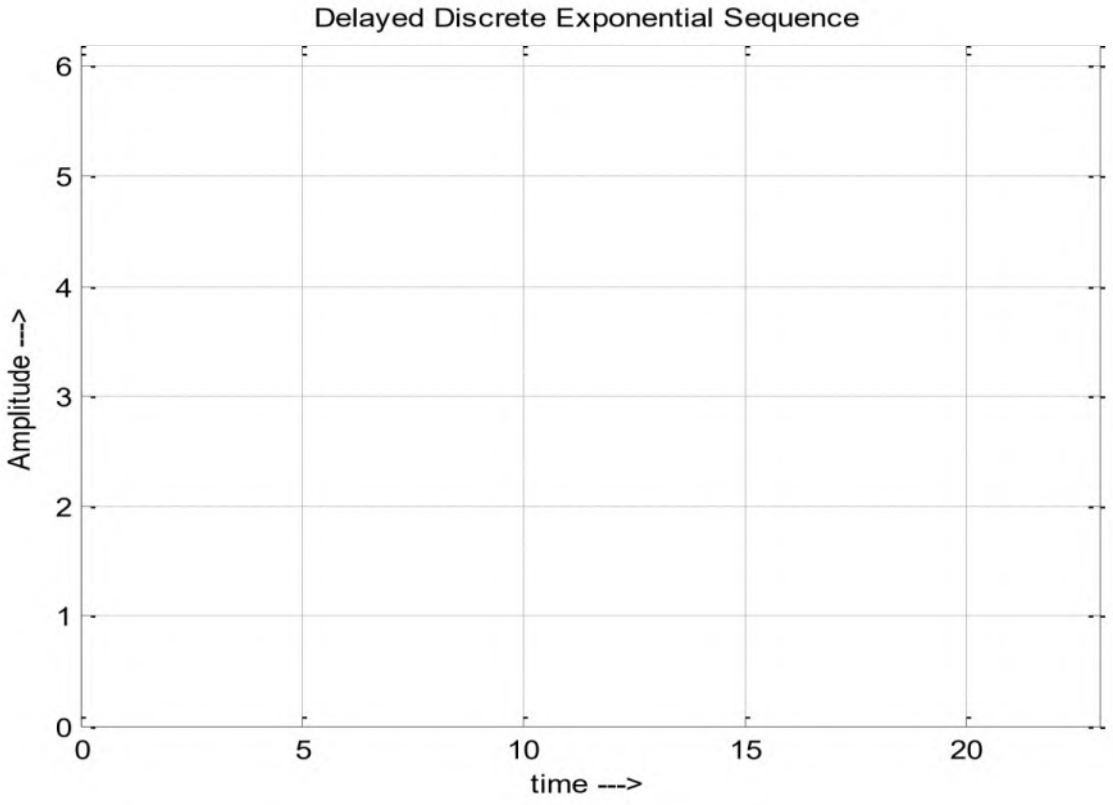


Question 3: Generate a time-delayed Discrete Exponential Sequence ($x[n] = 1.2^n$ using MATLAB. The time delay should be input from the command window. Plot the diagram using suitable azes parameters.

PROGRAM:

```
% delay in exponential signal
clc;   clear all;  close all;
d = input('Enter the delay = ');
n = 0:0.5:10;
x = (1.2).^n;
x1 = [zeros(1,d) x];
N = length(x1);
stem(0:N-1, x1)
axis([0 N-1 0 max(x)])
xlabel('time --->')
ylabel('Amplitude --->')
title('Delayed Discrete Exponential Sequence')
grid on;
```

OUTPUT: (Enter the delay = 3)



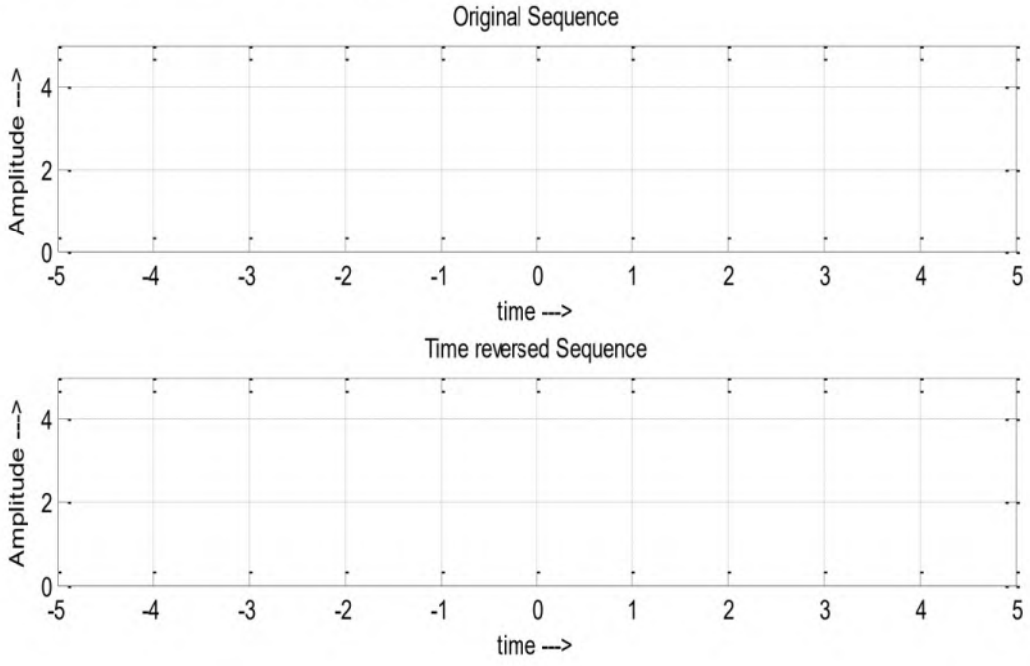
Question 4: Obtain the TIME-REVERSED Sequence of the any Discrete Sequence using MATLAB. Plot the original sequence and the time reversed sequence on a single figure.

PROGRAM:

```
%TIME REVERSAL OF SIGNAL x[-n]
clc;        clear all;      close all;
x=input('Enter the Discrete sequence:');
M = length(x);
n = 0:M-1;
subplot(2,1,1)
stem(n,x)
axis([-M M 0 max(x)])
xlabel('time --->')
ylabel('Amplitude --->')
title('Original Sequence')
grid on;

n=-n;
subplot(2,1,2)
stem(n,x);
axis([-M M 0 max(x)])
xlabel('time --->')
ylabel('Amplitude --->')
title('Time reversed Sequence')
grid on;
```

OUTPUT: Enter the Discrete sequence:[1 2 3 4 5]

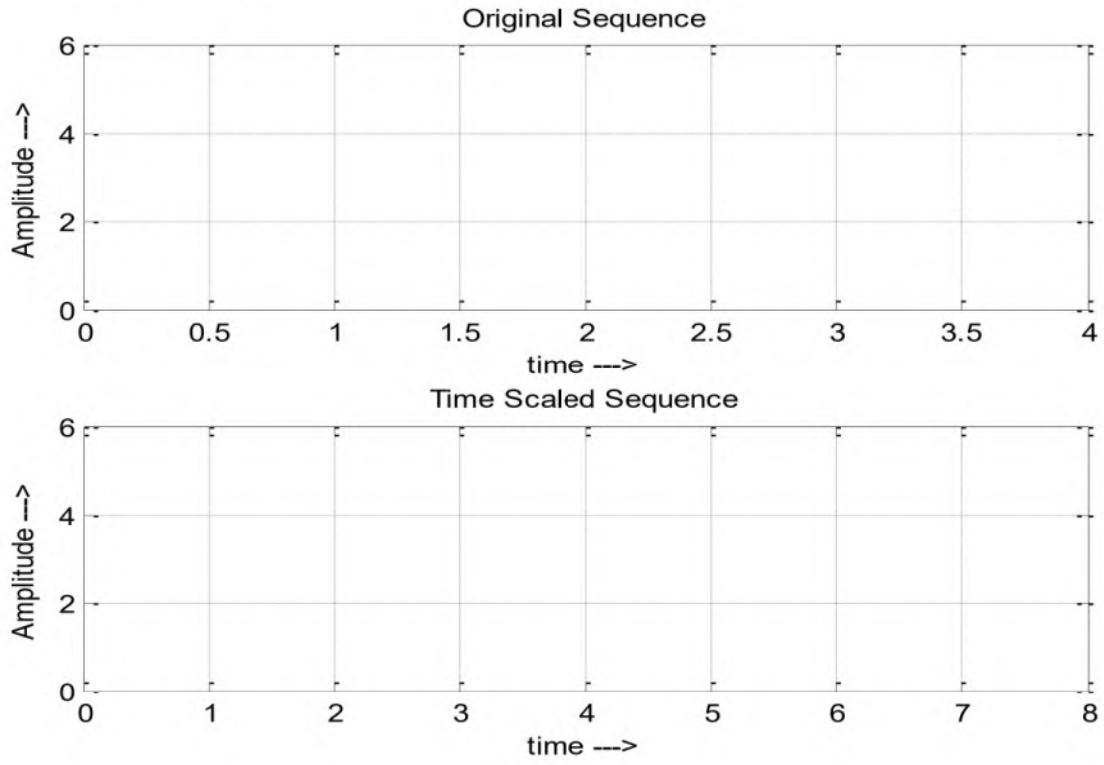


Question 5: Obtain the TIME-SCALED Sequence of the any Discrete Sequence using MATLAB. Plot the original sequence and the time scaled sequence on a single figure.

PROGRAM:

```
%TIME SCALING OF SIGNAL x[an]
clc;   clear all;  close all;
x=input('Enter the Discrete sequence:');
a = input('Enter the scaling factor: ');
M = length(x);
n = 0:M-1;
subplot(2,1,1)
stem(n,x);  xlabel('time --->');   ylabel('Amplitude --->');   title('Original Sequence')
grid on;
n=a*n;
subplot(2,1,2)
stem(n,x);   xlabel('time --->');      ylabel('Amplitude --->');     title('Time Scaled
Sequence')
grid on;
```

OUTPUT: Enter the Discrete sequence:[1 2 3 4 5]
Enter the scaling factor: 2



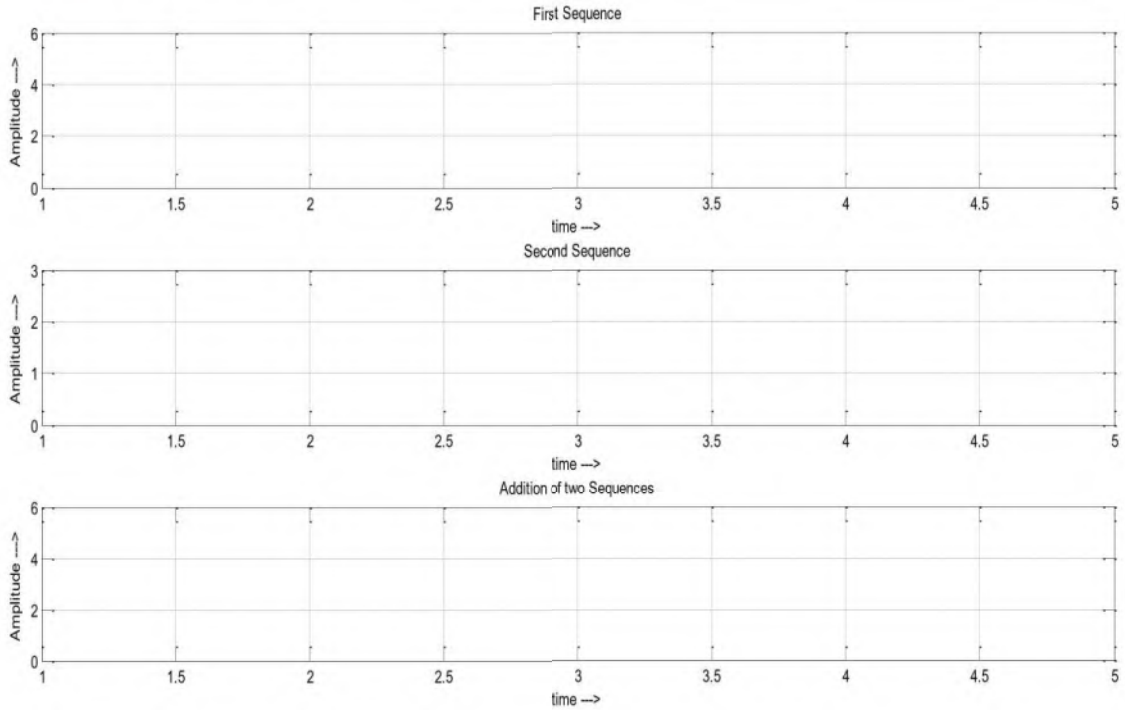
Question 6: Write MATLAB program to ADD TWO Discrete sequences. Plot all the sequences.

PROGRAM:

```
clc;   clear all;     close all;
x1 = input('Enter the first signal:');
x2 = input('Enter the Second Signal:');
n1 = length(x1);
n2 = length(x2);
if(n2>n1)
   x1 = [x1 zeros(1,n2-n1)];     %Padding x1 with extra zeroes if it is smaller than x2
else
   x2 = [x2 zeros(1,n1-n2)];    %Padding x2 with extra zeroes if it is smaller than x1
end
y = x1+x2
subplot(3,1,1)
stem(x1); xlabel('time --->');   ylabel('Amplitude --->');   title('First Sequence'); grid on;
subplot(3,1,2)
stem(x2); xlabel('time --->');   ylabel('Amplitude --->');   title('Second Sequence'); grid on;
subplot(3,1,3)
stem(y); xlabel('time --->');   ylabel('Amplitude --->');   title('Addition of two Sequences');
grid on;
```

OUTPUT: **Enter the first signal: [1 2 3 4 5]** **Enter the Second Signal: [1 2 3]**

Output Sequence is:



EXERCISE

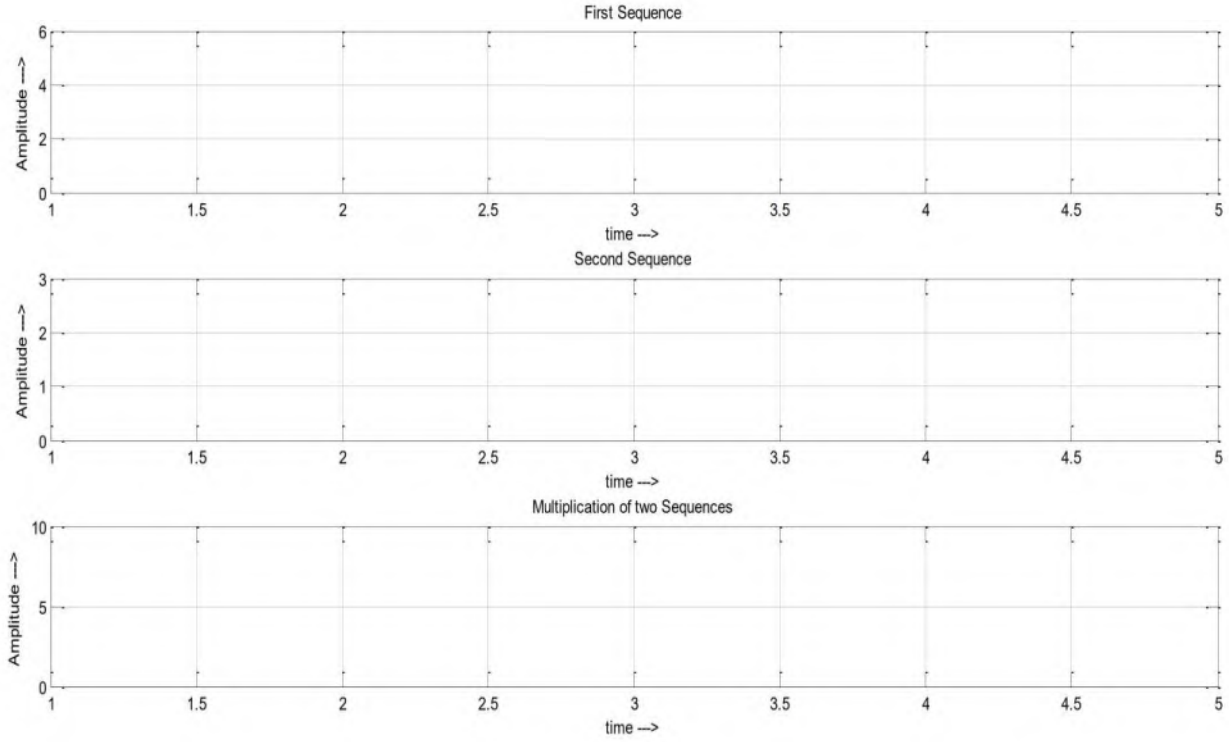
Question 7: Write MATLAB program to MULTIPLY TWO Discrete sequences. Plot all the sequences.

PROGRAM:

OUTPUT: Enter the first signal: [1 2 3 4 5]

Enter the Second Signal: [1 2 3]

Output Sequence is:



QUESTION 8: Find the Even part and Odd part of any discrete Sequence.

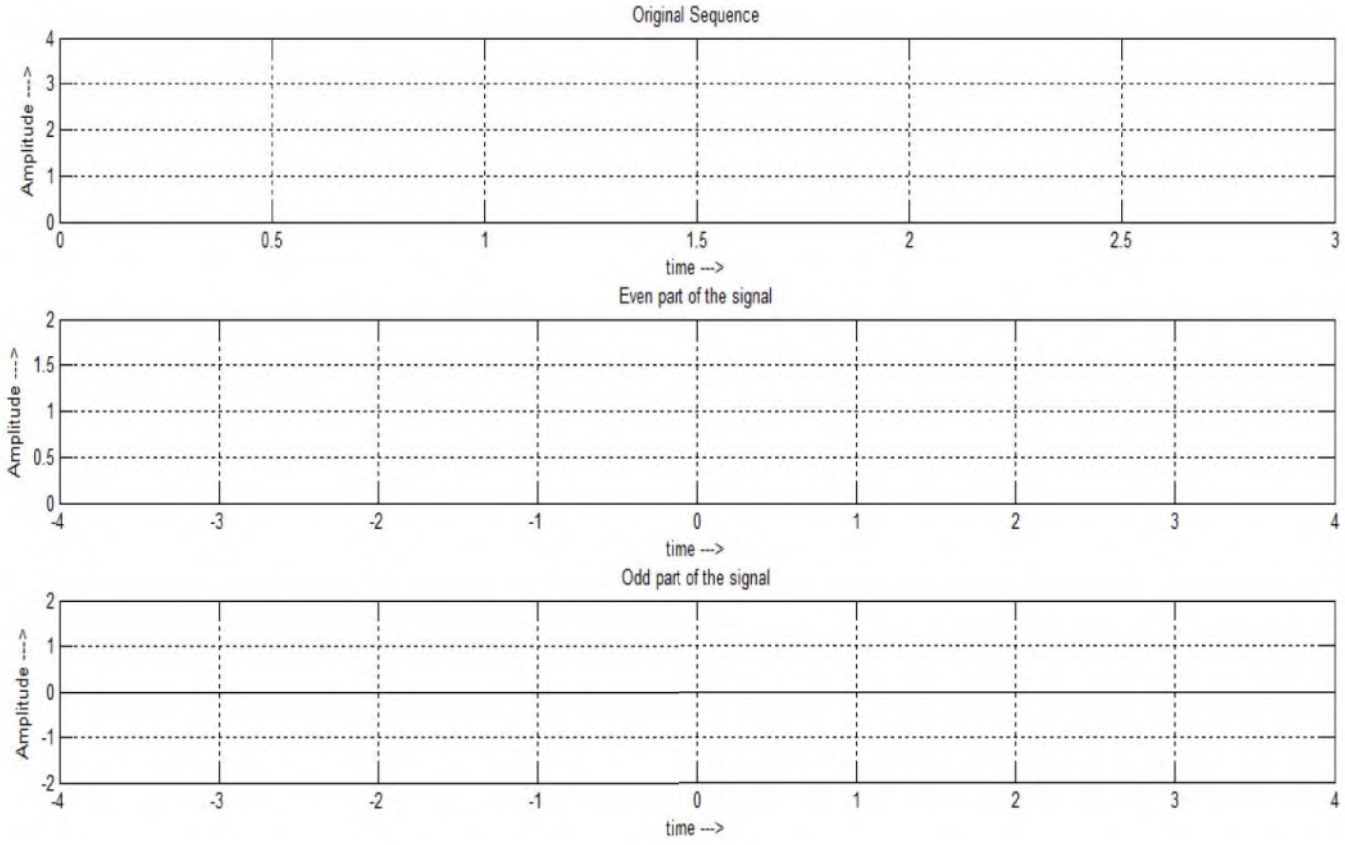
PROGRAM:

OUTPUT:
Enter the Discrete Sequence: [1 2 3 4]

Even Part of the Signal = xe =

Odd Part of the Signal = xo =

Original Signal retrieved = xe+xo =



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Experiment # 4 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

Lab Day: _____ Section Number: _____ Serial Number: _____

Experiment # 4

Sampling and Quantization

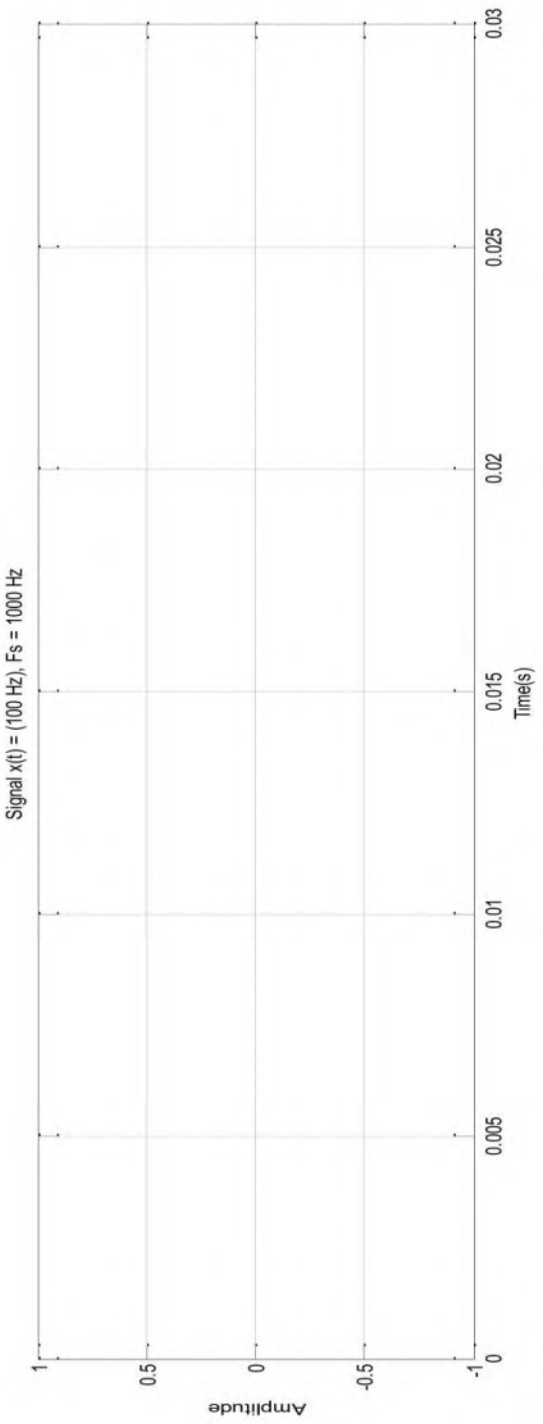
Question 1: Sampling of a sinusoidal sequence for a given sampling frequency

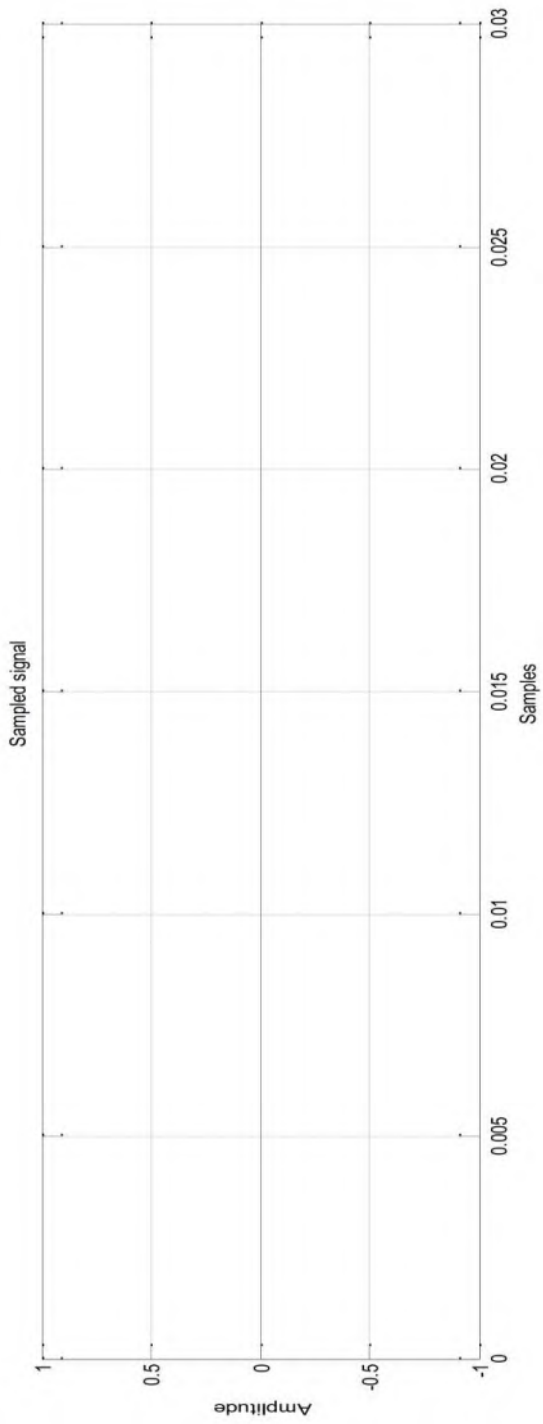
```
clc
clear all
close all
%f =100;  frequency of the main signal
f=input('enter the frequency of the main signal');
%fs=1000;  Use sampling frequency
fs = input('enter the sampling frequency');

 Ts = 1/fs; % Sampling Period
 t = 0:1e-4:3/f; % time vector for continuous plot
 w = f*2*pi;
 xa = sin(w*t); % signal in continuous form

 t2=(0:Ts:3/f);  % time vector for sampling
 xb = sin(w*t2); % sampled signal
 figure
 subplot(211);
 plot(t,xa) % continous signal plot
 str = ['Signal x(t) = (' num2str(f) ' Hz)', ', Fs = ' num2str(fs) ' Hz'];
 title(str);
 ylabel('Amplitude');
 xlabel('Time(s)');

 subplot(212);
  stem(t2,xb); % sampled signal plot
 title('Sampled signal');
 ylabel('Amplitude')
 xlabel('Samples');
```

OUTPUUT

enter the frequency of the main signal100

enter the sampling frequency1000


Signal x(t) = (100 Hz), Fs = 1000 Hz
Amplitude
Time(s)
1
0.5
0
-0.5
-1
0
0.005
0.01
0.015
0.02
0.025
0.03


Sampled signal
Amplitude
Samples
1
0.5
0
-0.5
-1
0
0.005
0.01
0.015
0.02
0.025
0.03

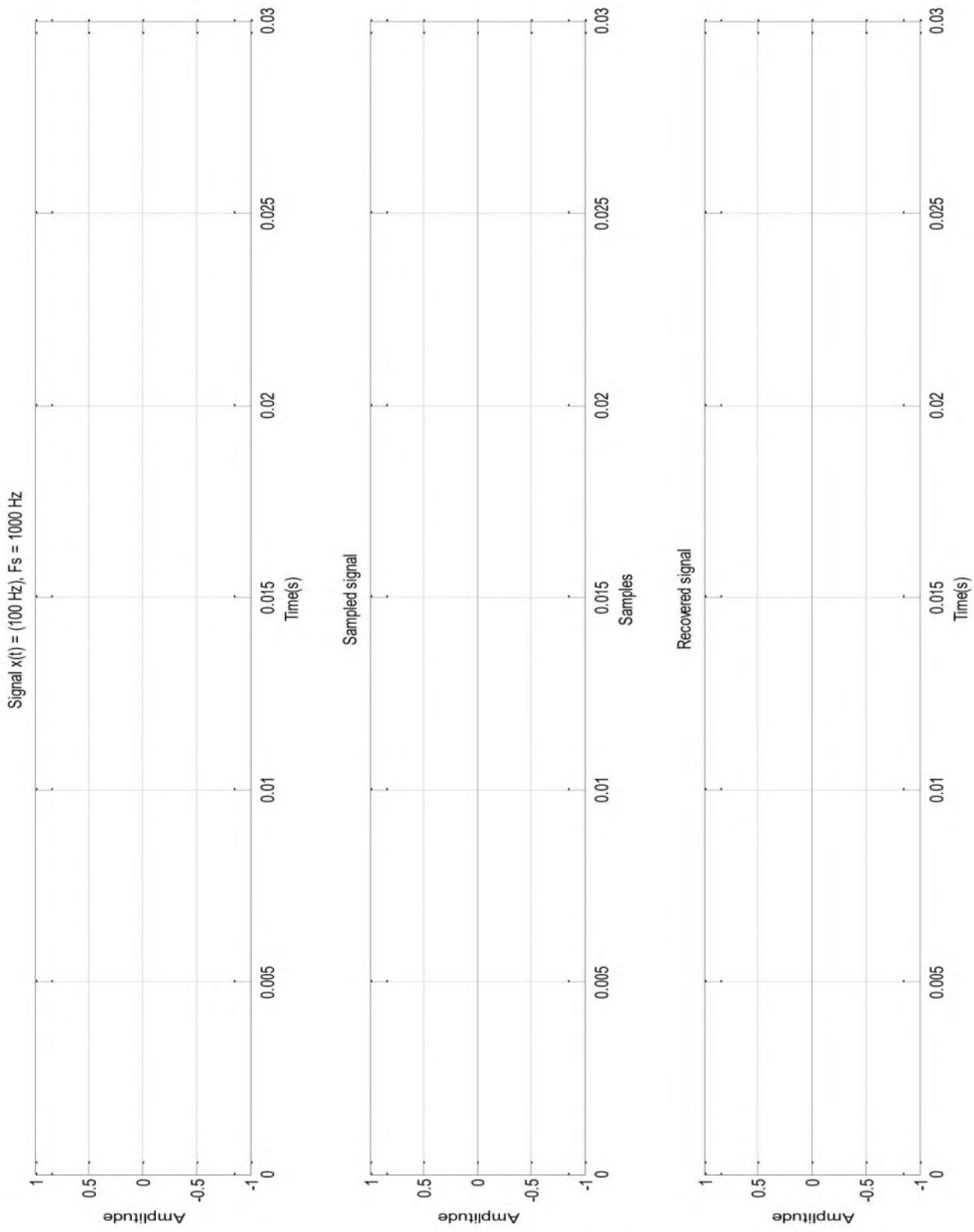
Question 2: Reconstruct the signal which is sampled in the Question -1

```
clc
clear all
close all
f=input('enter the frequency of the main signal');
fs = input('enter the sampling frequency');
Ts = 1/fs; % Sampling Period
 t = 0:1e-4:6/f; % time vector for continous plot
 w = f*2*pi;
 xa = sin(w*t); % signal in continuous form
 t2=(0:Ts:6/f);  % time vector for sampling
 xb = sin(w*t2); % sampled signal
 figure
 subplot(311);
 plot(t,xa) % continous signal plot
 str = ['Signal x(t) = (' num2str(f) ' Hz)', ', Fs = ' num2str(fs) ' Hz'];
 title(str);
 ylabel('Amplitude');
 xlabel('Time(s)');
 subplot(312);
 stem(t2,xb); % sampled signal plot
 title('Sampled signal');
 ylabel('Amplitude')
 xlabel('Samples');
 xr = zeros(length(t));
 Tr = 1/10000;  %reconstruction time period
 for k=1:length(t)
 for p=1:length(xb)
 xr(k)=xr(k) + xb(p)*sinc( ((k-1)*Tr-(p-1)*Ts)/Ts );
 end
 end
 subplot(313);
 plot(t,xr);
 title('Recovered signal');
 ylabel('Amplitude');  xlabel('Time(s)');
```

OUTPUUT

enter the frequency of the main signal100

enter the sampling frequency1000


Signal x(t) = (100 Hz), Fs = 1000 Hz
Amplitude
Time(s)
Sampled signal
Samples
Recovered signal

Question 3: Quantize the signal x(t) = 5+4sint(t) by usig different quantization levels

```
clc;
clear all;
close all;
t=0:0.001: 5*pi; %time base
x = 5+4*sin(t);
subplot(3,1,1)
plot(t,x);
grid;%plot original signal
xlabel('Time');
ylabel('Amplitude'); %label axes
title('Original signal') %add title
axis([0 14 0 max(x)+1]) %scale axes
x1=fix(5+4*sin(t)); %quantize signal to integer values
subplot(3,1,2)
plot(t,x1);
grid; %plot quantized signal
xlabel('Time');
ylabel('Amplitude'); %label axes
title('Quantized signal') %add title
axis([0 14 0 max(x1)+1]) %scale axes
x2=fix(10*(5+4*sin(t)))/10; % quantized signal
subplot(3,1,3)
plot(t,x2);
grid; % plot quantized signal
xlabel('Time');
ylabel('Amplitude') % label axes
title('Quantized signal') % add title
axis([0 14 0 max(x2)+1]) %scale axes
```

OUTPUT


Original signal
Quantized signal
Quantized signal
Amplitude
Time
0
2
4
6
8
10
12
14

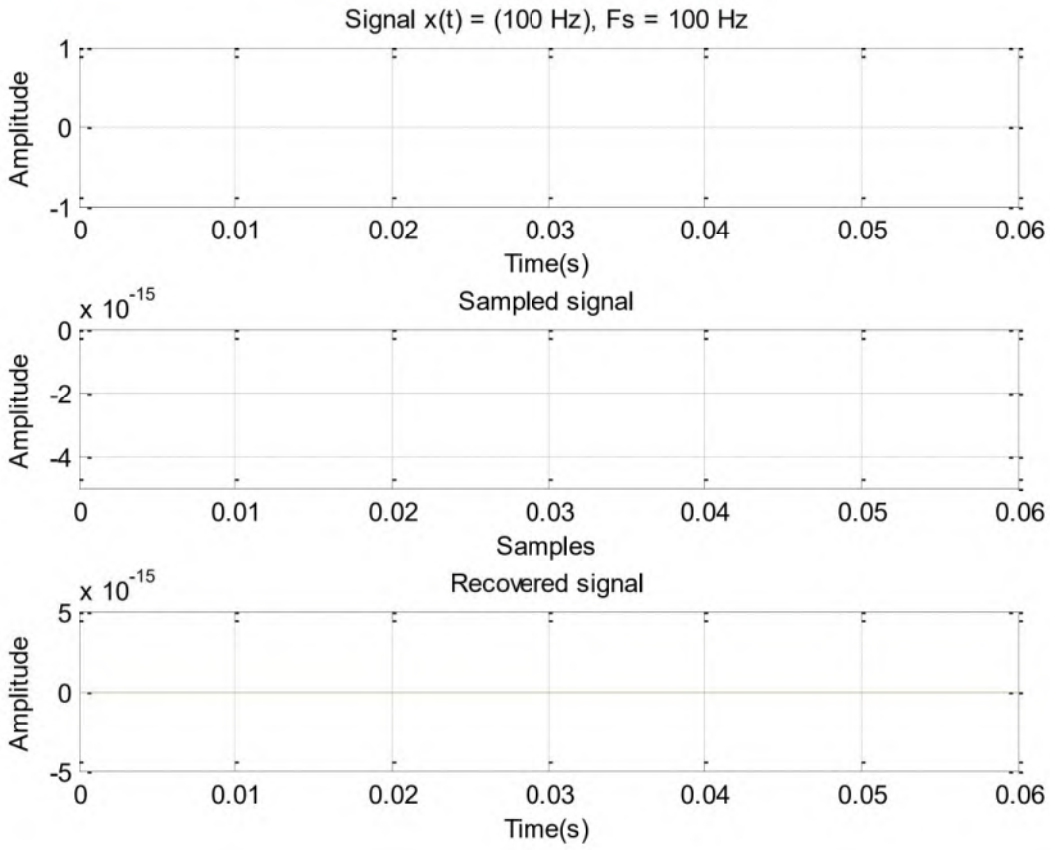
LAB ACTIVITY - EXERCISE

QUESTION 4: **Sample and reconstruct the signal of frequency 100 Hz for the following cases and write your observations.**

a) **Under sampling (Use sampling frequency = 100 Hz)**
b) **Uniform Sampling (Use sampling frequency = 200 Hz)**
c) **Over sampling (Use sampling frequency = 500 Hz)**

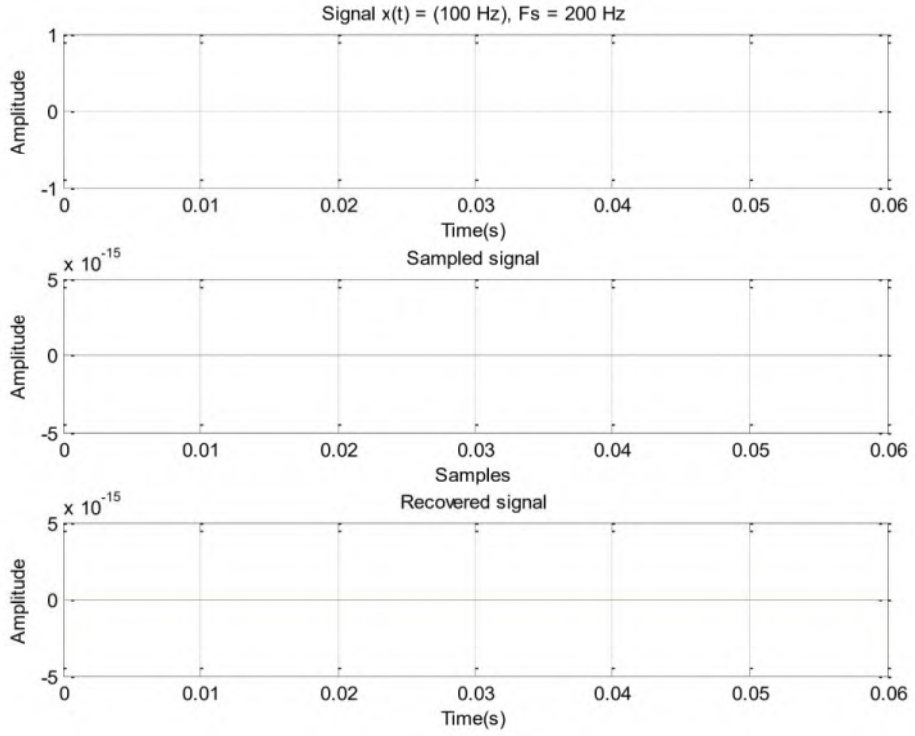
RESULTS:

a) **Under sampling (Use sampling frequency = 100 Hz)**

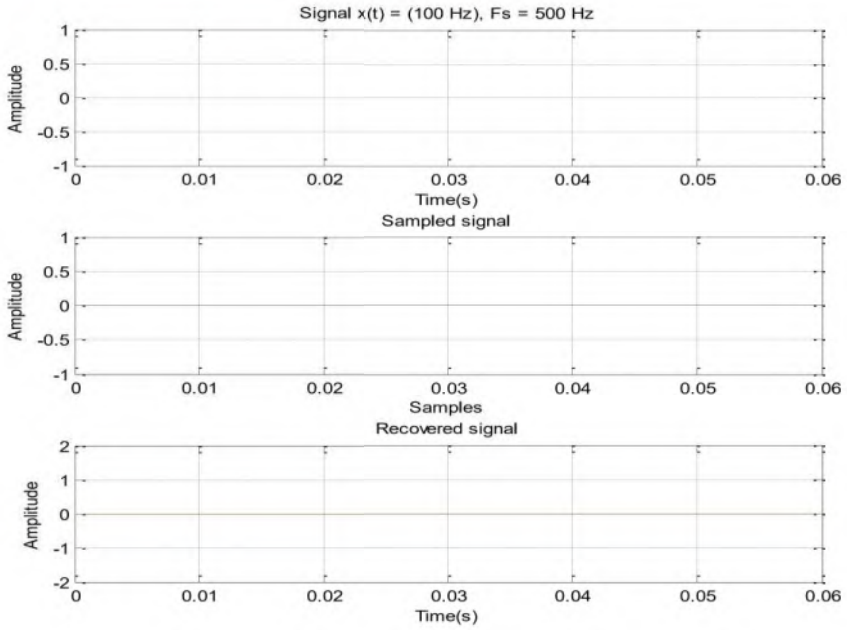


Observation:

b) Uniform Sampling (Use sampling frequency = 200 Hz)



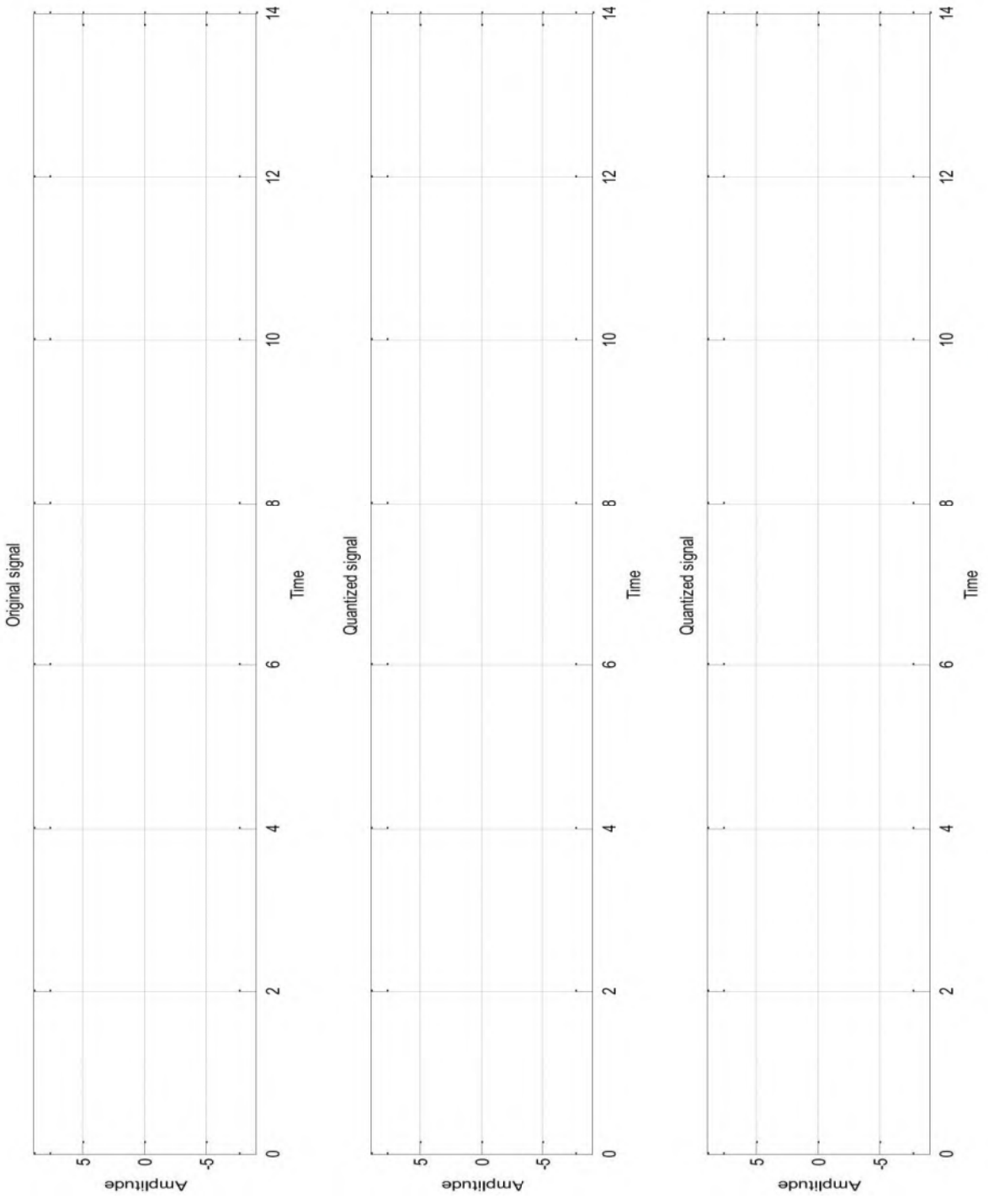
c) Over sampling (Use sampling frequency = 500 Hz)



NOTE: Write your observation beside the above figures

QUESTION 5: **Quantize the signal given by:**

$$x(t) = 5sin(2t) + 4\,cos(t)$$


Original signal
Quantized signal
Quantized signal
Amplitude
Time
5
0
-5
0
2
4
6
8
10
12
14

Digital Signal Processing

262 CPE

King Khalid University

College of Computer Science
Department of Computer Engineering

Experiment # 5 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ **ID Number:** _____

Lab Day: _____ **Section Number:** _____ **Serial Number:** _____

Experiment #5

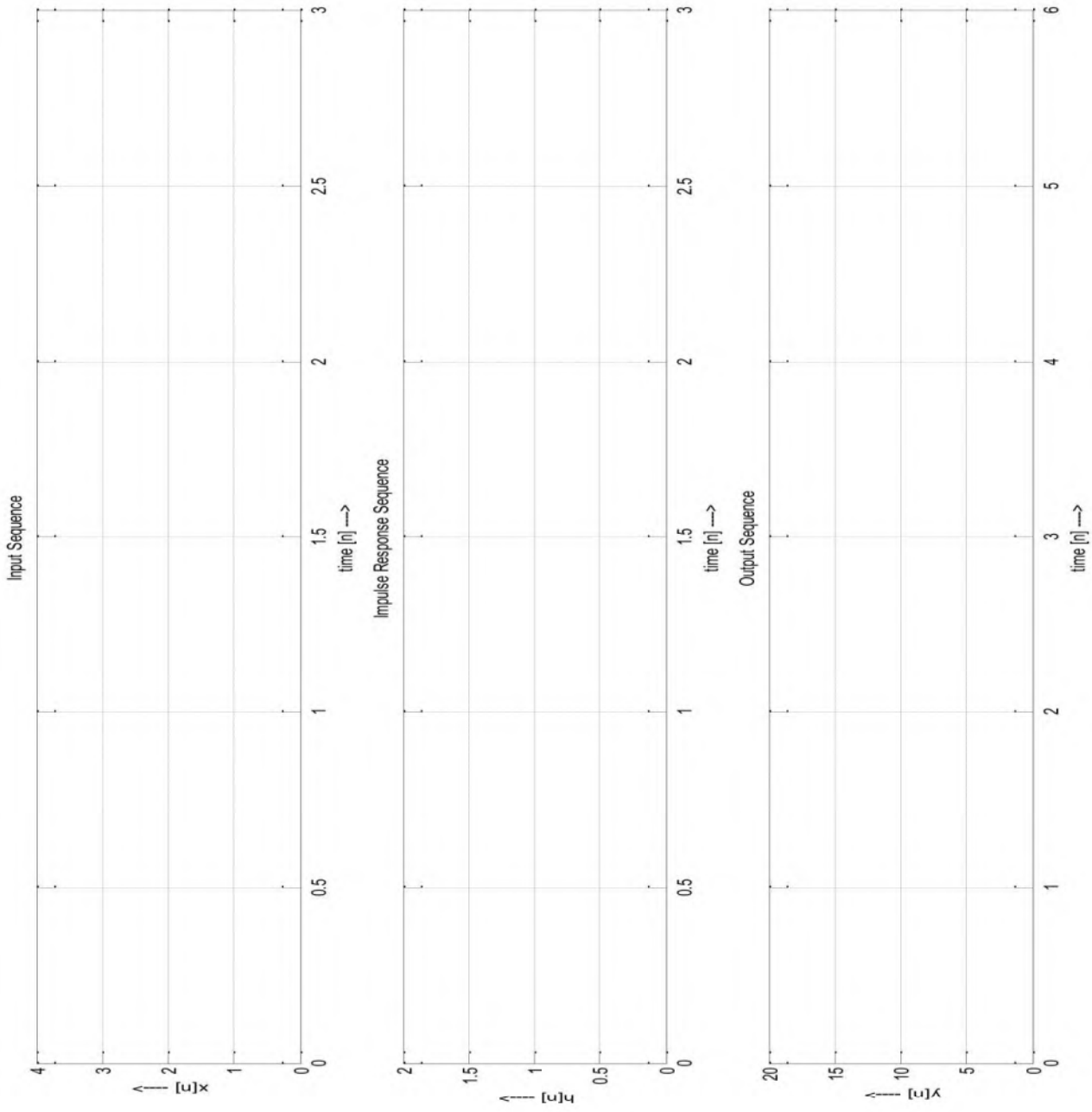
Digital Convolution and Correlation

Question 1: Using Linear Convolution, find the output of the LTI system if the input sequence and the discrete impulse response are causal. Sketch all the sequences.

PROGRAM:

```
clc; clear all; close all;
x = input('Enter the Input Sequence:');          n1 = length(x);
h = input('Enter the Impulse Response Sequence:'); n2 = length(h);
y = conv(x,h);       n3 = length(y);

disp('The output sequence is:'); disp(y);
subplot(3,1,1)
stem(0:n1-1,x);
xlabel('time [n] ---->');
ylabel('x[n] ---->');
title('Input Sequence');
grid on;
subplot(3,1,2)
stem(0:n2-1,h);
xlabel('time [n] ---->');
ylabel('h[n] ---->');
title('Impulse Response Sequence');
grid on;
subplot(3,1,3)
stem(0:n3-1,y);
xlabel('time [n] ---->');
ylabel('y[n] ---->');
title('Output Sequence');
grid on;
```

Output: Enter the Input Sequence:[1 2 3 4]
Enter the Impulse Response Sequence:[2 1 2 1]
The output sequence is:

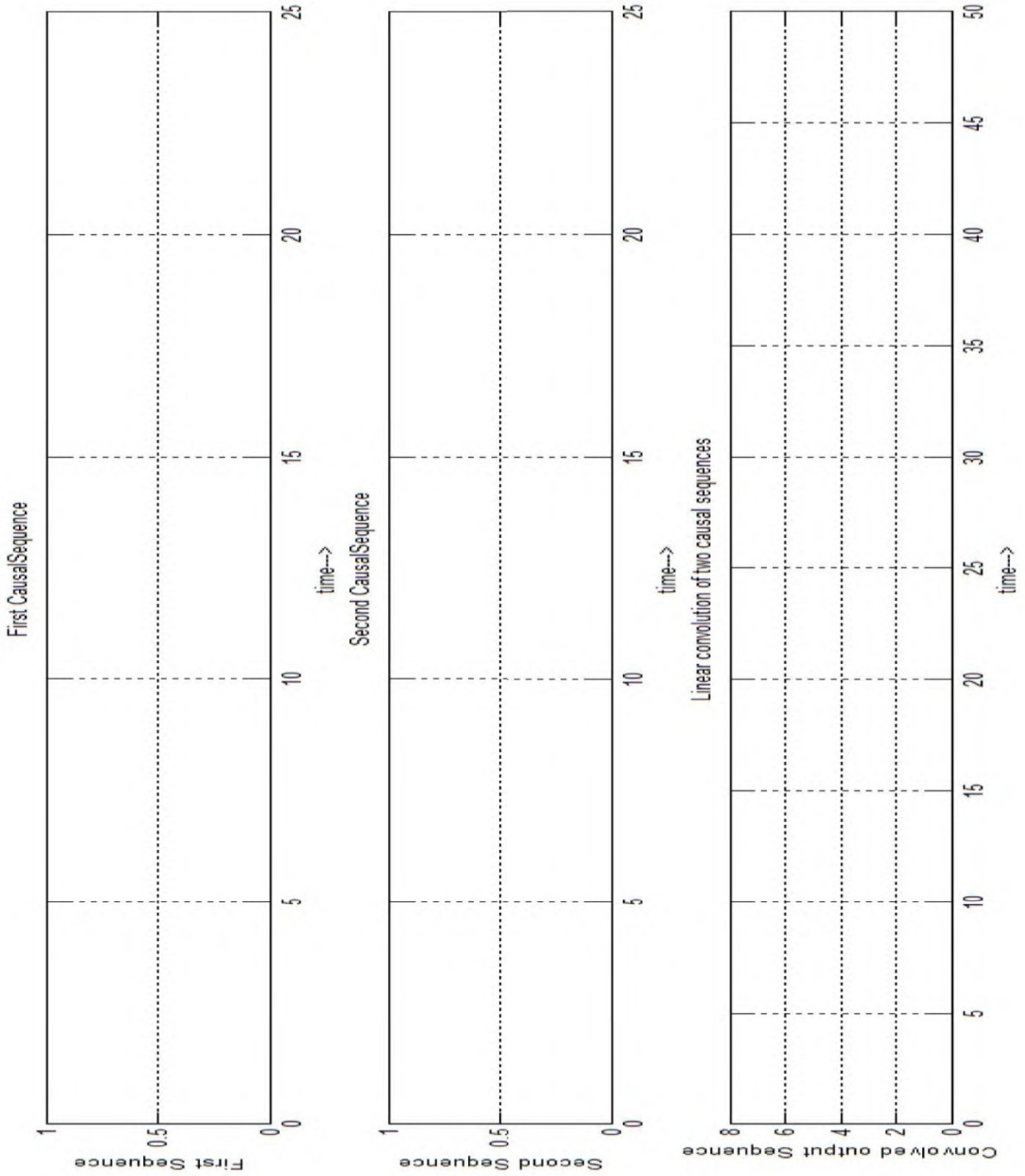

Input Sequence
x[n] ---->
time [n] --->
Impulse Response Sequence
h[n] ---->
time [n] --->
Output Sequence
y[n] ---->
time [n] --->

Question 2: Let the rectangular pulse x(n) = u(n) − u(n − 10) be an input to an LTI system with impulse response h(n) = (0.9) ^{n} u(n). Determine the output y(n) [take time for n = 0 to 25 seconds]

PROGRAM:

```
clc; clear all; close all;
n=0:25;
S1=[ones(1,11), zeros(1,15)];  %generation of u[n]-u[n-10]
S2=((0.9).^n);   %generate the exponential sequence
y = conv(S1,S2);
disp('Convolution of two sequences is ='); disp(y)
subplot(3,1,1);
stem(n,S1);
xlabel('time--->');
ylabel('First Sequence');
title('First CausalSequence' );
grid on;
subplot(3,1,2);
stem(n,S2);
xlabel('time--->');
ylabel('Second Sequence');
title('Second CausalSequence' );
grid on;
subplot(3,1,3);
m= 0:2*length(n)-2; %start and end of the convolution
stem(m,y);
xlabel('time--->');
ylabel('Convolved output Sequence');
title('Linear convolution of two causal sequences' );
grid on;
```

OUTPUT: Convolution of two sequences is = (write 10 values)


First CausalSequence
First Sequence
time-->
Second CausalSequence
Second Sequence
time-->
Linear convolution of two causal sequences
Convolved output Sequence
time-->

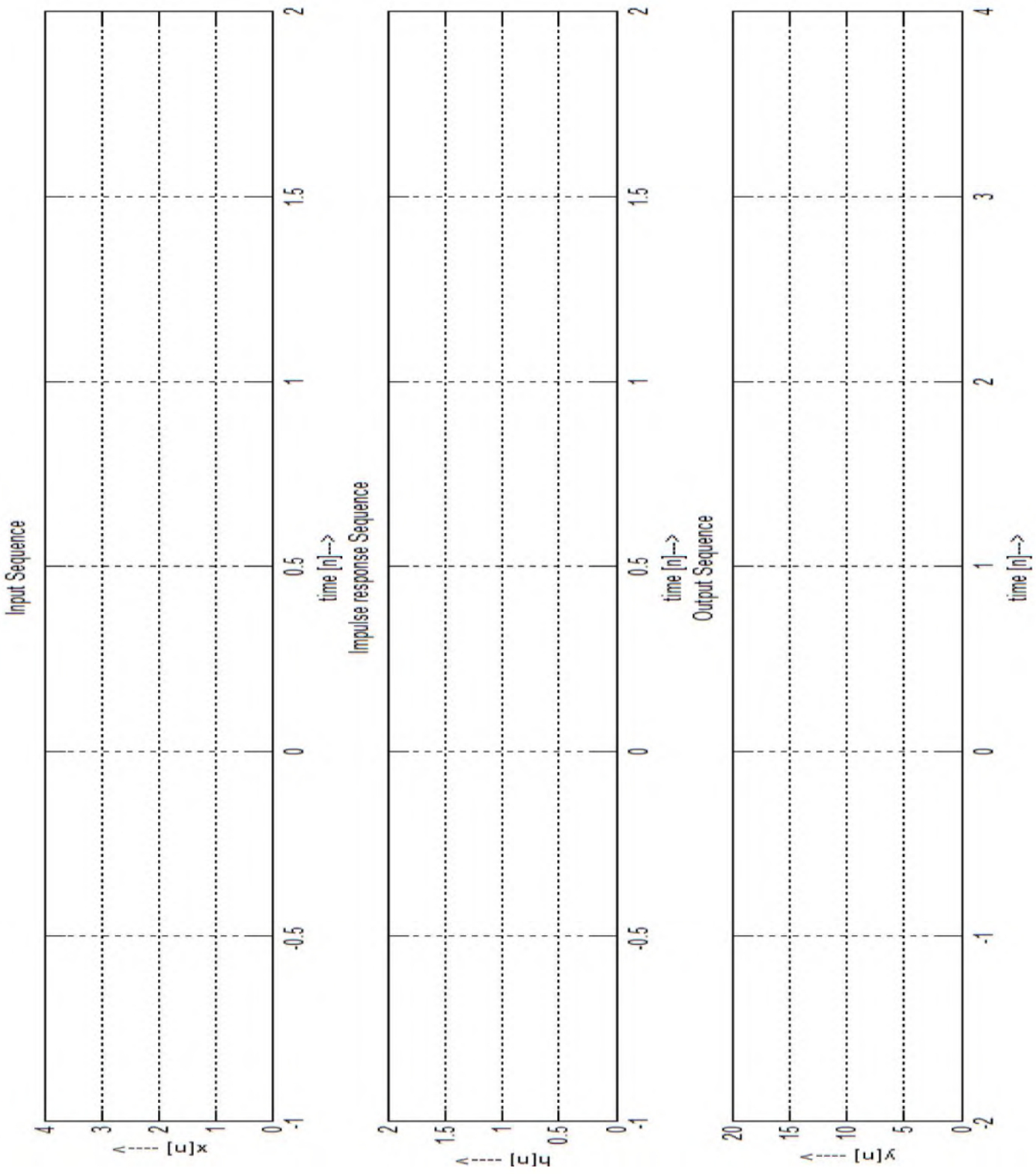
Question 3: Using Linear Convolution, find the output of the NON-CAUSAL system if the input sequence and the discrete impulse response are NON-CAUSAL. Sketch all the sequences.

PROGRAM:

```
clc
clear all
close all
x = input('enter the input sequence x[n]:');
nx = input('enter the time period of the input sequence:');
h = input('enter the impulse response sequence h[n]:');
nh = input('enter the time period of the impulse response sequence:');

nyb = nx(1)+nh(1);
nye = nx(length(x)) + nh(length(h));
ny = [nyb:nye];

y = conv(x,h);
disp('The Output sequence y[n] is:'); disp(y)
disp('Start time of Output Sequence = '); disp(nyb);
disp('End time of Output Sequence = '); disp(nye);

subplot(3,1,1); stem(nx,x); xlabel('time [n]--->'); ylabel('x[n] ---->');
title('Input Sequence'); grid on;
subplot(3,1,2); stem(nh,h); xlabel('time [n]--->'); ylabel('h[n] ---->');
title('Impulse response Sequence'); grid on;
subplot(3,1,3); stem(ny,y); xlabel('time [n]--->'); ylabel('y[n] ---->');
title('Output Sequence'); grid on;
```

OUTPUT: Enter the input sequence x[n]:[1 2 3 4]
Enter the time period of the input sequence:[-1:2]
Enter the impulse response sequence h[n]:[2 1 2 1]
Enter the time period of the impulse response sequence:[-1:2]
The Output sequence y[n] is: _____
Start time of Output Sequence =_____
End time of Output Sequence = _____

x [n] = [1 , 2 , 3 , 4]
h [n] = [2 , 1 , 2 , 1]


Input Sequence
x[n] ----->
time [n]--->
Impulse response Sequence
h[n] ----->
time [n]--->
Output Sequence
y[n] ----->
time [n]--->
4
3
2
1
0
-1
-0.5
0
0.5
1
1.5
2
0.5
-2
5
10
15
20
-1
2
3
4

Question 4: Find the cross correlation of two causal discrete signals using MATLAB. Plot all the sequences.

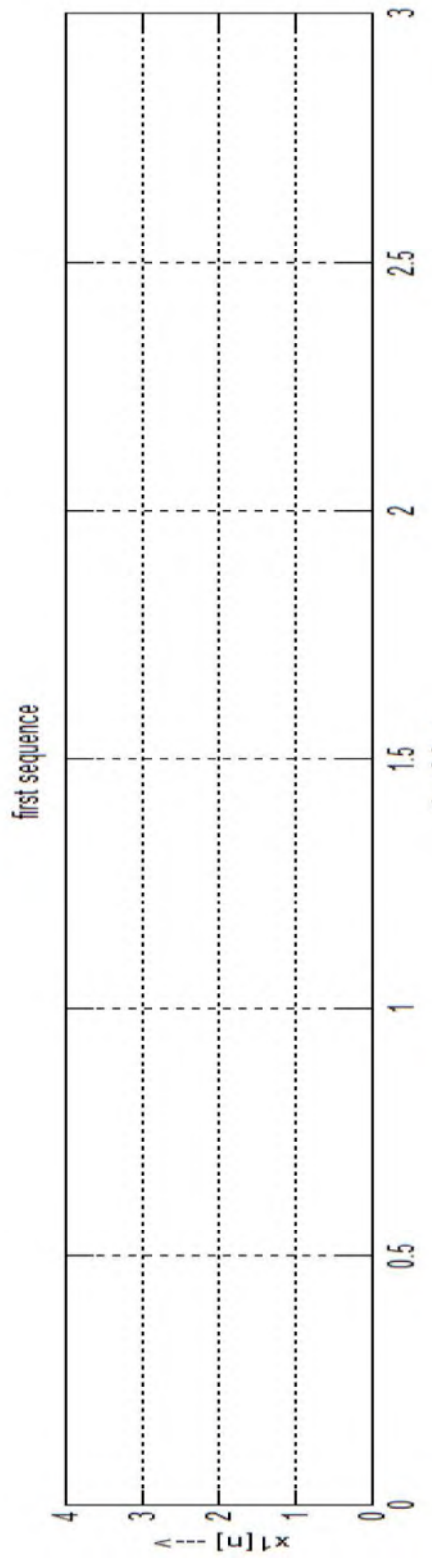
PROGRAM:

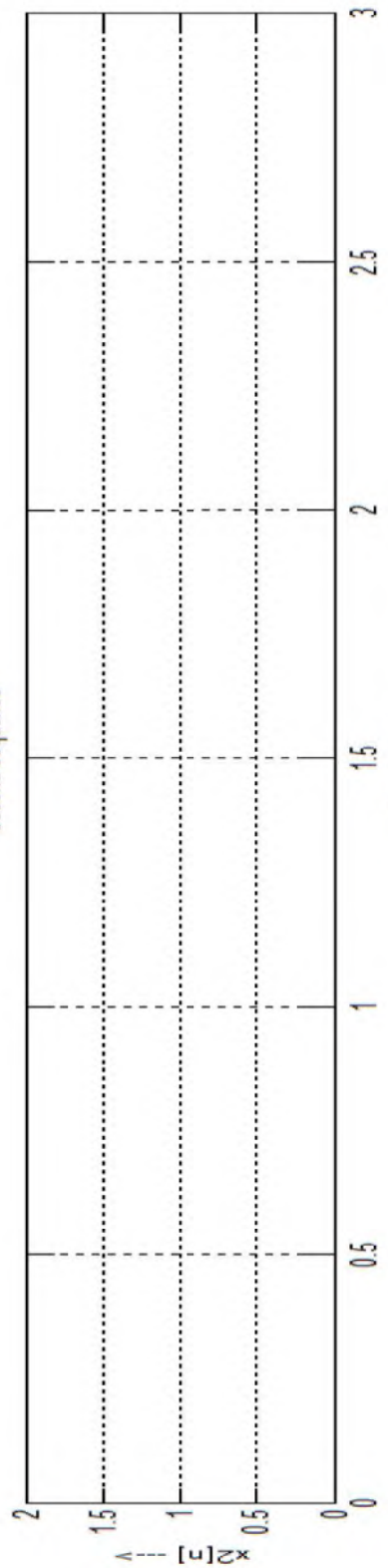
```
clc; close all; clear all;

x1=input('Enter the first sequence:  ')
x2 = input('Enter the second sequence: ')
n1 = length(x1);
n2 = length(x2);

z=xcorr(x1,x2);
ze = n1+n2-2;

disp('Cross Correaltion of two sequences = ');disp(z);
subplot(3,1,1); stem(0:n1-1,x1); xlabel('time [n] --->'); ylabel('x1[n] --->');
title('first sequence'); grid on;
subplot(3,1,2); stem(0:n2-1,x2); xlabel('time [n] --->'); ylabel('x2[n] --->');
title('second sequence'); grid on;
subplot(3,1,3); stem(0:ze,z); xlabel('time [n] --->'); ylabel('z[n] --->');
title('Cross correlation of two sequences'); grid on;
```

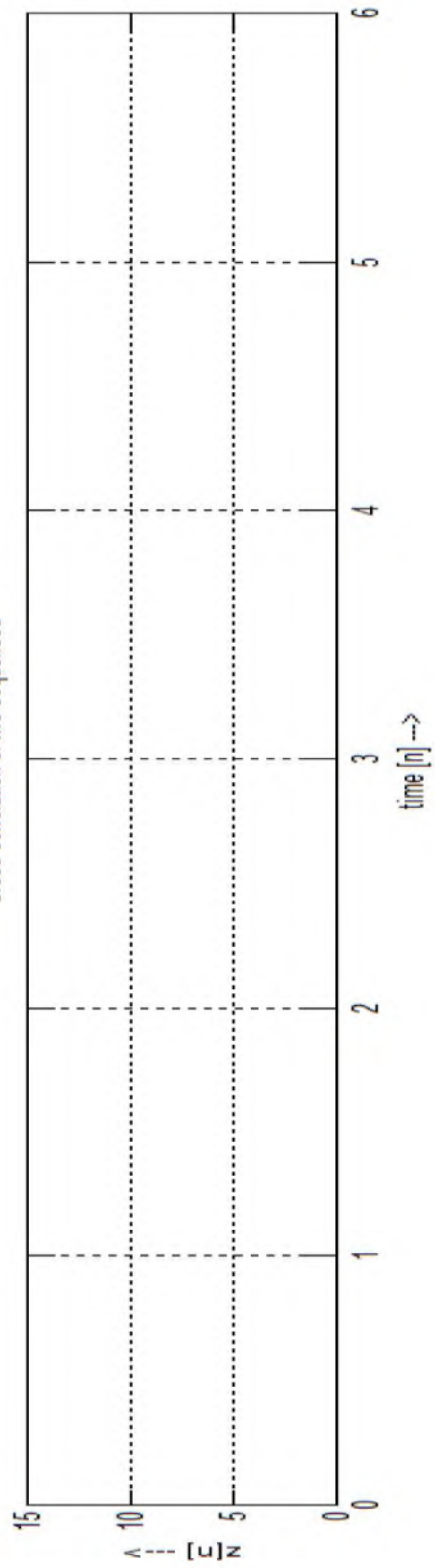
OUTPUT: Enter the first sequence: [1 2 3 4]

Enter the second sequence: [2 1 2 1]

Cross Correaltion of two sequences = _____


first sequence
x1[n] ---->
0
1
2
3
4
0
0.5
1
1.5
2
2.5
3


time [n] --->
second sequence
x2[n] ---->
0
0.5
1
1.5
2
0
0.5
1
1.5
2
2.5
3


time [n] --->
Cross correlation of two sequences
z[n] ---->
0
5
10
15
0
1
2
3
4
5
6
time [n] --->

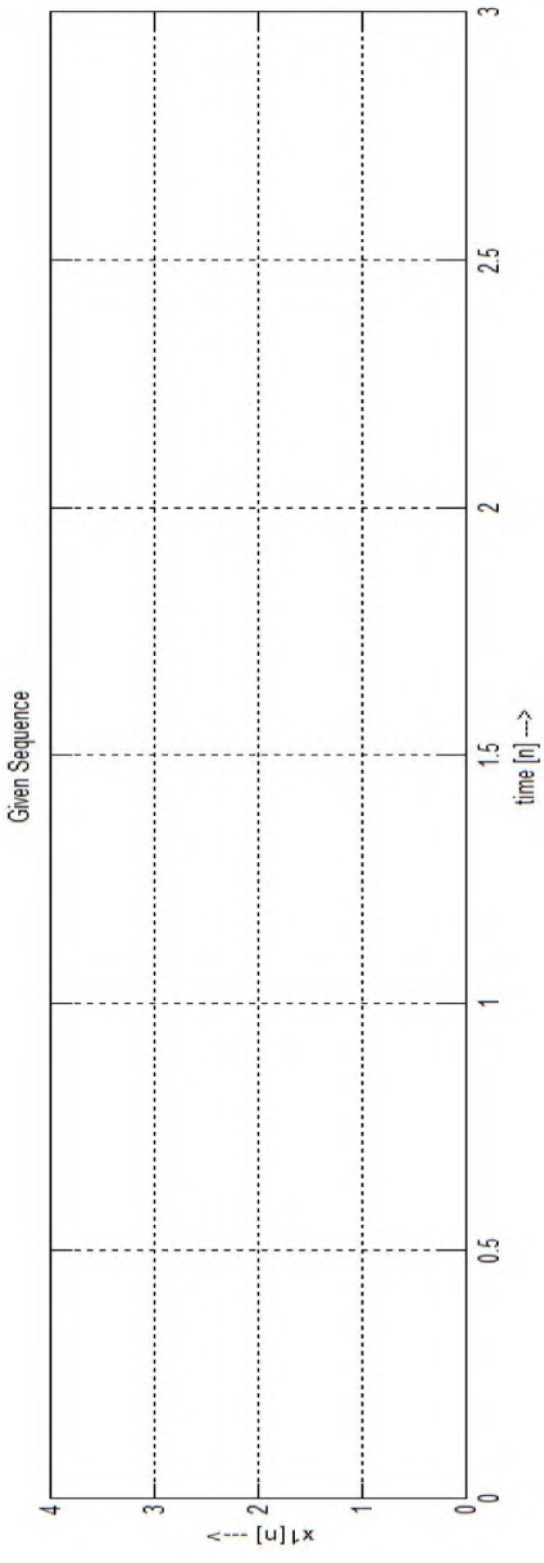
Question 5: Find the AUTO correlation of a causal discrete signal using MATLAB. Plot all the sequences.

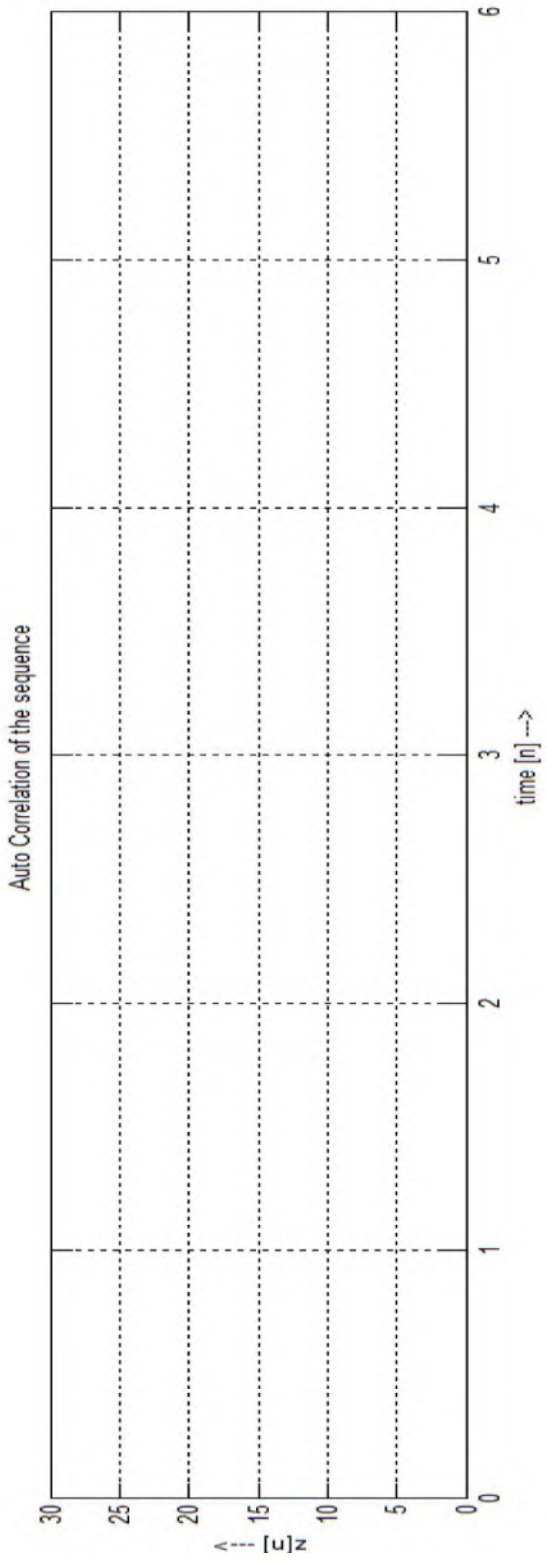
PROGRAM:

```
clc;
close all;
clear all;
 x=input('Enter the sequence:  ')
n = length(x);
z=xcorr(x,x);
ze = 2*n-2;
disp('Auto Correlation the given sequence = ');disp(z);
subplot(2,1,1);
stem(0:n-1,x);
xlabel('time [n] --->');
ylabel('x1[n] --->');
title('Given Sequence');
grid on;
subplot(2,1,2)
stem(0:ze,z);
xlabel('time [n] --->');
ylabel('z[n] --->');
title('Auto Correlation of the sequence');
grid on;
```

OUTPUT: Enter the sequence: [1 2 3 4]

Auto Correlation the given sequence = _____


Given Sequence
x1[n] --->
time [n] --->
0
0.5
1
1.5
2
2.5
3
0
1
2
3
4


Auto Correlation of the sequence
z[n] --->
time [n] --->
0
1
2
3
4
5
6
0
5
10
15
20
25
30

EXERCISE

Question 1: Determine and sketch the convolution sum of, x(n) = [−2 0 1 −1 3] and h(n) = [1 2 0 −1]
↑ ↑

PROGRAM:

OUTPUT: enter the first sequence : _____

enter the time period of the first sequence: _____

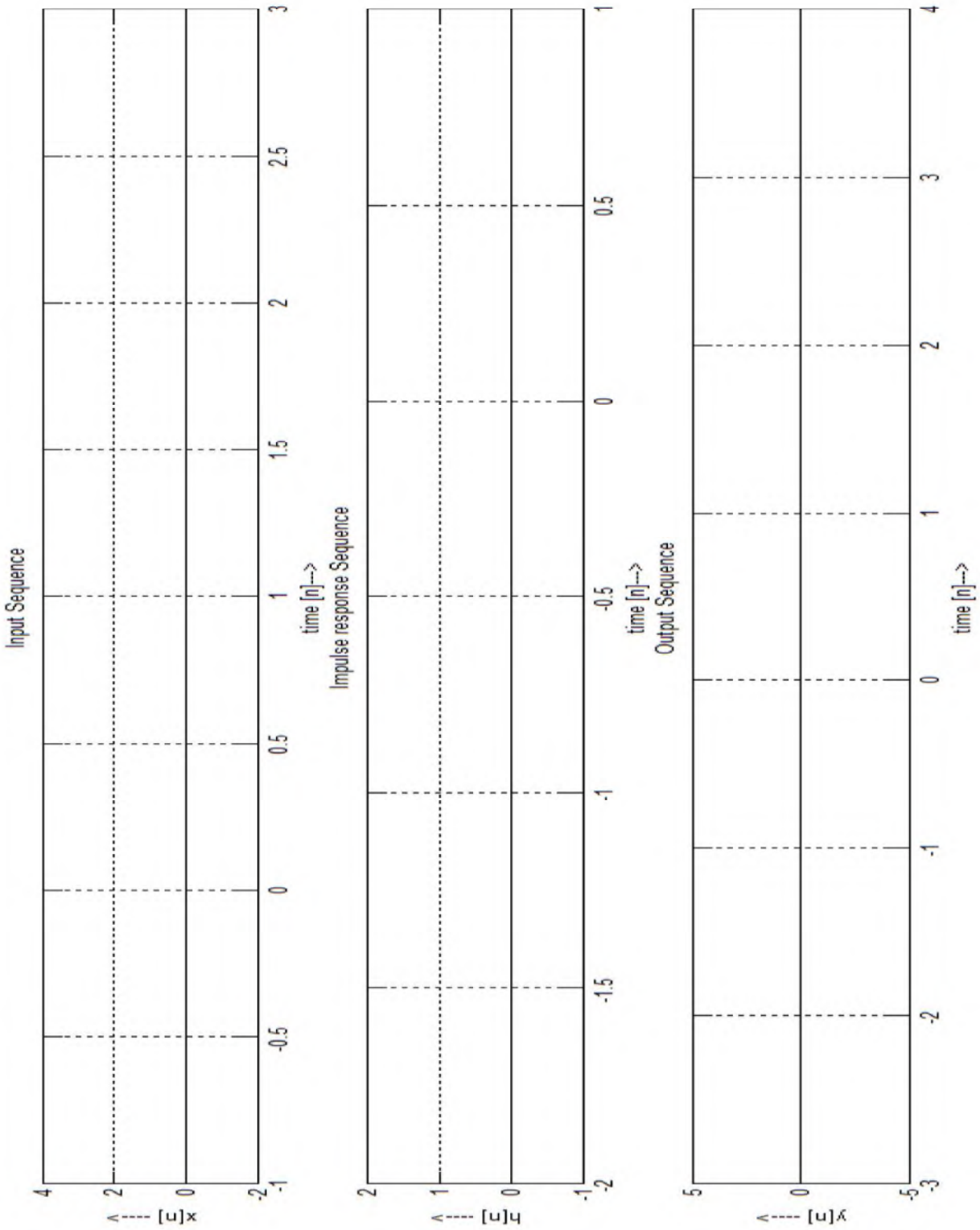
enter the second sequence : _____

enter the time period of the impulse response sequence:_____

The Output sequence y[n] is:_____

Start time of Output Sequence = _____

End time of Output Sequence = _____


Input Sequence
x[n] ----->
time [n]--->
Impulse response Sequence
h[n] ----->
time [n]--->
Output Sequence
y[n] ----->
time [n]--->
4
2
0
-2
-1
-0.5
0
0.5
1
1.5
2
2.5
3
2
1
0
-1
-2
-1.5
-1
-0.5
0
0.5
1
5
0
-5
-3
-2
-1
0
1
2
3
4

QUESTION 2: Determine and sketch the cross correlation of, x(n) = [−2 0 1 −1 3] and h(n) = [1 2 0 −1]

↑ ↑

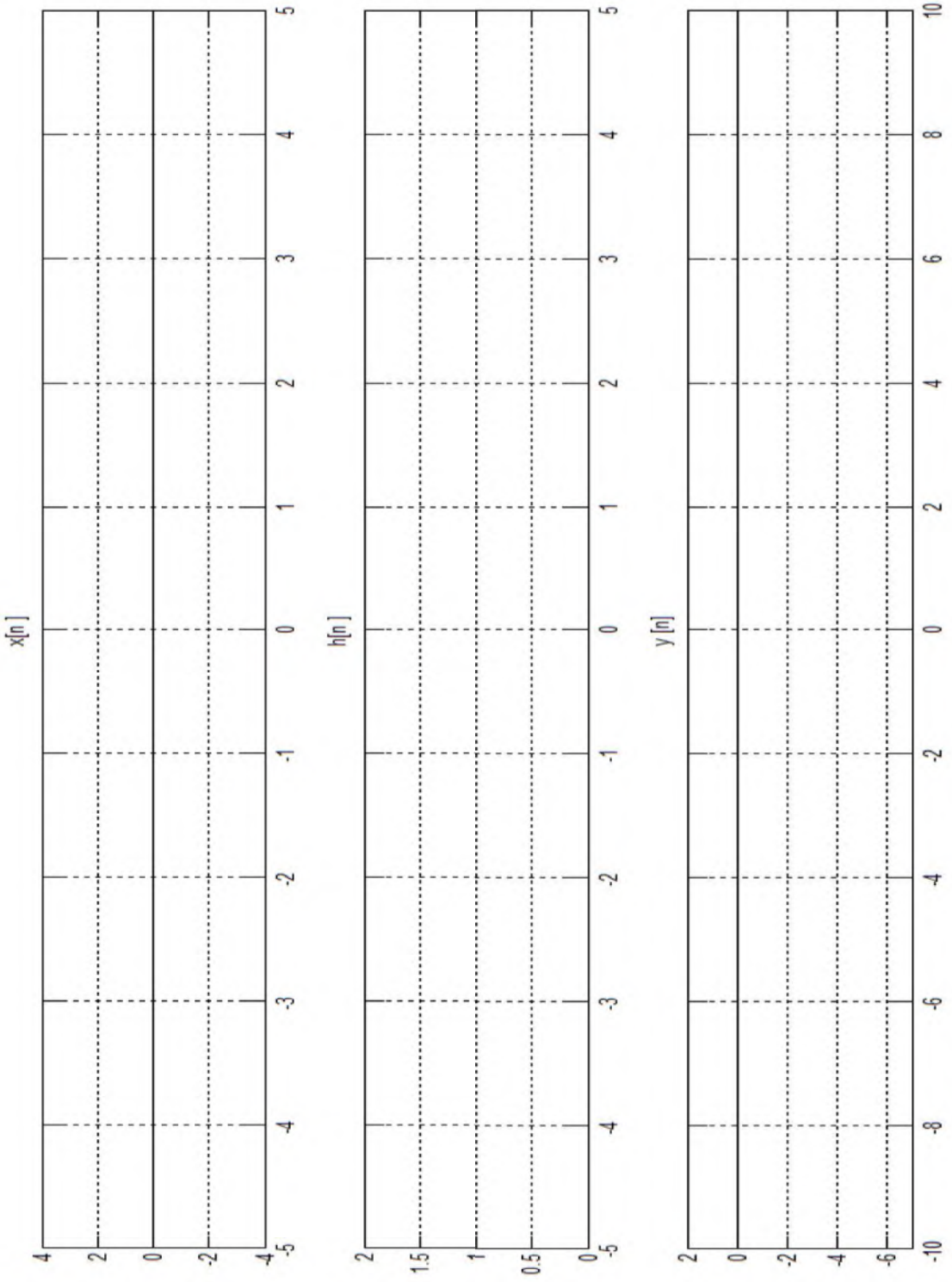
PROGRAM:

```
clc; clear all; close all;
n = [ -5 -4 -3 -2 -1 0 1 2 3 4 5]; % x - axis
x1 = [ 0 0 0 0 0 0 1 -2 3 -4 0]; % input
x2 = [ 0 0 0 0.5 1 2 1 0.5 0 0 0]; % response
y = xcorr (x1 ,x2 );
n1 = length (x1) -1;
n2 = length (x2) -1;
k = - n1 :1: n2 ;
disp ('cross correlation = '); disp(y);
figure ;
subplot (3,1,1)
stem(n ,x1); title ('x[n ]'); grid on;
subplot (3,1,2)
stem(n ,x2); title ('h[n ]'); grid on;
subplot (3,1,3)
stem(k ,y) , title ('y[n]'); grid on;
```

OUTPUT:

Cross Correaltion of two sequences = _____

OUTPUT:


x[n]
4
2
0
-2
-4
5
4
3
2
1
0
-1
-2
-3
-4
-5
h[n]
2
1.5
1
0.5
0
5
4
3
2
1
0
-1
-2
-3
-4
-5
y [n]
2
0
-2
-4
-6
10
8
6
4
2
0
-2
-4
-6
-8
-10

King Khalid University
College of Computer Science
Department of Computer Engineering

Experiment # 6 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

Lab Day: _____ Section Number: _____ Serial Number: _____

Experiment #6

Z- Transforms and Analysis

Question 1: Write MATLAB program to find out the Z-Transform of commonly used discrete Signals, ex: Unit Step Sequence, sin(an)u[n], cos[an]u[n], a^nu[n], e^{-an}u[n]

MATLAB PROGRAM:

```
clc
clear all
close all
syms a n z;
disp('The Z Transform of Unit Step function is:')
U = ztrans(heaviside(0.5),n,z);  %MATLAB's heaviside defines H(0) to be 0.5
therefore use heaviside(0.5) for unit step
disp(U);
disp('The Z Transform of sin[an]u[n] is');
S = ztrans(sin(a*n));
disp(S);
disp('The Z transform of cos[an]u[n] is');
C = ztrans(cos(a*n));
disp(C);
disp('The Z transform of a^n u[n] is');
A = ztrans((a^n).*heaviside(0.5),n,z);
disp(A);
disp('The Z Transform of exp(-an)u[n] is');
E = ztrans((exp(-a.*n))*heaviside(0.5));
disp(E)
```

OUTPUT:

Question 2: Write MATLAB Program to find the Z-Transform of any Causal Sequence

MATLAB PROGRAM:

```
clc;
close all;
clear all;
syms 'z'; % creates symbolic variable
x= input('Enter the sequence x[n]= ');
N = length(x);
syms 'm';
syms 'y';
f(y,m)=(y*(z^(-m)));
disp('Z-transform of the input sequence is displayed below');
k=1;
for n= 0:N-1
    answer(k)=(f((x(k)),n));
   k=k+1;
end
disp(sum(answer));
```

OUTPUT:

Enter the sequence x[n]= [1 2 3 4 5]

Z-transform of the input sequence is displayed below: _____

Question 3: Write MATLAB Program to find the Z-Transform of any Non-Causal Sequence

MATLAB PROGRAM:

```
clc;
close all;
clear all;
syms 'z';
x= input('Enter the sequence x[n]= ');

ns=input('Please input the initial value of n = ');
ne=input('Please input the final value of n = ');

syms 'm';
syms 'y';
f(y,m)=(y*(z^(-m)));
disp('Z-transform of the input sequence is displayed below');
k=1;
for n=ns:1:ne
   answer(k)=(f((x(k)),n));
  k=k+1;
end
disp(sum(answer));
```

OUTPUT:

Enter the sequence x[n]= [1 2 3 4 5]

Please input the initial value of n = -2

Please input the final value of n = 2

Z-transform of the input sequence is displayed below: _____

2. Pole Zero Plot:

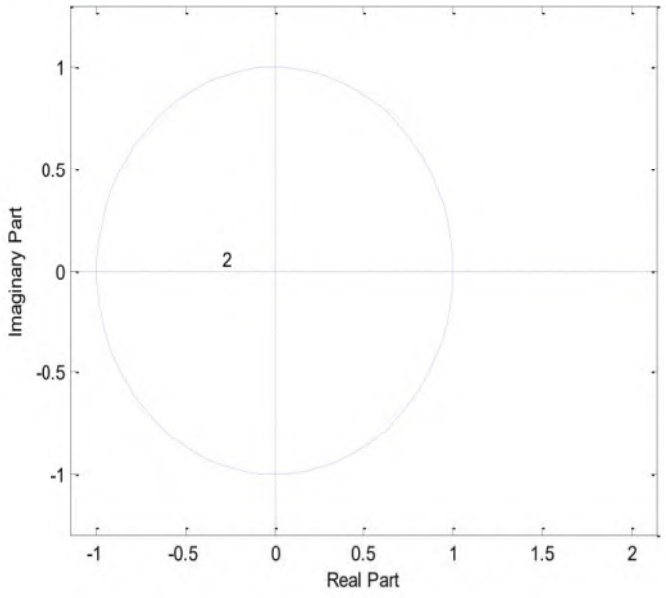
QUESTION 4: **Find the Find poles and zeros of the following pulse transfer function and plot them onto the z-plane.**

$$H(z) = \frac{2.25 - 2.1z^{-1} - 3.95z^{-2} - 1.6z^{-3} - 0.2z^{-4}}{4 - 2.96z^{-1} + 0.8z^{-2} - 0.1184z^{-3} - 0.0064z^{-4}}$$

MATLAB PROGRAM:

```
clc
clear all
close all
num  = [2.25   -2.1   -3.95  -1.6   -0.2];
den = [4   -2.96  0.8   -0.1184   -0.0064];
zeroes= roots(num)
poles = roots(den)
zplane(num,den)
```

OUTPUT:



LAB ACTIVITY - EXERCISE

QUESTION 5: **Find the Z- Transform of the following sequences:**

$$x\{n] = \left(\frac{1}{4}\right)^n u[n]$$

$$f[n] = 2 \times 2^n + 4\left(\frac{1}{2}\right)^n \quad n \geq 0$$

$$g[n] = n\,u[n]$$

MATLAB PROGRAM:

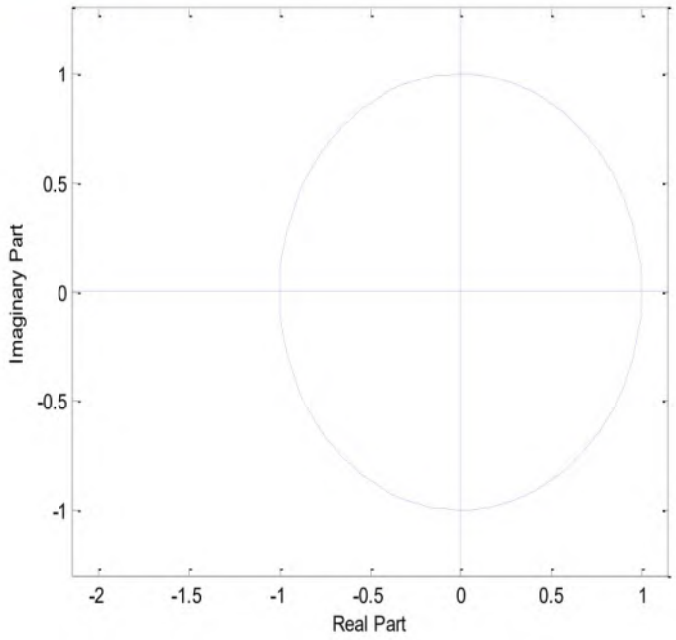
OUTPUT:

QUESTION 6: **Find the pole-zero plot of the system shown below:**

$$H(z) = \frac{z + 2}{z^2 + \frac{1}{4}}$$

MATLAB PROGRAM:

OUTPUT:

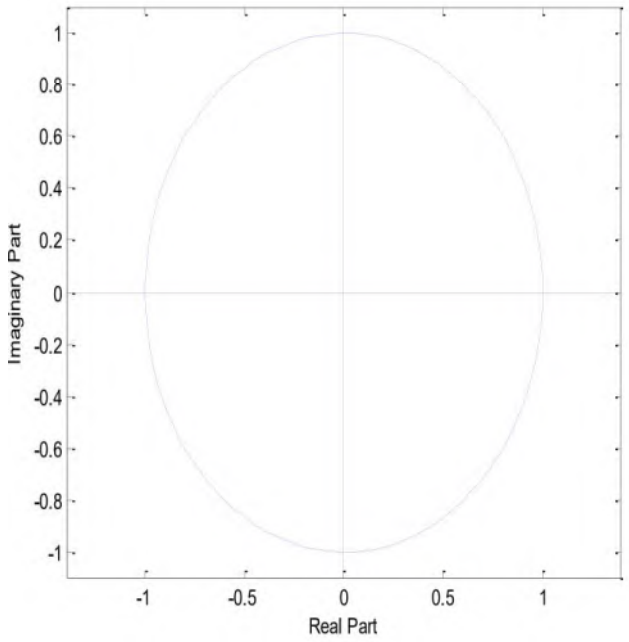


QUESTION 7: **Given a causal system, y(n) = 0.9y(n − 1) + x(n). Determine H(z) and sketch its pole-zero plot.**

[Hint: Take Z-Transform on both sides, to get: $H(z) = \frac{1}{1-0.9\,z^{-1}}$]

MATLAB PROGRAM:

OUTPUT:

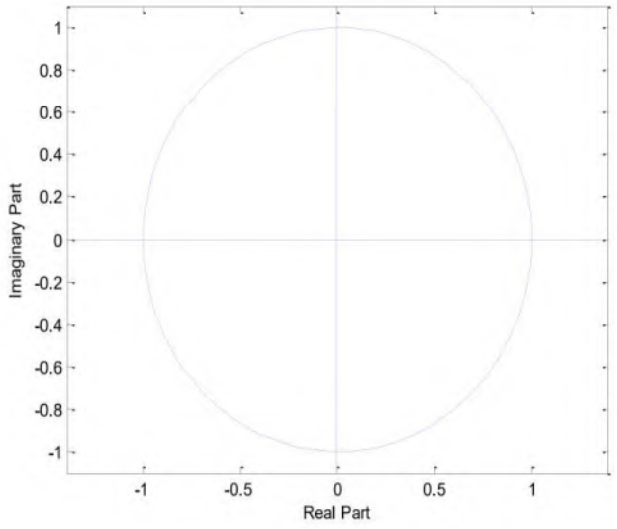


QUESTION 8: **Find the pole-zero plot of the system shown below:**

$$H(z) = \frac{2 - z^{-1}}{1 - 0.1z^{-1} - 0.02z^{-2}}$$

MATLAB PROGRAM:

OUTPUT:



King Khalid University
College of Computer Science
Department of Computer Engineering

Experiment # 7 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

Lab Day: _____ Section Number: _____ Serial Number: _____

Experiment #7

Inverse Z- Transform

Question 1: Write MATLAB program to find inverse z-transform of the following:

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

MATLAB PROGRAM:

```
clc;
close all;
clear all;
syms n;
syms k;
syms f(z);
f(z) = input('Please input a function to obtain its inverse z transform ');
answer = iztrans(f(z));
disp(answer);
```

OUTPUT:

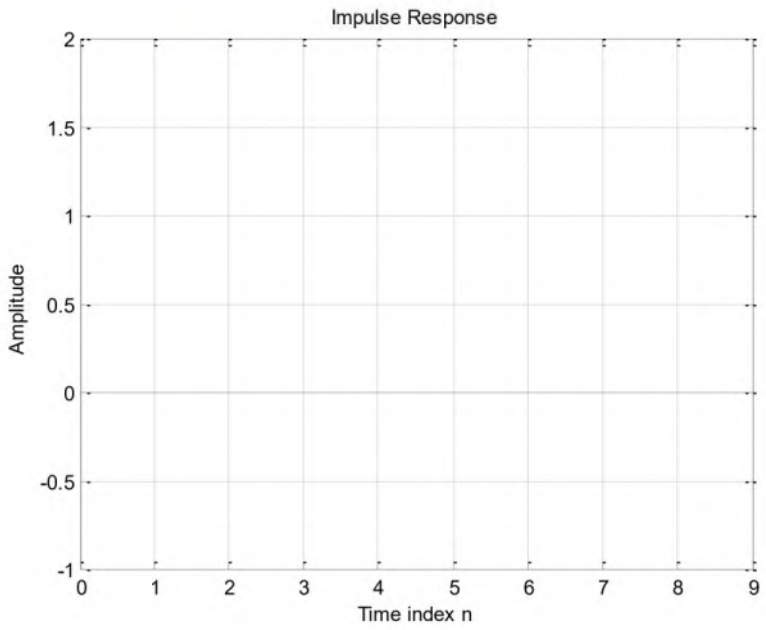
Question 2: Write MATLAB program to find the inverse z-transform of the following using power series method (or) long division method

$$H(z) = \frac{1 + 2\,z^{-1}}{1 + 0.4z^{-1} - 0.12\,z^{-2}}$$

MATLAB PROGRAM:

```
clc
clear all
close all
L = 10; %length of the output vector
num = [1 2];
den = [1 0.4 -0.12];
[h,n] = impz(num,den,L)  % impulse response

% Plot the impulse response
stem(n,h);
xlabel ('Time index n');
ylabel ('Amplitude ');
title ('Impulse Response');
grid ;
```

OUTPUT:



Question 3: Write MATLAB program to find the inverse z-transform using partial fraction method

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

MATLAB PROGRAM:

```
clc
clear all
close all
num = [0 1];
den = [3 -4 1];
[r,p,k] = residuez(num,den)
```

OUTPUT:

LAB ACTIVITY - EXERCISE

QUESTION 4: **Find the inverse z-transform of the following using symbolics:**

$$X(Z) = \frac{Z}{Z^2 + 5Z + 6}$$

MATLAB PROGRAM:

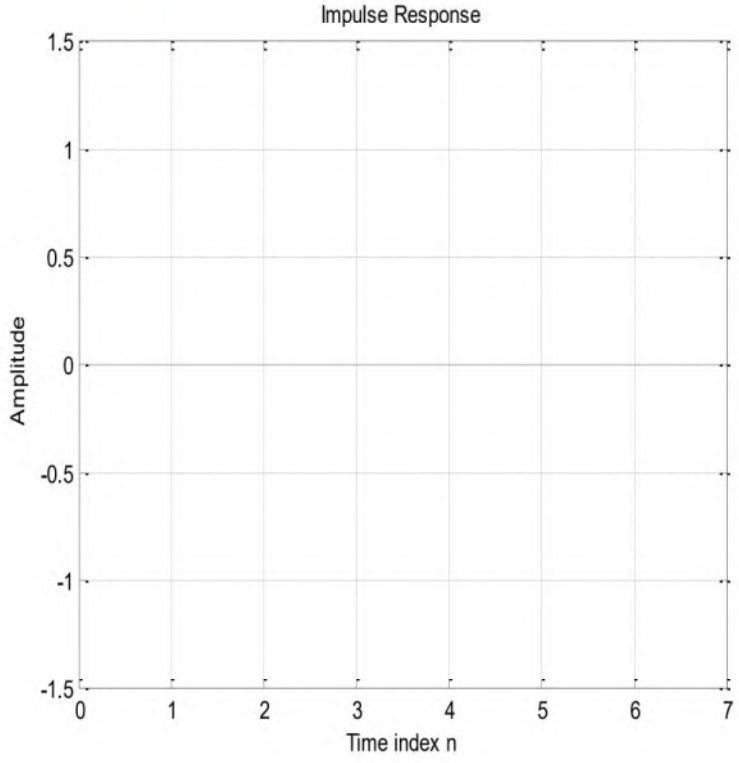
OUTPUT:

QUESTION 5: **Find the inverse z-transform using power expansion method**

$$H(z) = \frac{z}{z^2 - 1.414z + 1}$$

MATLAB PROGRAM:

OUTPUT:



QUESTION 6: **Find the inverse z-transform using partial fraction method**

$$H(z) = \frac{-4 + 8\,z^{-1}}{1 + 6z^{-1} + 8\,z^{-2}}$$

MATLAB PROGRAM:

OUTPUT:

QUESTION 7: **Find the Inverse Z – Transform using partial fraction method:**

$$H(z) = \frac{2z^2 - 2.05z}{z^2 - 2.05z + 1}$$

MATLAB PROGRAM:

OUTPUT:

QUESTION 8: **Find the partial fraction expansion for the Inverse Z – Transform: (repeated poles)**

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

MATLAB PROGRAM:

Z – TRANSFORMS OF SOME USEFUL SIGNALS

Signal $x[n]$	z-Transform $X(z)$	ROC
$\delta[n]$	1	All z
$u[n]$	$\frac{1}{1-z^{-1}}$	$\lvert z\rvert > 1$
$n\,u[n]$	$\frac{z^{-1}}{(1-z^{-1})^2}$	$\lvert z\rvert > 1$
$a^n u[n]$	$\frac{1}{1-az^{-1}}$	$\lvert z\rvert > \lvert a\rvert$
$na^n\,u[n]$	$\frac{az^{-1}}{(1-az^{-1})^2}$	$\lvert z\rvert > \lvert a\rvert$
$-a^n u[-n-1]$	$\frac{1}{1-az^{-1}}$	$\lvert z\rvert < \lvert a\rvert$
$-na^n\,u[-n-1]$	$\frac{az^{-1}}{(1-az^{-1})^2}$	$\lvert z\rvert < \lvert a\rvert$
$(\cos\omega_o n)u[n]$	$\frac{1-z^{-1}\cos\omega_o}{1-2z^{-1}\cos\omega_o+z^{-2}}$	$\lvert z\rvert > 1$
$(\sin\omega_o n)u[n]$	$\frac{z^{-1}\sin\omega_o}{1-2z^{-1}\cos\omega_o+z^{-2}}$	$\lvert z\rvert > 1$
$(a^n\cos\omega_o n)u[n]$	$\frac{1-az^{-1}\cos\omega_o}{1-2az^{-1}\cos\omega_o+a^2z^{-2}}$	$\lvert z\rvert > \lvert a\rvert$
$(a^n\sin\omega_o n)u[n]$	$\frac{az^{-1}\sin\omega_o}{1-2az^{-1}\cos\omega_o+a^2z^{-2}}$	$\lvert z\rvert > \lvert a\rvert$

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Experiment # 8 LAB RECORD

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Experiment #8

Discrete Time Fourier Series

Question 1: Write MATLAB program to find the discrete time fourier series coefficients of the periodic sequence given by

$$x[n] = \cos\left(\frac{2\pi}{3}n\right) + \sin\left(\frac{2\pi}{5}n\right)$$

Solution: The time period of the signal is:

$N_1 = 3$ $N_2 = 5$ N = LCM of 3 and 5 = 15.

```
clc;        clear all;        close all;
N=15;
for n=0:N-1;
x(n+1) =  cos(2*pi*n/3) + sin(2*pi*n/5);
end
% Computing the Fourier Coefficients Ck
for k = 1:N;
SUM = 0;
for n = 1:N;
C(k) = (1/N)*x(n)*exp(-j*2*pi*(k-1)*(n-1) /N);
SUM = SUM + C(k);
end
C(k) = SUM;
end
disp('The Fourier coefficients are:'); [C]
% Computing the Discrete Fourier Series X[k]
for k = 1:N;
sum = 0;
for n = 1:N;
Xk(k) = x(n)*exp(j*2*pi*(k-1)*(n-1) /N);
sum = sum + C(k);
end
Xk(k) = sum;
end
disp('The Discrete Fourier Series terms are:'); [Xk]
n_2 = 0:N-1;
subplot(2,1,1)
stem(n_2, abs(Xk))
title('Magnitude Spectrum (abs)')
grid;
subplot(2,1,2)
stem(n_2, angle(Xk))
title('Phase Spectrum (angle)'); grid;
```

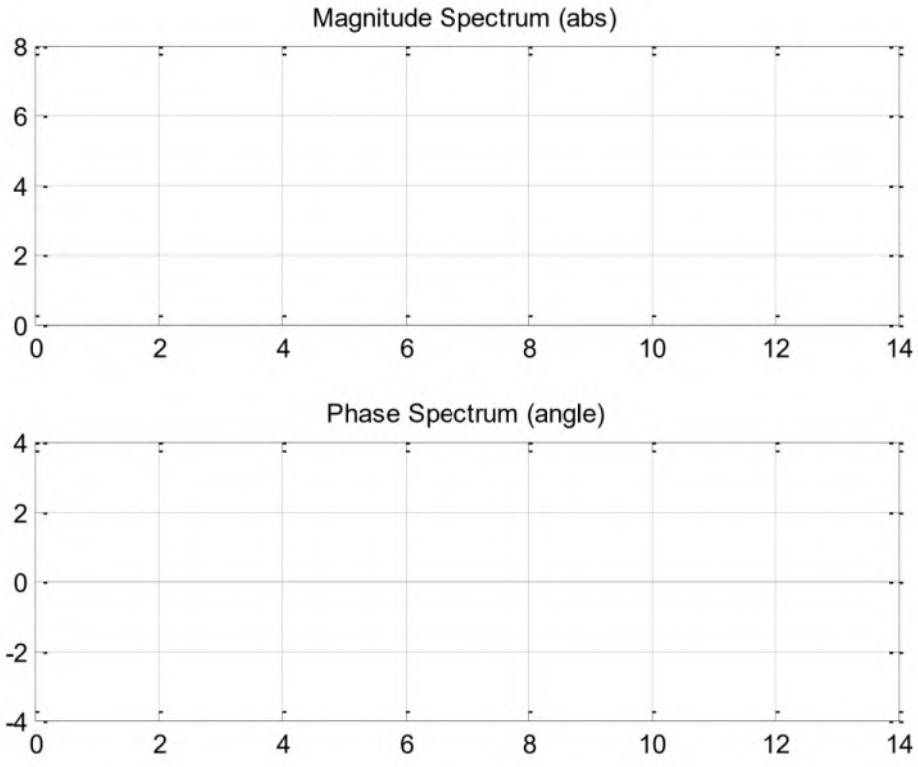
OUTPUT:

The Fourier coefficients are:

C =

The Discrete Fourier Series terms are:

Xk =



Question 2: write the MATLAB program to find the power spectral density of the discrete periodic sequence given in the above question:

$$x[n] = \cos\left(\frac{2\pi}{3}n\right) + \sin\left(\frac{2\pi}{5}n\right)$$

MATLAB PROGRAM:

```
clc
clear all
close all
N=15;
for n=0:N-1;
x(n+1) =  cos(2*pi*n/3) + sin(2*pi*n/5);
end
for k = 1:N;
SUM = 0;
for n = 1:N;
C(k) = (1/N)*x(n)*exp(-j*2*pi*(k-1)*(n-1) /N);
SUM = SUM + C(k);
end
C(k) = SUM;
end
% calculating PSD using the first formula
for n = 1:N
   PSD_1(n) = (abs(x(n))).^2;
end
PSD_1 = sum(PSD_1)/N

% calculating PSD using the second formula
for k = 1:N;
   PSD_2(k) = (abs(C(k))).^2;
end
PSD_2 = sum(PSD_2)
```

OUTPUT:

Question 3: Write MATLAB program to find the discrete time fourier series coefficients of the periodic sequence of period = 5 given by:

$$x[n] = \begin{cases} 1, & n = 0, 1, 2 \\ 0, & n = 3, 4 \end{cases}$$

```
clc;
clear all;
close all
N=5;
x = [1 1 1 0 0];
% Computing the Fourier Coefficients Ck
for k = 1:N;
SUM = 0;
for n = 1:N;
C(k) = (1/N)*x(n)*exp(-j*2*pi*(k-1)*(n-1) /N);
SUM = SUM + C(k);
end
C(k) = SUM;
end
disp('The fourier coefficients are:')
for k = 1:N;
   disp(C(k))
end
% Computing the Discrete Fourier Series X[k]
for k = 1:N;
sum = 0;
for n = 1:N;
Xk(k) = x(n)*exp(j*2*pi*(k-1)*(n-1) /N);
sum = sum + C(k);
end
Xk(k) = sum;
end
disp('The Discrete Fourier Series terms are:')
for k = 1:N;
   disp(Xk(k))
end
n_2 = 0:N-1;
subplot(2,1,1)
stem(n_2, abs(Xk))
title('Magnitude Spectrum (abs)')
grid;
subplot(2,1,2)
stem(n_2, angle(Xk))
title('Phase Spectrum (angle)');
grid;
```

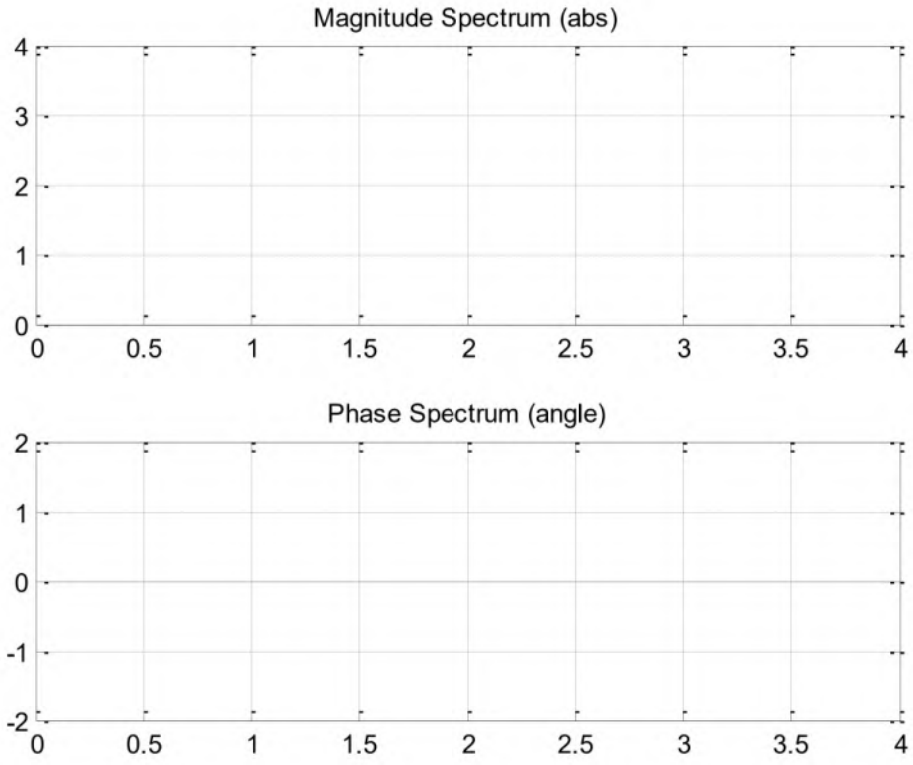
OUTPUT:

The Fourier coefficients are:

C =

The Discrete Fourier Series terms are:

Xk =



QUESTION 4: **Write the MATLAB program to find the power spectral density using parsevals relatoin for the periodic sequence of period = 5 given by:**

$$x[n] = \begin{cases} 1, & n = 0, 1, 2 \\ 0, & n = 3, 4 \end{cases}$$

```
clc
clear all
close all
N=5;
x = [1 1 1 0 0];
% Computing the Fourier Coefficients Ck
for k = 1:N;
SUM = 0;
for n = 1:N;
C(k) = (1/N)*x(n)*exp(-j*2*pi*(k-1)*(n-1) /N);
SUM = SUM + C(k);
end
C(k) = SUM;
end

% calculating PSD using the first formula
for n = 1:N
   PSD_1(n) = (abs(x(n))).^2;
end
PSD_1 = sum(PSD_1)/N

% calculating PSD using the second formula
for k = 1:N;
   PSD_2(k) = (abs(C(k))).^2;
end
PSD_2 = sum(PSD_2)
```

OUTPUT:

LAB ACTIVITY - EXERCISE

QUESTION 5: **Write MATLAB program to find the DTFS Coefficients and the Discrete Time Fourier Series for the discrete periodic signal given by:**

$$x[n] = \sin\left(\frac{3\pi}{4}n\right) + \cos\left(\frac{5\pi}{7}n\right)$$

MATLAB PROGRAM:

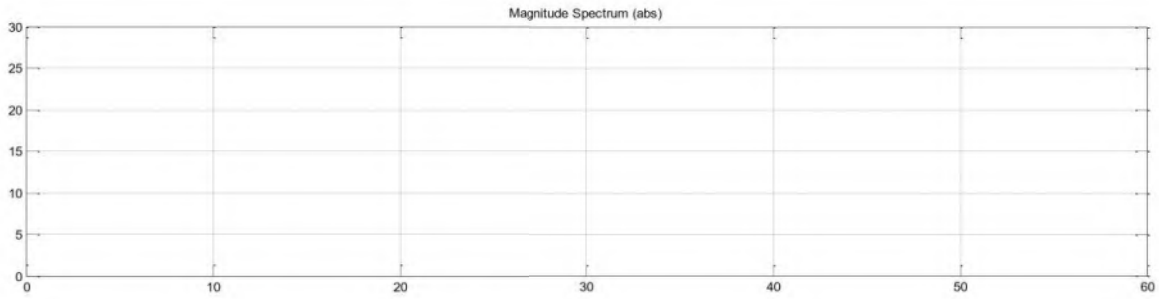
OUTPUT:

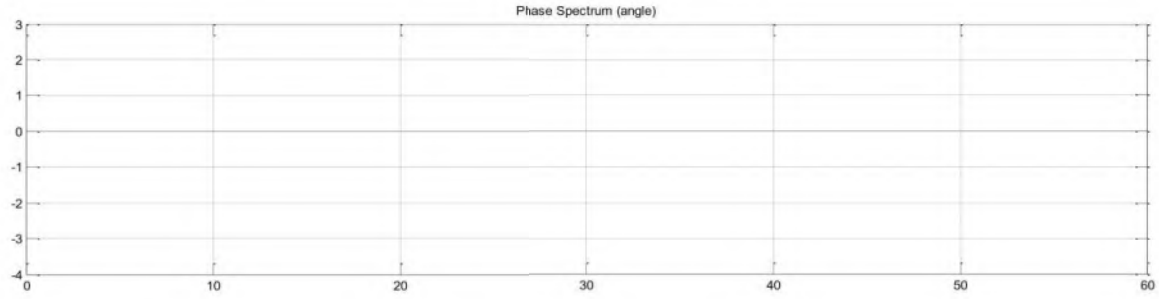
The Fourier coefficients are:

C =

The Discrete Fourier Series terms are:

Xk =





QUESTION 6: **Use MATLAB to find the Power Spectral Density using Parseval's relation for the discrete periodic signal given by:**

$$x[n] = \sin\left(\frac{3\pi}{4}n\right) + \cos\left(\frac{5\pi}{7}n\right)$$

MATLAB PROGRAM:

OUTPUT:

QUESTION 7: **Write MATLAB Program to Find the Discrete Time Fourier Series Coefficients of The Periodic Sequence of Period = 10 given by:**

$$x[n] = \begin{cases} 1, & n = 0, 1, 2 \\ 0, & n = 3, 4, \dots, 9 \end{cases}$$

MATLAB PROGRAM:

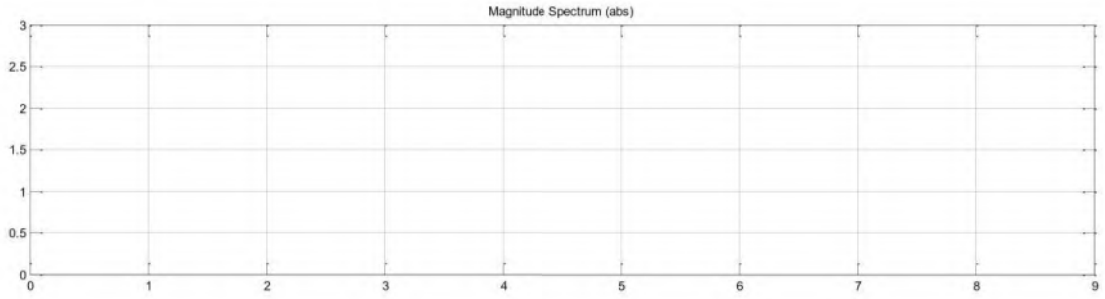
OUTPUT:

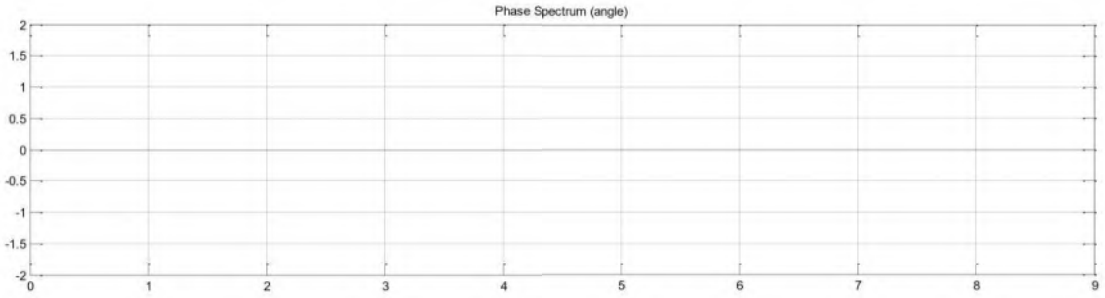
The Fourier coefficients are:

C =

The Discrete Fourier Series terms are:

Xk =





QUESTION 8: **Write MATLAB Program to Find the Power spectral density using Parseval's relation of the discrete Periodic Sequence of Period = 10 given by:**

$$x[n] = \begin{cases} 1, & n = 0, 1, 2 \\ 0, & n = 3, 4, \dots, 9 \end{cases}$$

MATLAB PROGRAM:

OUTPUT

King Khalid University
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Department of Computer Engineering

Experiment # 9 LAB RECORD

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Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

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Experiment #9

Discrete Time Fourier Transform

Question 1: Write MATLAB program to find the discrete time fourier transform of the sequence given by:

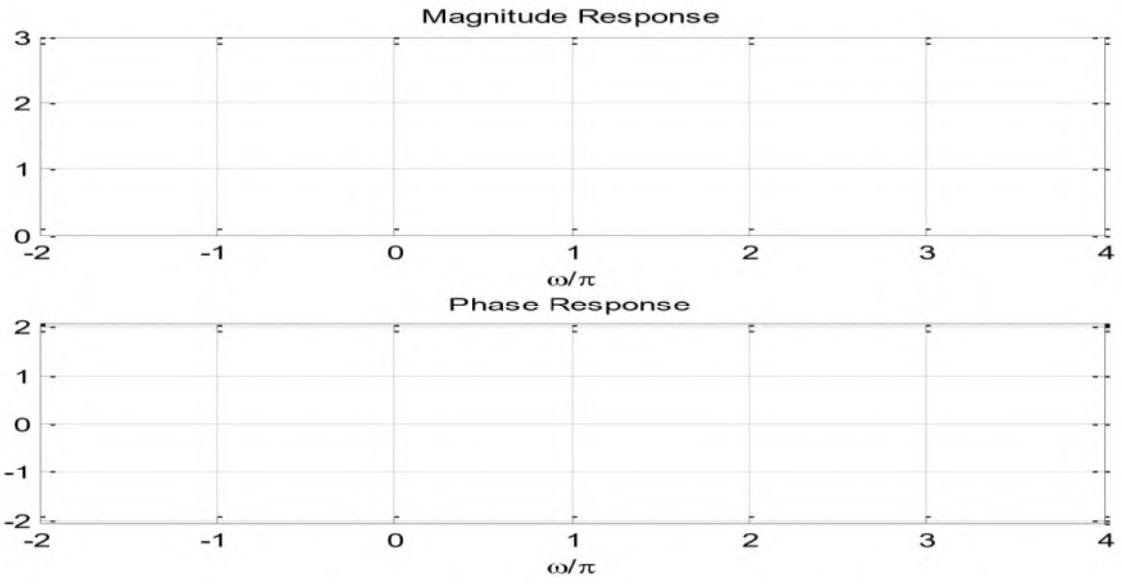
$$x[n] = \begin{cases} 1, & n = 0, 1, 2 \\ 0, & n = 3, 4 \end{cases}$$

Solution: The DTFT of x[n] is computed as:

$$\begin{aligned} X(e^{j\omega}) &= \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n} \\ &= 1 + e^{-j\omega} + e^{-j2\omega} \\ &= e^{-j\omega}\left(e^{j\omega} + 1 + e^{-j\omega}\right) \\ &= e^{-j\omega}\left[1 + 2\cos(\omega)\right] \end{aligned}$$

```
clc;   clear all;      close all;
w=-2*pi:0.01*pi:4*pi;              %separation frequency point separation is 0.01pi
dtft = exp(-j.*w).*(1+2*cos(w));   %define DTFT function
subplot(2,1,1)
Mag = abs(dtft);                   %compute magnitude
plot(w./pi,Mag);  grid;                %plot magnitude
title('Magnitude Response');    xlabel('\omega/\pi');       %x-axis is from 0 to 2
subplot(2,1,2)
Pha = angle(dtft);                 %compute phase
plot(w./pi,Pha);  grid;                %plot phase
axis([-2 4 -2.05 2.05])
title('Phase Response');   xlabel('\omega/\pi')
```

OUTPUT:

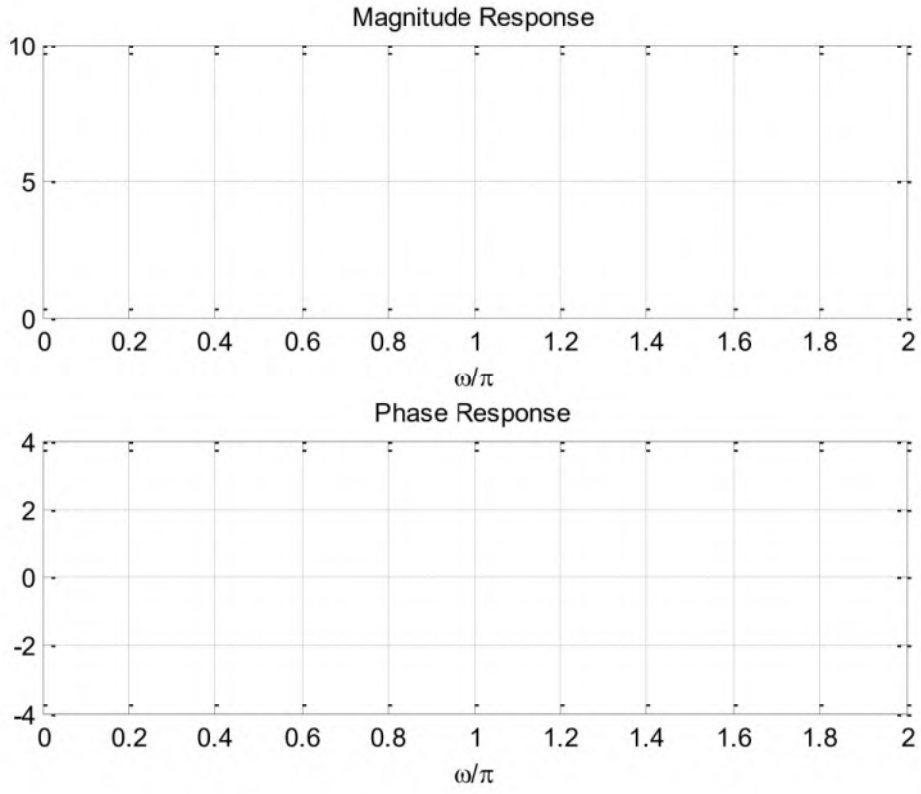


QUESTION 2: Write MATLAB program to find the discrete time fourier transform of the sequence given by: $x[n] = u[n] - u[n-10]$

MATLAB PROGRAM:

```
clc
clear all
close all
w=0:0.01*pi:2*pi;              %separation frequency point separation is 0.01pi
dtft = 1 + exp(-j.*w) + exp(-2*j.*w)+ exp(-3*j.*w)+ exp(-4*j.*w)+ exp(-5*j.*w)+ exp(-6*j.*w)+ exp(-
7*j.*w)+ exp(-8*j.*w)+ exp(-9*j.*w);   %define DTFT function
N =10;
subplot(2,1,1)
Mag = abs(dtft);                    %compute magnitude
plot(w./pi,Mag); grid;                  %plot magnitude
title('Magnitude Response');
xlabel('\omega/\pi');               %x-axis is from 0 to 2
subplot(2,1,2)
Pha = angle(dtft);                  %compute phase
plot(w./pi,Pha);  grid;                 %plot phase
title('Phase Response');  xlabel('\omega/\pi');
```

OUTPUT:

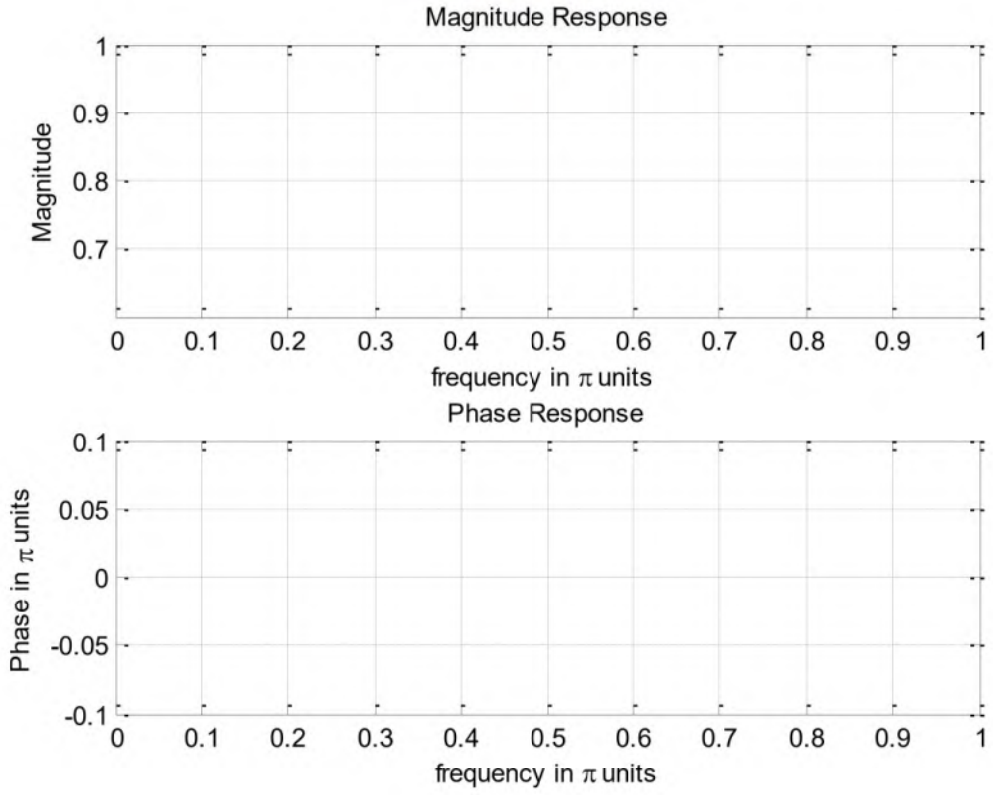


Question 3: Write MATLAB program to find the frequency response of the sequence whose transfer function is given below:

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

```
clc;    clear all;        close all;
num = [1, 2, 3]; % numerator of H(z)
den = [2, 3, 4]; % denominator of H(z)
[H ,w] = freqz (num ,den ,100) ;    %100 points along the upper half of unit circle.
magH = abs (H); phaH = angle (H);
subplot (2 ,1 ,1) ; plot(w/pi , magH); grid
xlabel ('frequency in \pi units ');
ylabel ('Magnitude');
title ('Magnitude Response')
subplot (2 ,1 ,2) ; plot(w/pi , phaH/pi); grid
xlabel ('frequency in \pi units'); ylabel ('Phase in \pi units');   title ('Phase Response')
```

OUTPUT:

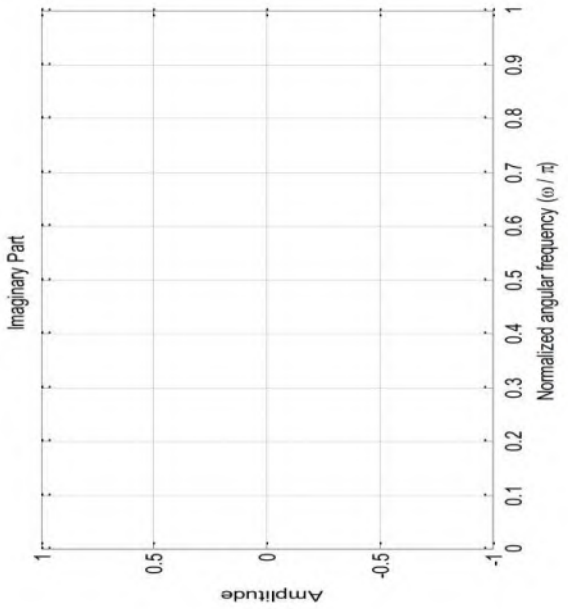


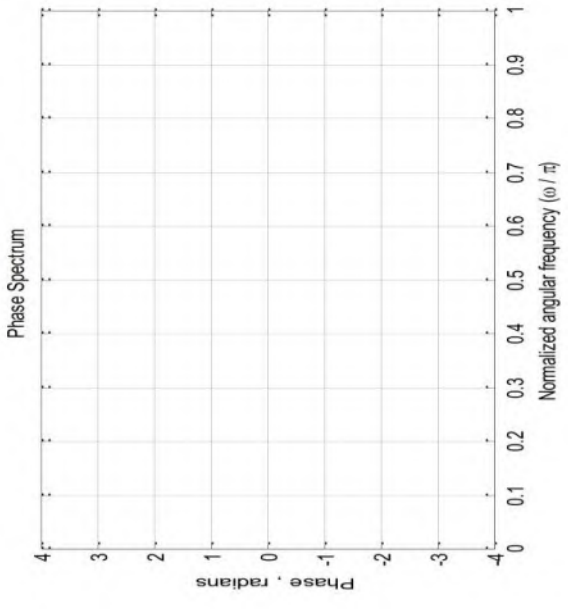
QUESTION 4: **Write the MATLAB program to find the magnitude and phase spectrum of the following system whose dtft is given by:**

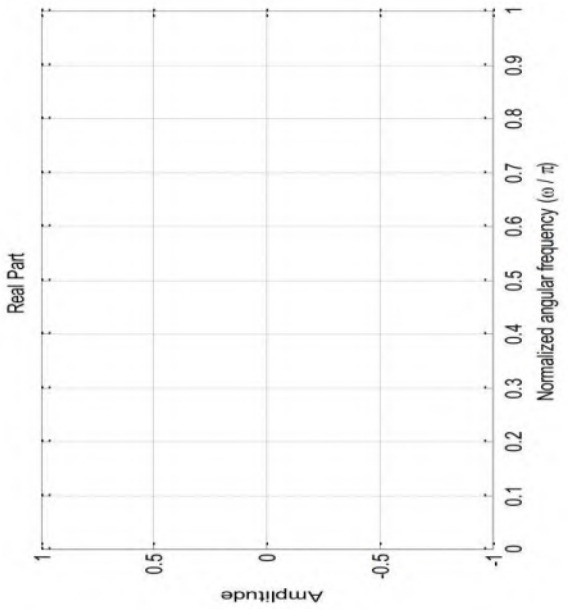
$$X(e^{j\omega}) = \frac{0.008 - 0.033e^{-j\omega} + 0.05e^{-j2\omega} - 0.033e^{-j3\omega} + 0.008e^{-j4\omega}}{1 + 2.37e^{-j\omega} + 2.7e^{-j2\omega} + 1.6e^{-j3\omega} + 0.41e^{-j4\omega}}$$

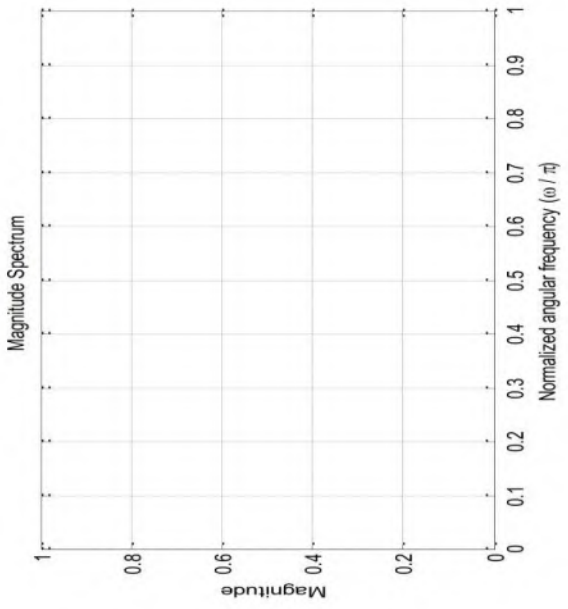
```
clc;
clear all;
close all;
k = 256; % frequency points
num = [0.008 -0.033 0.05 -0.033 0.008];
den = [1 2.37 2.7 1.6 0.41];
w = 0: pi /(k -1) :pi;
h = freqz (num ,den ,w);
subplot (221)
plot(w/pi ,real (h)),grid
title ('Real Part ')
xlabel ('Normalized angular frequency (\omega / \pi)')
ylabel ('Amplitude ')
subplot (222)
plot(w/pi ,imag (h)),grid
title ('Imaginary Part ')
xlabel ('Normalized angular frequency (\omega / \pi)')
ylabel ('Amplitude ')
subplot (223)
plot(w/pi ,abs (h)),grid
title ('Magnitude Spectrum ')
xlabel ('Normalized angular frequency (\omega / \pi)')
ylabel ('Magnitude ')
subplot (224)
plot(w/pi ,angle (h)); grid
title ('Phase Spectrum ')
xlabel ('Normalized angular frequency (\omega / \pi)')
ylabel ('Phase , radians ')
```

OUTPUT:


Imaginary Part
Amplitude
Normalized angular frequency (ω / π)


Phase Spectrum
Phase , radians
Normalized angular frequency (ω / π)


Real Part
Amplitude
Normalized angular frequency (ω / π)


Magnitude Spectrum
Magnitude
Normalized angular frequency (ω / π)

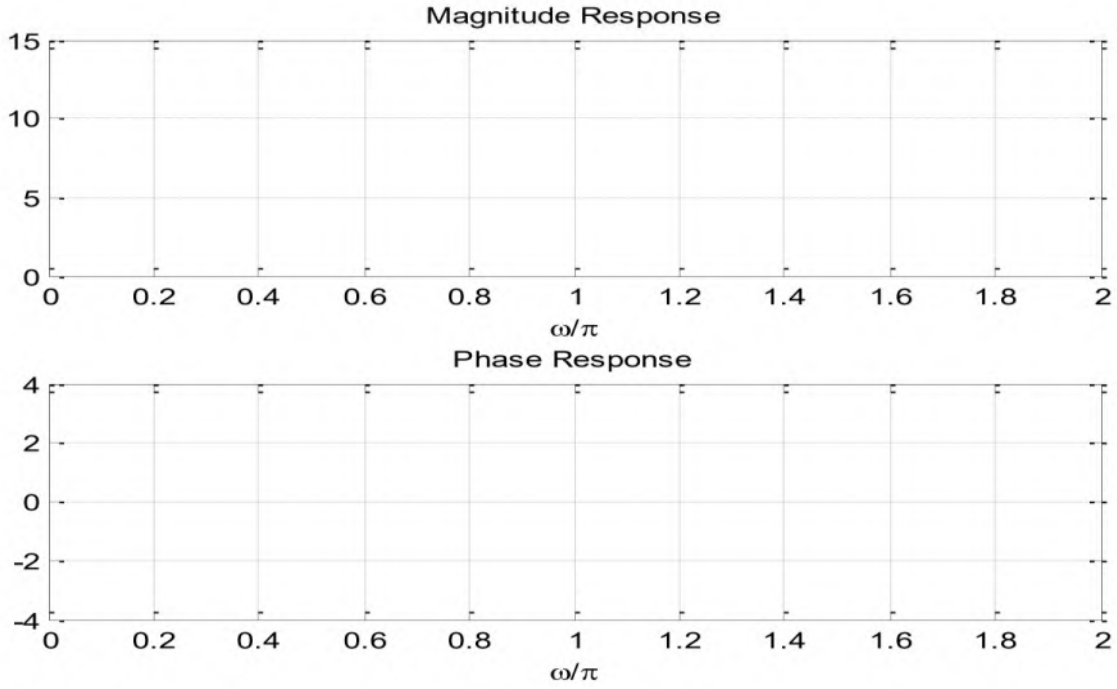
LAB ACTIVITY - EXERCISE

QUESTION 5: **Use MATLAB to obtain the magnitude and phase plot for the DTFT of the discrete finite duration signal given by:**

$$x[n] = \{1, 2, 3, 4, 5\} \quad for -1 \leq n \leq 3$$

MATLAB PROGRAM:

OUTPUT:

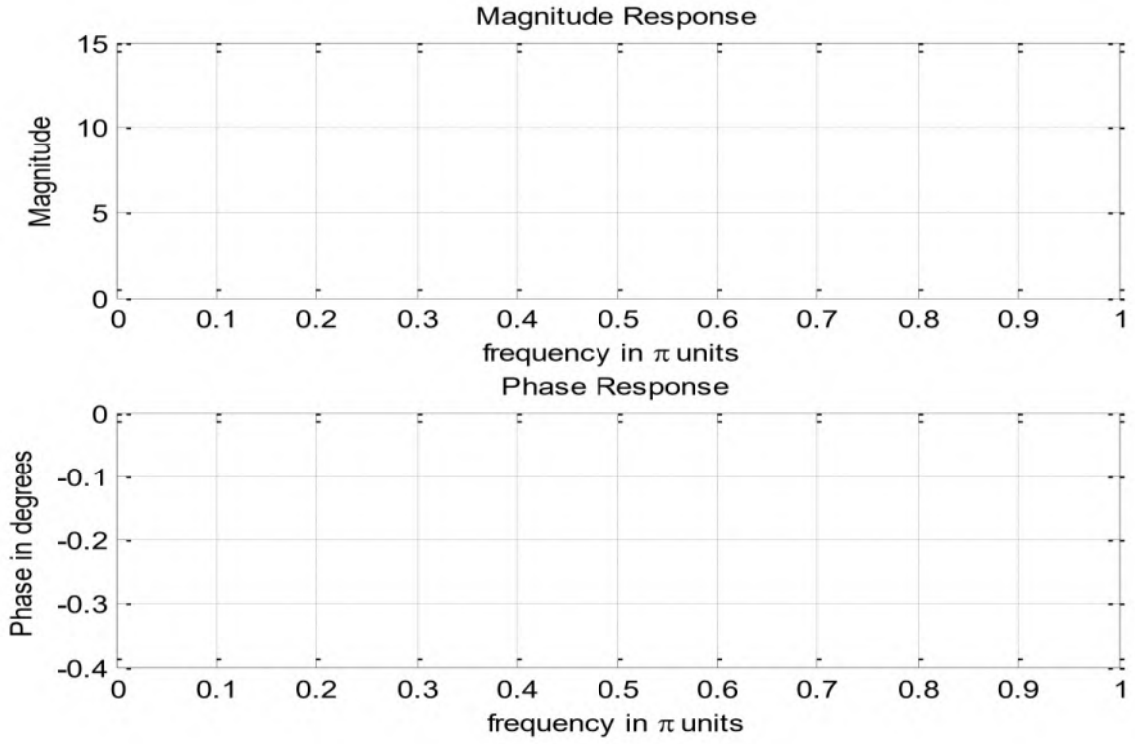


QUESTION 6: **Write the MATLAB program to find the frequency response of the sequence whose transfer function is given below:**

$$H(z) = \frac{1}{1 - 0.9\,z^{-1}} \qquad |z| > 0.9$$

MATLAB PROGRAM:

OUTPUT:

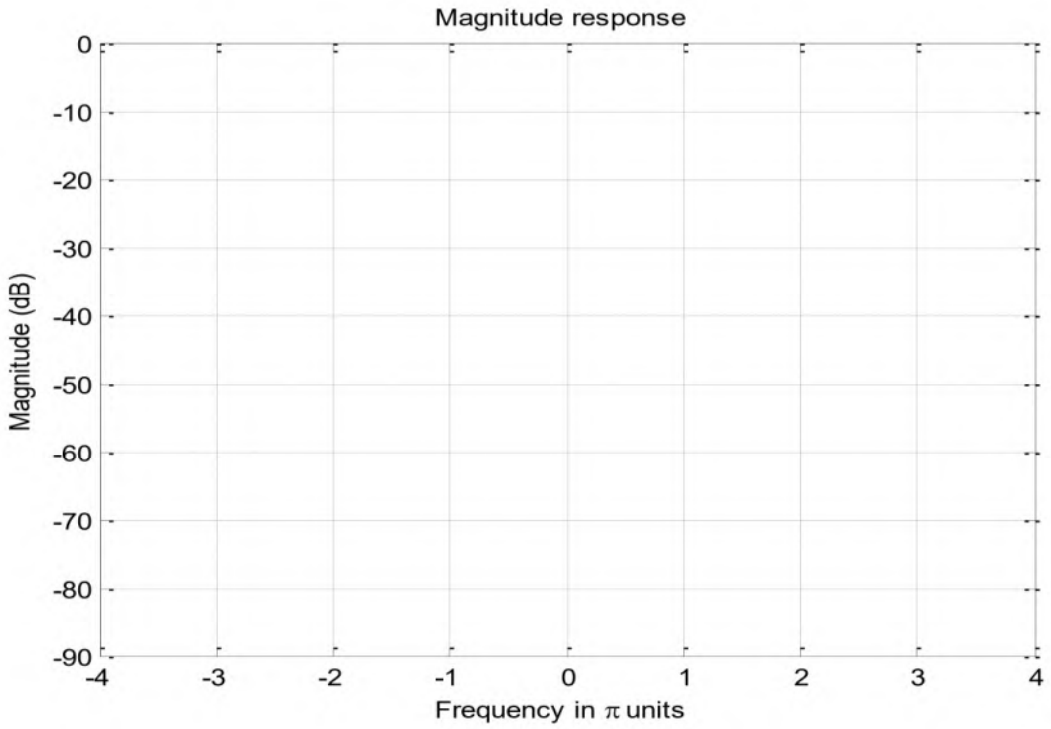


QUESTION 7: **Using the MATLAB script, sketch the normalized frequency response function of the system having the pulse transfer function.**

$$H(z) = \frac{1 + 0.95z^{-1}}{1 - 1.8z^{-1} + 0.81z^{-2}}$$

MATLAB PROGRAM:

OUTPUT:



King Khalid University
College of Computer Science
Department of Computer Engineering

Experiment # 10 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

Lab Day: _____ Section Number: _____ Serial Number: _____

Experiment #10

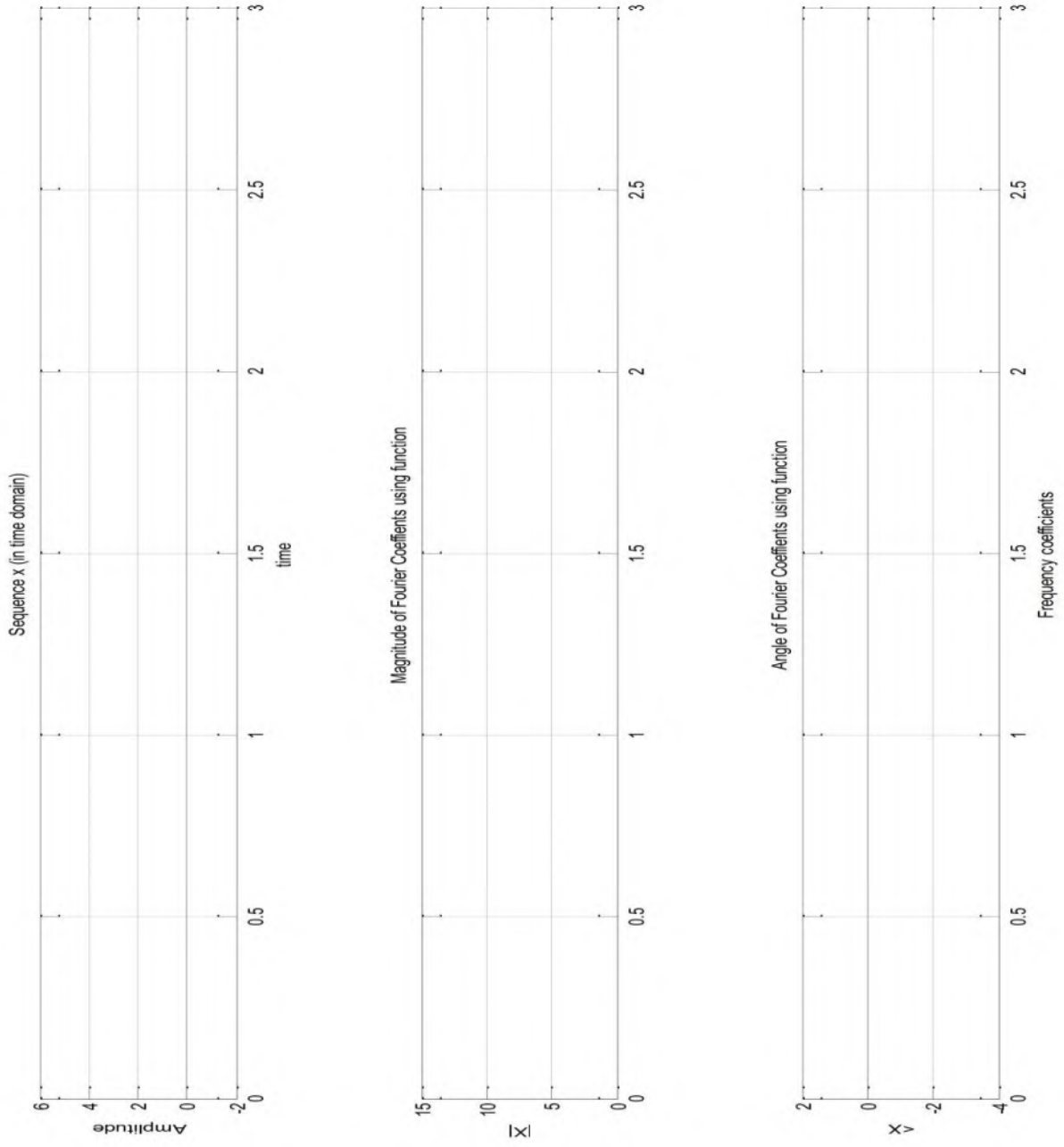
Discrete Fourier Transform and Fast Fourier Transform

Question 1: Write MATLAB program to find the discrete fourier transform of a finite discrete sequence using direct method:

```
% Computation of DFT by Direct Method
clc;   clear all;   close all
x  = input('enter the sequence to find the Discrete Fourier Transform')
N=length(x);
for k=1:N
   X(k)=0;
   for n=1:N
      X(k)=X(k)+x(n).*exp(-1j.*2.*pi.*(n-1).*(k-1)./N);
   end
end
disp('The DFT of the given sequence is'); X
subplot(311)
stem(0:N-1,x)
title('Sequence x (in time domain)')
xlabel('time')
ylabel('Amplitude')
grid;
subplot(312)
stem(0:N-1,abs(X))
title('Magnitude of Fourier Coeffients using function')
ylabel('|X|')
grid;
subplot(313)
stem(0:N-1,angle(X))
title('Angle of Fourier Coeffients using function')
xlabel('Frequency coefficients')
ylabel('<X'); grid;
```

OUTPUT:

Enter the sequence to find the Discrete Fourier Transform[2 4 -1 6]
The DFT of the given sequence is



QUESTION 2: Write MATLAB program to find the Inverse Discrete Fourier Transform of the given sequence by direct method:

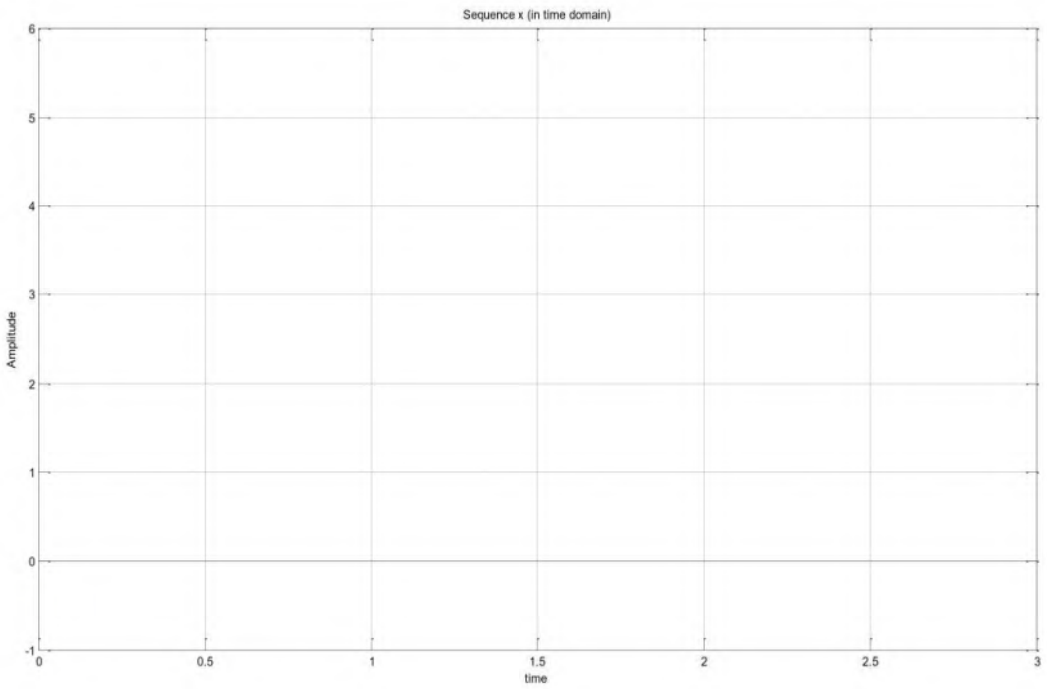
MATLAB PROGRAM:

```
% Computation of IDFT by Direct Method
clc;    clear all;  close all;
X = input('Enter the sequence to find the Inverse Discrete Fourier Transform')
N=length(X);
for n=1:N
   x(n)=0;
   for k=1:N
      x(n)=x(n)+X(k).*exp(1j.*2.*pi.*(k-1).*(n-1)./N);
   end
end
disp('The IDFT of the given sequence is'); x/N
stem(0:N-1, real(x/N)); title('Sequence x (in time domain)')
xlabel('time'); ylabel('Amplitude'); grid;
```

OUTPUT:

Enter the sequence to find the Inverse Discrete Fourier Transform[11 3+2i -9 3-2i]

The IDFT of the given sequence is



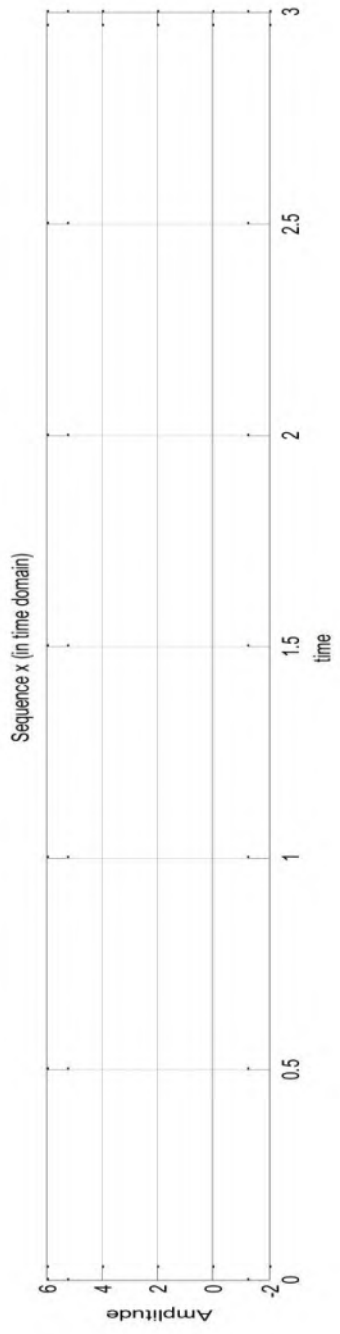
Question 3: Write MATLAB program to find the discrete fourier transform of a given finite discrete sequence using FFT:

```
clc
clear all
close all
x  = input('Enter the sequence to find the Discrete Fourier Transform')
N = length(x);
X = fft(x);
disp('The DFT of the given sequence using FFT is'); X

subplot(311)
stem(0:N-1,x)
title('Sequence x (in time domain)')
xlabel('time')
ylabel('Amplitude')
grid;

subplot(312)
stem(0:N-1,abs(X))
title('Magnitude of Fourier Coeffients using fft function')
ylabel('|X|')
grid;

subplot(313)
stem(0:N-1,angle(X))
title('Angle of Fourier Coeffients using fft function')
xlabel('Frquency coefficients')
ylabel('<X')
grid;
```

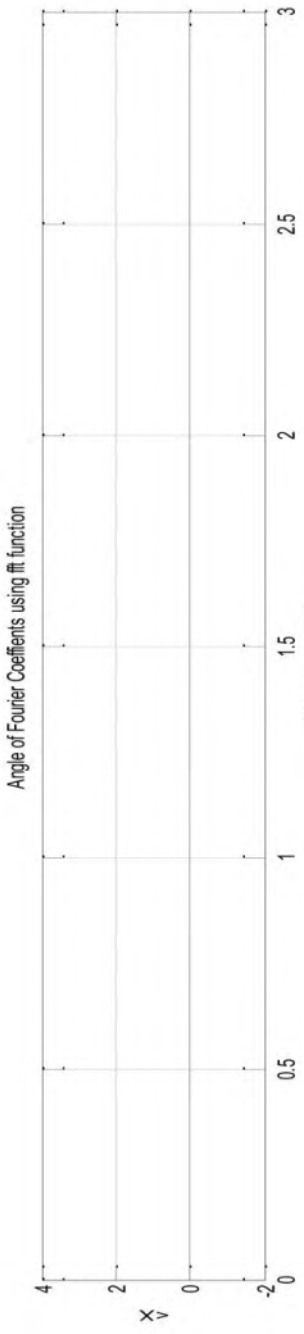
OUTPUT:

Enter the sequence to find the Discrete Fourier Transform[2 4 -1 6]

The DFT of the given sequence using FFT is


Sequence x (in time domain)
Amplitude
time
6
4
2
0
-2
0
0.5
1
1.5
2
2.5
3


Magnitude of Fourier Coeffients using fft function
|X|
15
10
5
0
0
0.5
1
1.5
2
2.5
3


Angle of Fourier Coeffients using fft function
<X
Frquency coefficients
4
2
0
-2
0
0.5
1
1.5
2
2.5
3

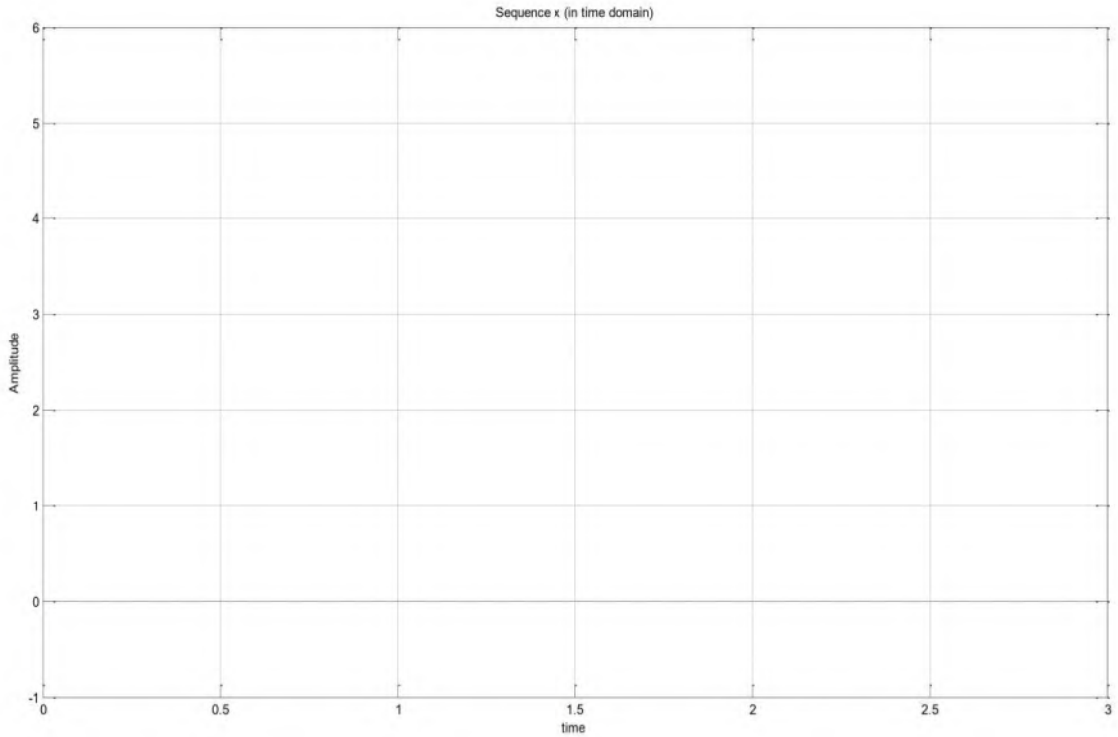
QUESTION 4: Write the MATLAB program to find the inverse discrete fourier transform of a finite discrete sequence using FFT:

```
clc
clear all
close all
X  = input('Enter the sequence to find the Inverse Fast Fourier Transform')
N = length(X);
x = ifft(X);
disp('The IFFT of the given sequence is'); x
stem(0:N-1,x)
title('Sequence x (in time domain)')
xlabel('time')
ylabel('Amplitude')
grid;
```

OUTPUT:

Enter the sequence to find the Inverse Fast Fourier Transform[11 3+2i -9 3-2i]

The IFFT of the given sequence is _____



QUESTION 5: **Use MATLAB to find the circular convolution of the two given sequences**

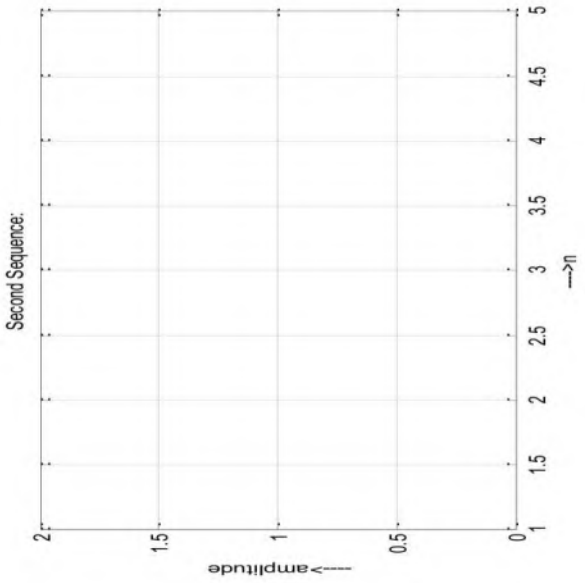
$$x[n] = \{1, 2, 3, 4, 5\} \quad for -1 \leq n \leq 3$$

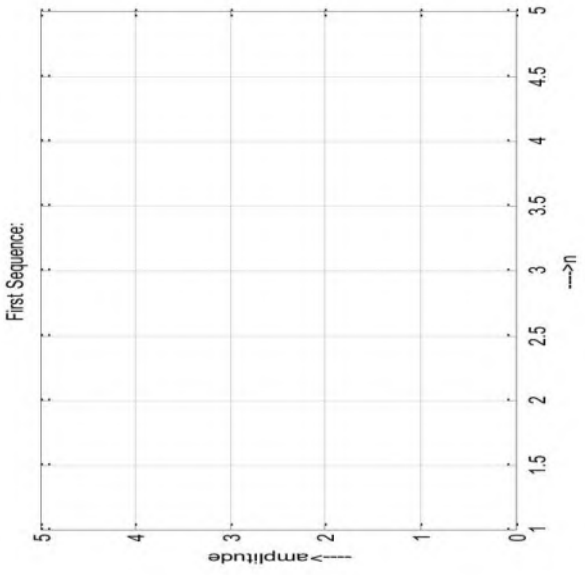
MATLAB PROGRAM:

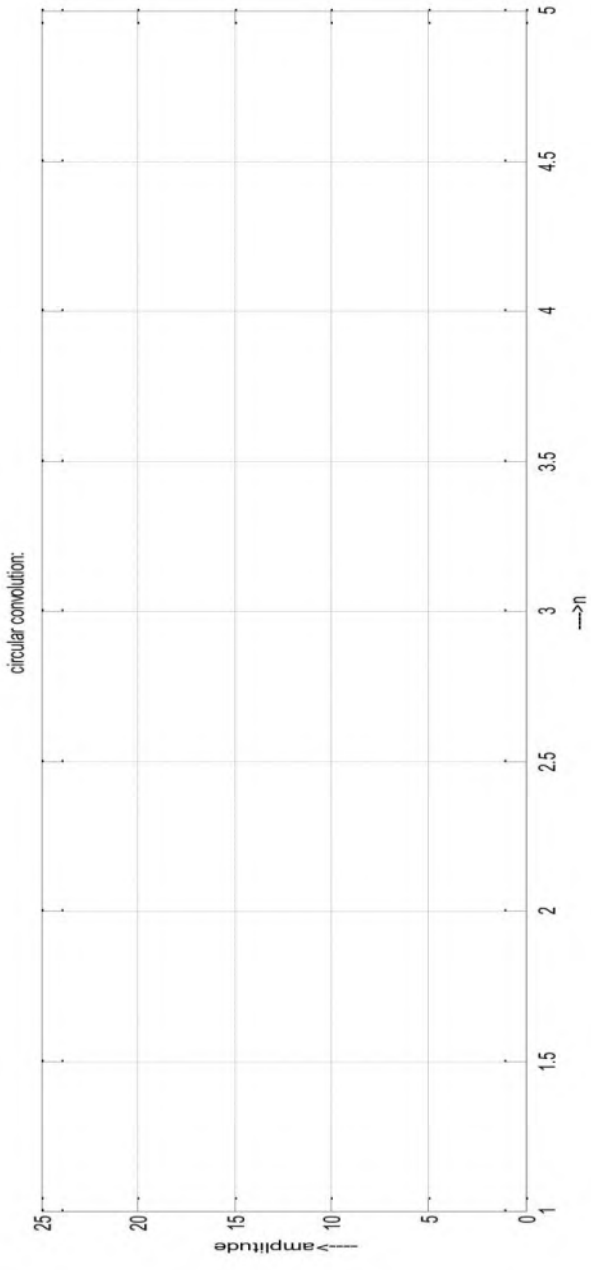
```
clc;    clear all;     close all;
x1=input('Enter the first sequence:')
n1=length(x1);
x2=input('Enter the second sequence:')
n2=length(x2);
if (n1>n2)
   x2 = [x2 zeros(n1-n2)]
else
   x1 = [x1 zeros(n2-n1)]
end
n = length(x1);
subplot(2,2,1), stem(x1);
title('First Sequence');
xlabel('---->n' );
ylabel('---->amplitude');
grid;
subplot(2,2,2), stem(x2);  title('Second Sequence');
xlabel('---->n' );
ylabel('---->amplitude');
grid;
y1=fft(x1,n);
y2=fft(x2,n);
y3=y1.*y2;
y=ifft(y3,n);
disp('circular convolution is:');
disp(y);
subplot(2,2,[3,4])
stem(y); title('circular convolution');
xlabel('---->n' );
ylabel('---->amplitude' );grid;
```

OUTPUT:

Enter the first sequence:[1 2 3 4 5]
Enter the second sequence:[2 1 2 1]
circular convolution is: _____







LAB ACTIVITY - EXERCISE

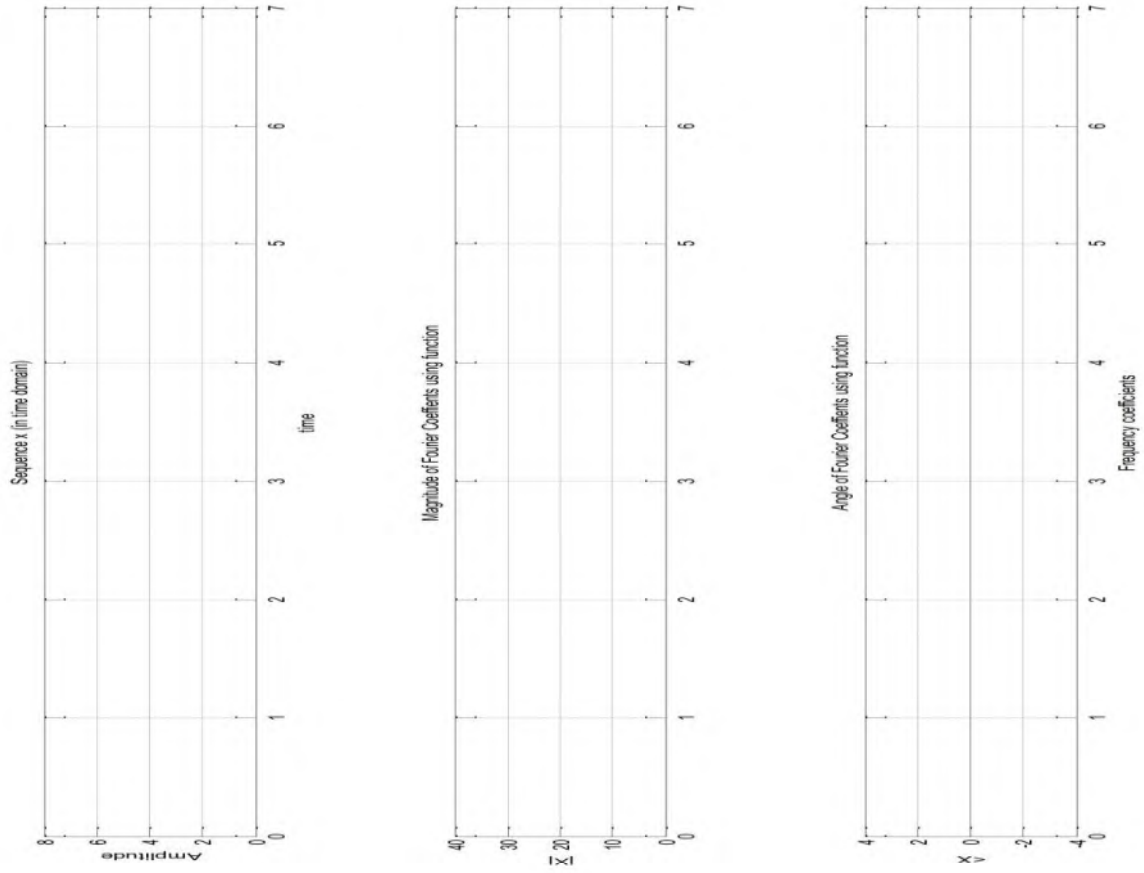
QUESTION 7: **Find the DFT of the sequence x[n] = {1, 2, 3, 4, 5, 6, 7, 8} by direct method.**

MATLAB PROGRAM:

OUTPUT:

Enter the sequence to find the Discrete Fourier Transform[1 2 3 4 5 6 7 8]

The DFT of the given sequence is



QUESTION 8: **Find the IDFT of the sequence X[K] = {36, -4+9.6569i, -4+4i, -4+1.6569i, -4, -4-1.6569i, -4-4i -4-9.6569i} by direct method.**

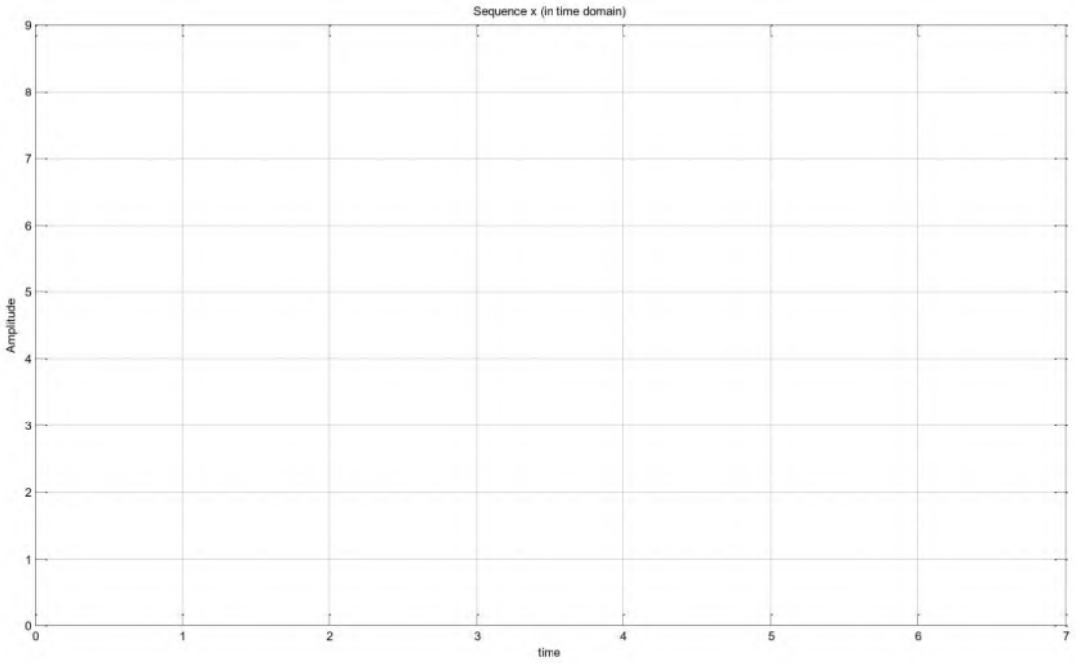
MATLAB PROGRAM

OUTPUT

Enter the sequence to find the Inverse Discrete Fourier Transform

[36, -4+9.6569i, -4+4i, -4+1.6569i, -4, -4-1.6569i, -4-4i -4-9.6569i]

The IDFT of the given sequence is: _____

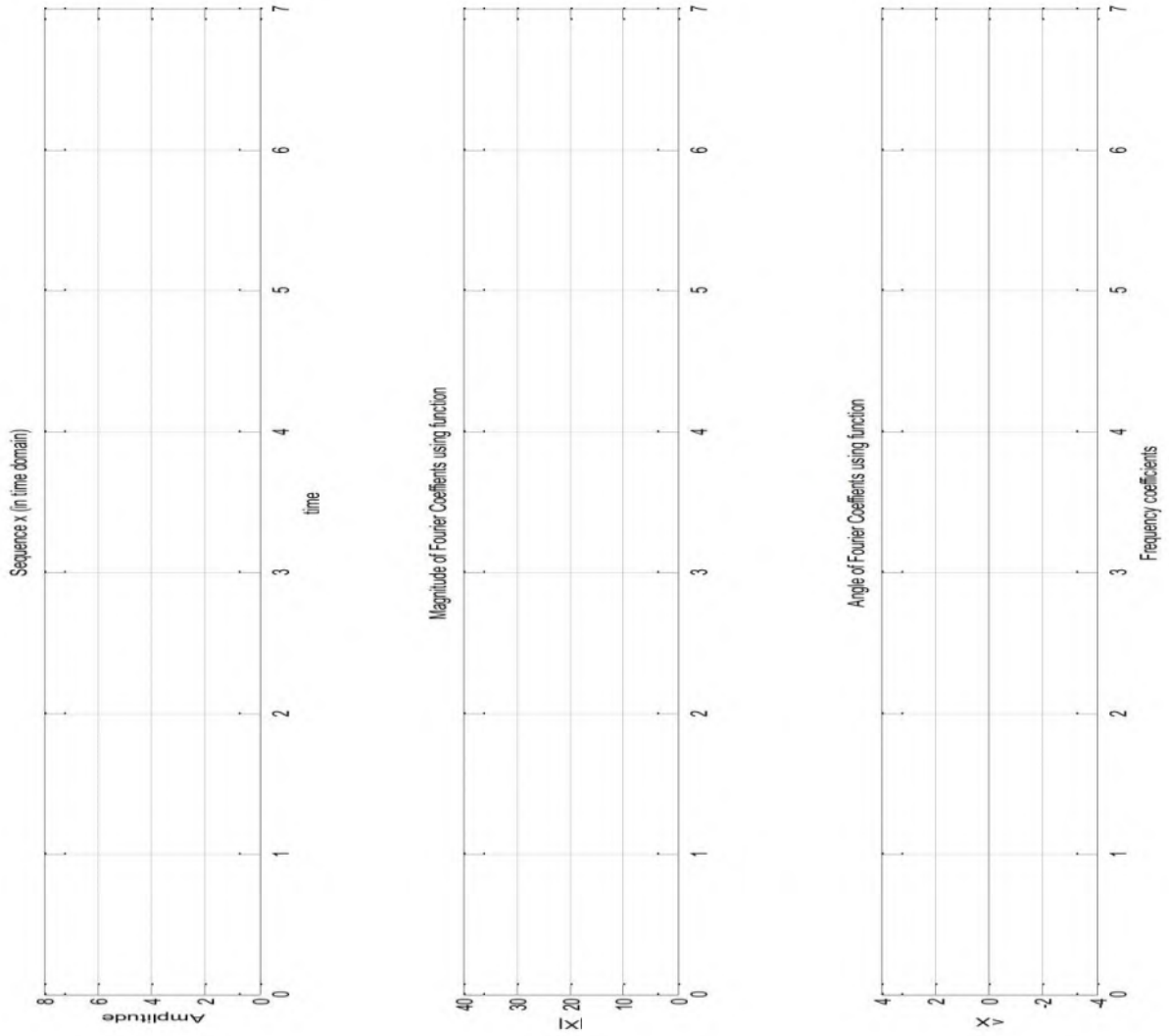


QUESTION 9: **Find the DFT of the sequence x[n] = {1, 2, 3, 4, 5, 6, 7, 8} using FFT.**

MATLAB PROGRAM:

OUTPUT:

Enter the sequence to find the Discrete Fourier Transform[1 2 3 4 5 6 7 8]
The DFT of the given sequence is



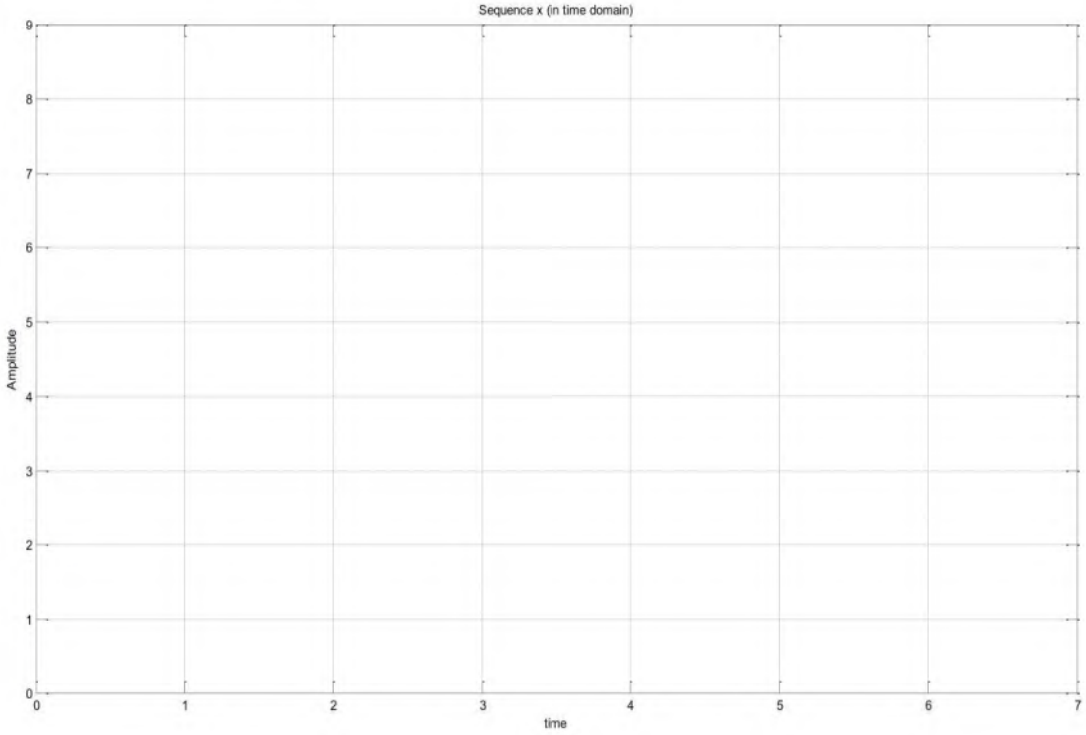
QUESTION 10: **Find the IDFT of the sequence X[K] = {36, -4+9.6569i, -4+4i, -4+1.6569i, -4, -4-1.6569i, -4-4i -4-9.6569i} by direct method.**

MATLAB PROGRAM

Enter the sequence to find the Inverse Discrete Fourier Transform

[36, -4+9.6569i, -4+4i, -4+1.6569i, -4, -4-1.6569i, -4-4i -4-9.6569i]

The IDFT of the given sequence using FFT is: _____



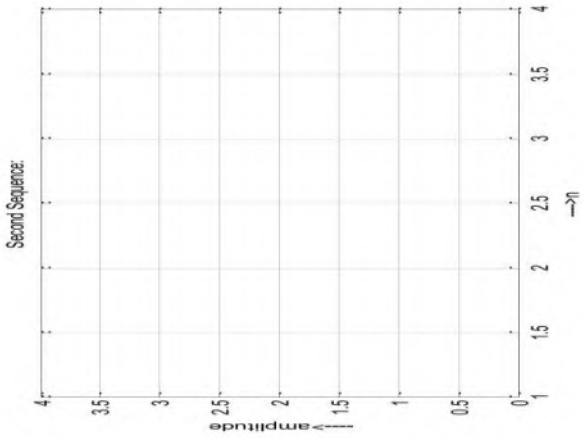
QUESTION 11: **Find the circular convolution of the two sequences given by:**

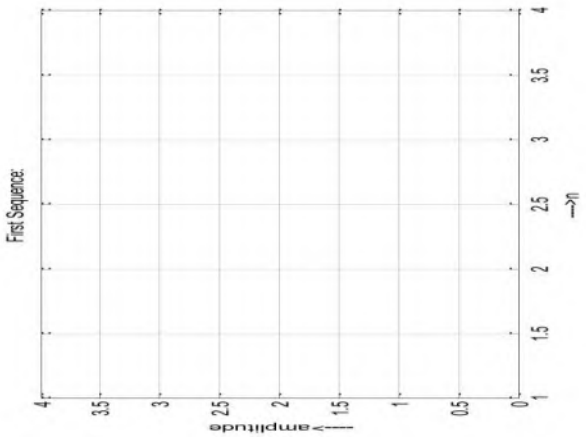
$x_1[n] = \{1,2,3,4\}$ and $x_2[n] = \{4,3,2,1\}$ using FFT.

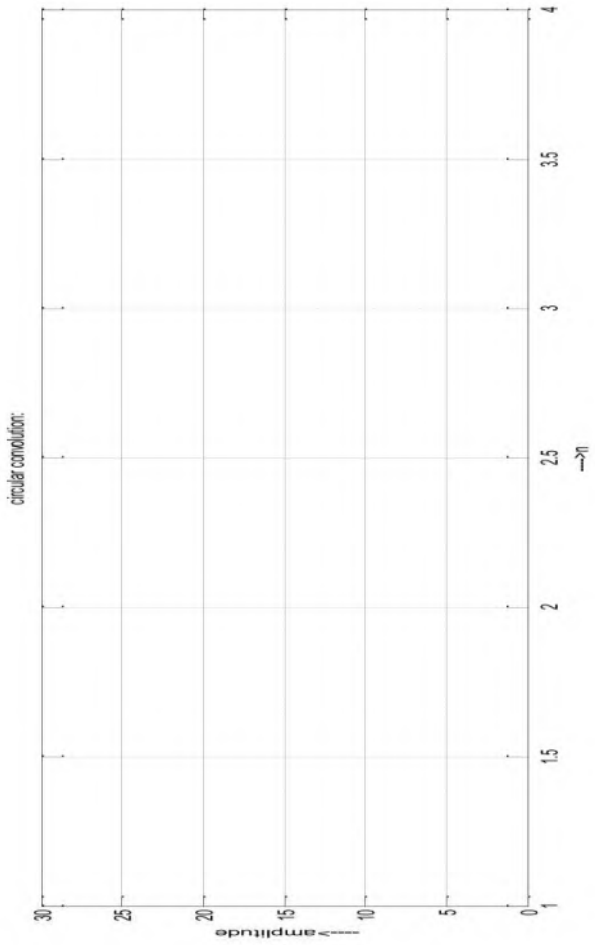
MATLAB PROGRAM

OUTPUT

Enter the first sequence:[1 2 3 4]
Enter the second sequence:[4 3 2 1]
circular convolution is: _____







King Khalid University
College of Computer Science
Department of Computer Engineering

Experiment # 11 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ ID Number: _____

Lab Day: _____ Section Number: _____ Serial Number: _____

Experiment #11

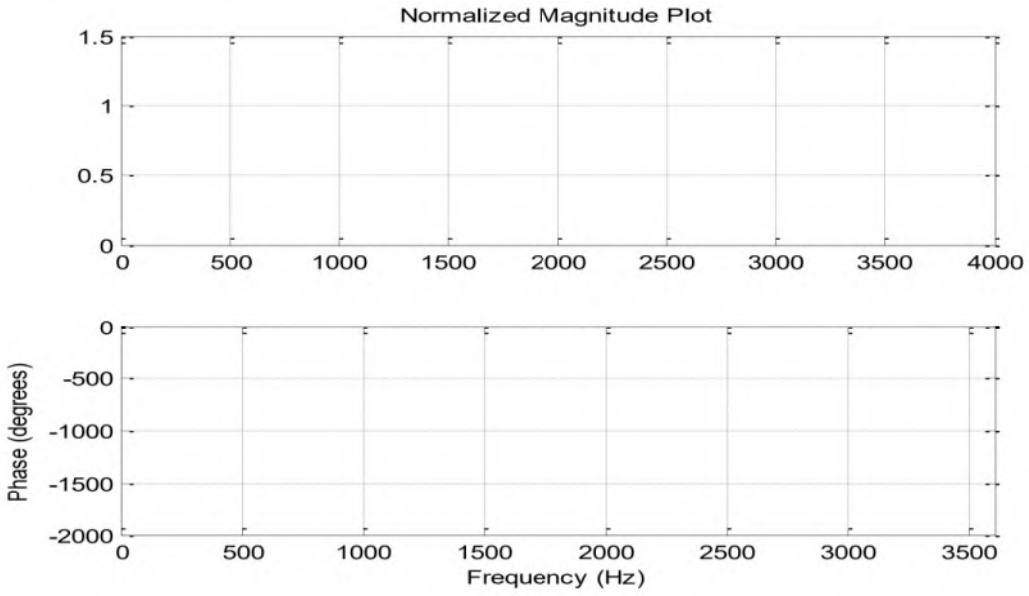
Finite Impulse Response (FIR) filters

QUESTION 1: Design a digital FIR low pass filter of order 50 which allows all the frequencies less than 1200 Hz. use hamming window.

```
clc;    clear all;        close all;
fc = input('Enter the cut off frequency of the LPF: '); % cut off frequency
n= input('Enter the order of the FIR Filter: '); % order of the filter
fs=6*fc; % let sampling frequency = 6 times the cutoff freq
w= 2*pi*fc/fs; %normalized frequency
b=fir1(n,w/pi,'low'); % Zeros of the filter
freqz(b,1,128,fs); % Magnitude and Phase Plot of the filter
[h,w]=freqz(b,1,128,fs);
subplot(2,1,1);
plot(w,abs(h));% Normalized Magnitude Plot
title('Normalized Magnitude Plot'); grid
subplot(2,1,2);
figure;
zplane(b,1); % the plot in lab
title('zplane');
```

OUTPUT:

Enter the cut off frequency of the LPF: 1200
Enter the order of the FIR Filter: 50



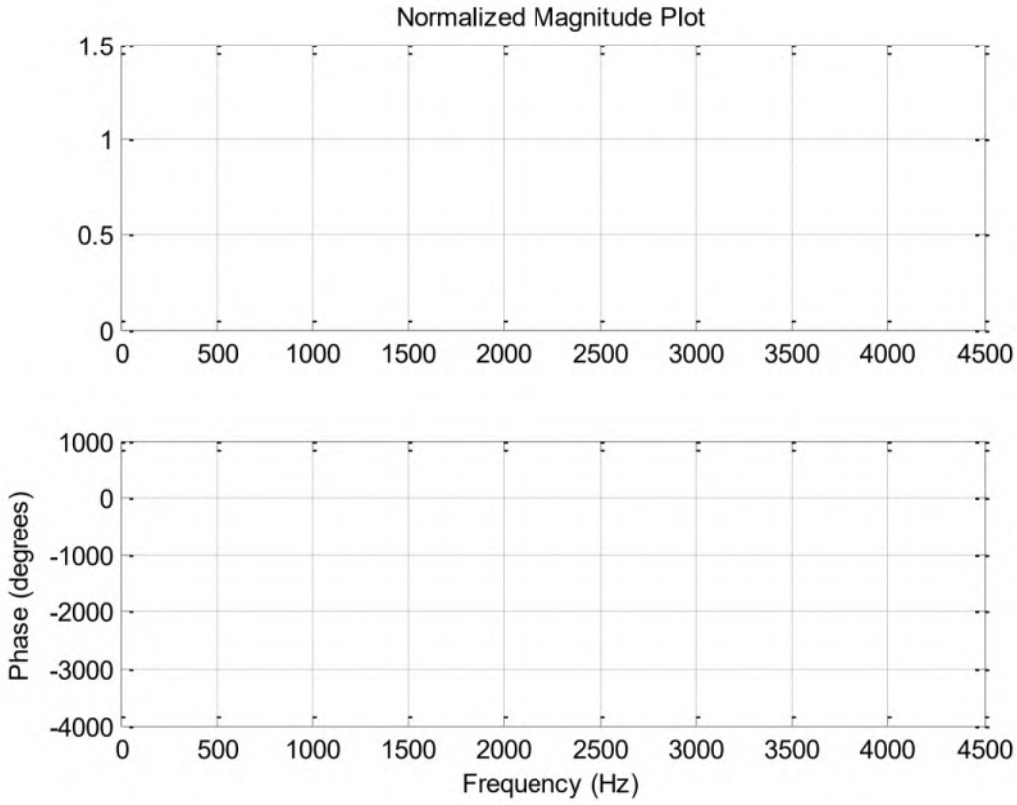
QUESTION 2: Design a digital FIR high pass filter of order 50 which allows all the frequencies greater than 1500 hz. Use rectangular window.

```
clc;     clear all;         close all
fc = input('Enter the cut off frequency of the HPF: '); % cut off frequency
n= input('Enter the order of the FIR Filter: '); % order of the filter
fs=6*fc; % let sampling frequency = 6 times the cutoff freq
w= 2*pi*fc/fs; %normalized frequency
b=fir1(n,w/pi,'high', rectwin(n+1)); % Zeros of the filter
freqz(b,1,128,fs); % Magnitude and Phase Plot of the filter
[h,w]=freqz(b,1,128,fs);
subplot(2,1,1);
plot(w,abs(h));% Normalized Magnitude Plot
title('Normalized Magnitude Plot');     grid
subplot(2,1,2);
```

OUTPUT:

Enter the cut off frequency of the HPF: 1500

Enter the order of the FIR Filter: 50

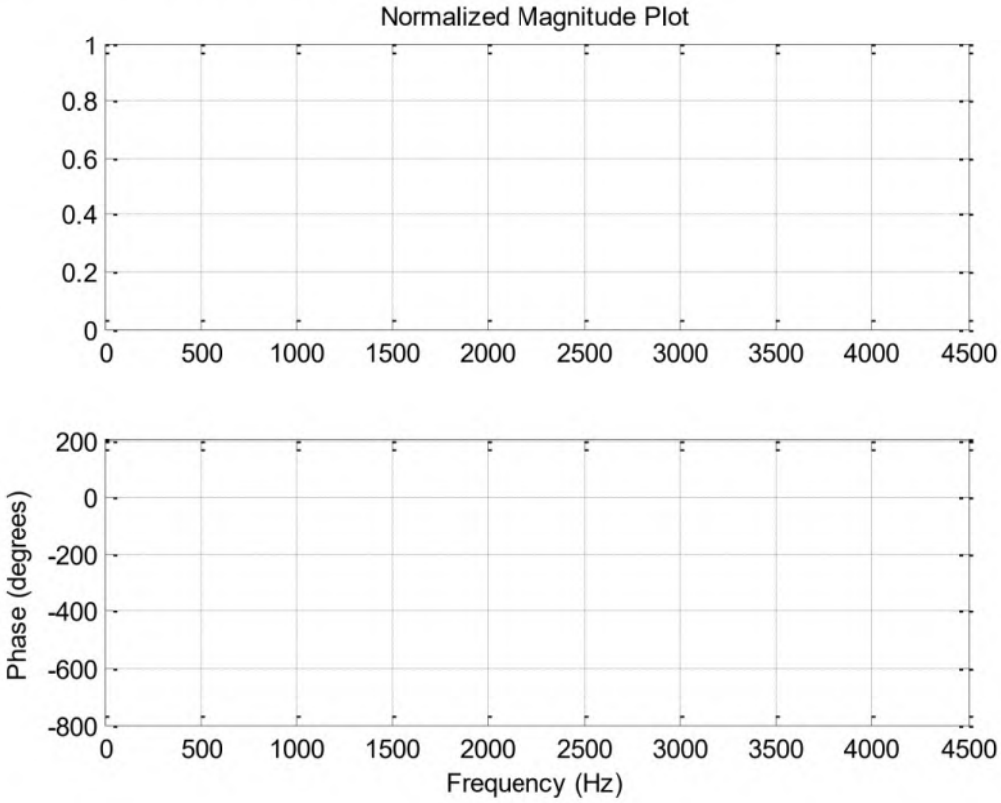


QUESTION 3: Design a digital FIR band pass filter of order 50 which allows all the frequencies between 1200hz and 1500 hz. Use hanning window.

```
clc;     clear all;      close all;
fc1 = input('Enter the first cut off frequency of the BPF: ');
fc2 = input('Enter the second cut off frequency of the BPF: ');
n= input('Enter the order of the FIR Filter: '); % order of the filter
fs=6*fc2; % let sampling frequency = 6 times the cutoff freq
w= [2*pi*fc1/fs    2*pi*fc2/fs]; %normalized frequency
b=fir1(n,w/pi,'bandpass', hann(n+1)); % Zeros of the filter
freqz(b,1,128,fs); % Magnitude and Phase Plot of the filter
[h,w]=freqz(b,1,128,fs);
subplot(2,1,1);
plot(w,abs(h));% Normalized Magnitude Plot
title('Normalized Magnitude Plot'); grid
subplot(2,1,2);
```

OUTPUT:

Enter the first cut off frequency of the BPF: 1200
Enter the second cut off frequency of the BPF: 1500
Enter the order of the FIR Filter: 50

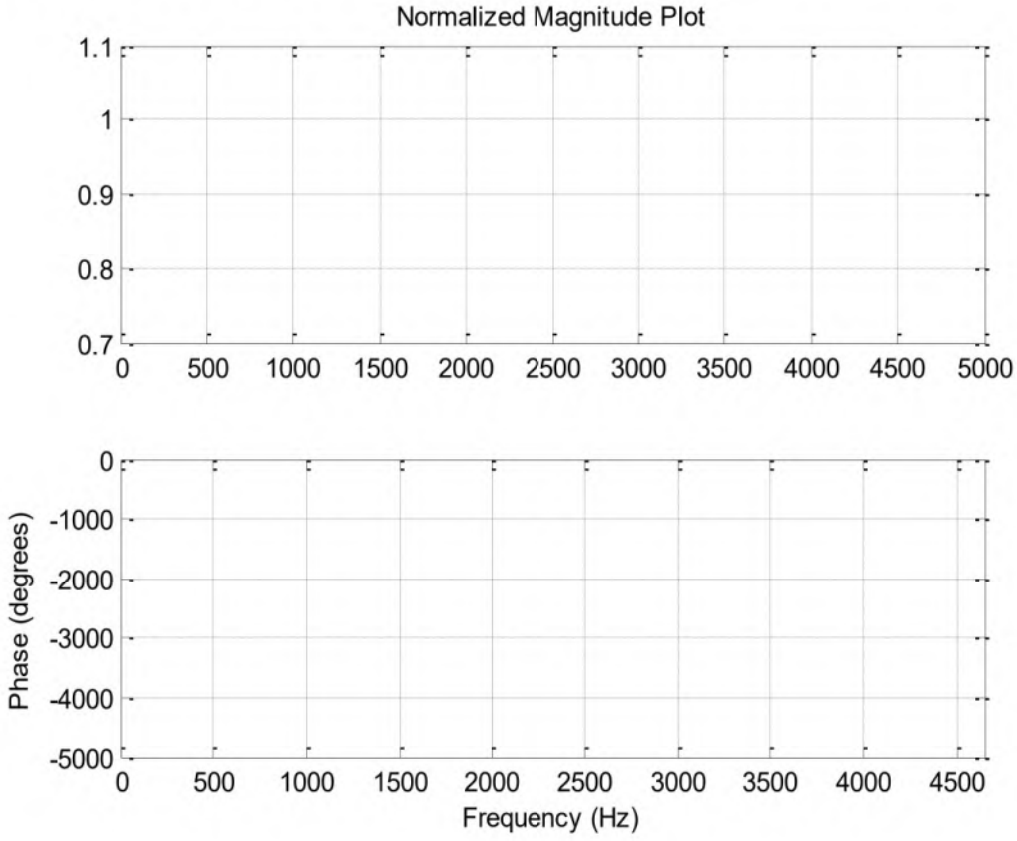


QUESTION 4: Design a digital FIR band reject filter of order 50 which stops all the frequencies between 1450hz and 1550 hz. Use bartlett window.

```
clc; clear all;  close all
fc1 = input('Enter the first cut off frequency of the BRF: ');
fc2 = input('Enter the second cut off frequency of the BRF: ');
n= input('Enter the order of the FIR Filter: '); % order of the filter
fs=6*fc2; % let sampling frequency = 6 times the cutoff freq
w= [2*pi*fc1/fs    2*pi*fc2/fs]; %normalized frequency
b=fir1(n,w/pi,'stop', bartlett(n+1)); % Zeros of the filter
freqz(b,1,128,fs); % Magnitude and Phase Plot of the filter
[h,w]=freqz(b,1,128,fs);
subplot(2,1,1);
plot(w,abs(h));% Normalized Magnitude Plot
title('Normalized Magnitude Plot'); grid; subplot(2,1,2);
```

OUTPUT

Enter the first cut off frequency of the BRF: 1450
Enter the second cut off frequency of the BRF: 1550
Enter the order of the FIR Filter: 50

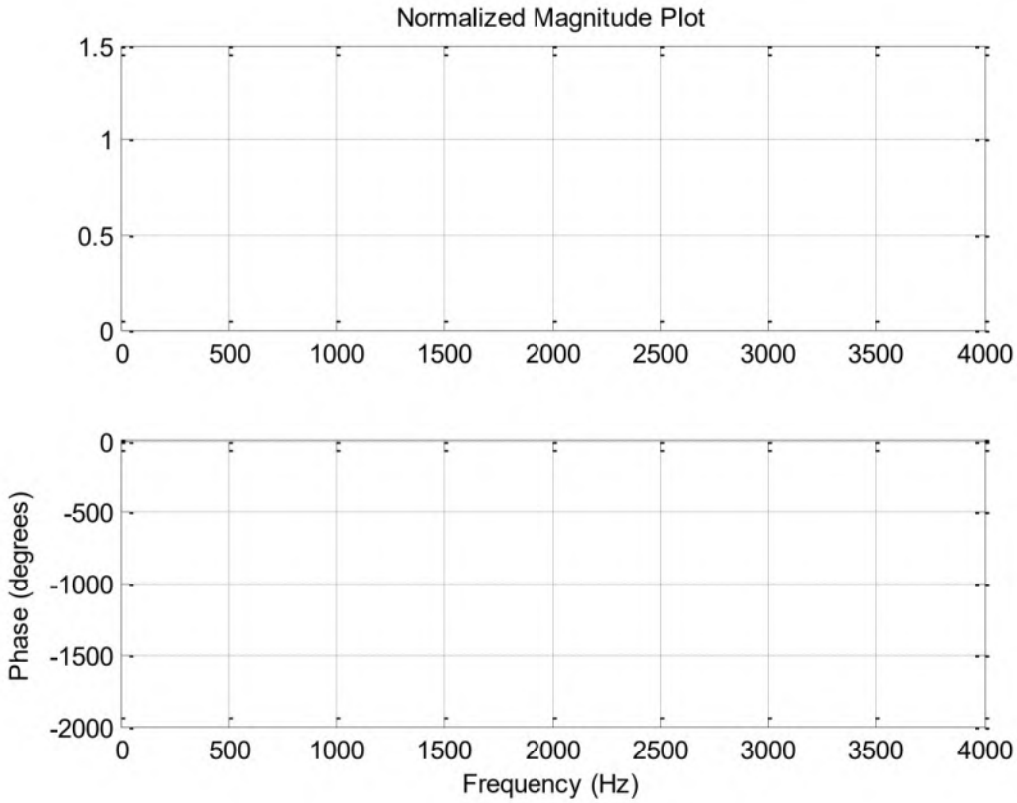


LAB ACTIVITY - EXERCISE

QUESTION 5: **Design a 21-tap FIR Low Pass filter with a cutoff frequency of 2400 Hz and a sampling rate of 8000 Hz using the Bartlett Window method.**

MATLAB PROGRAM:

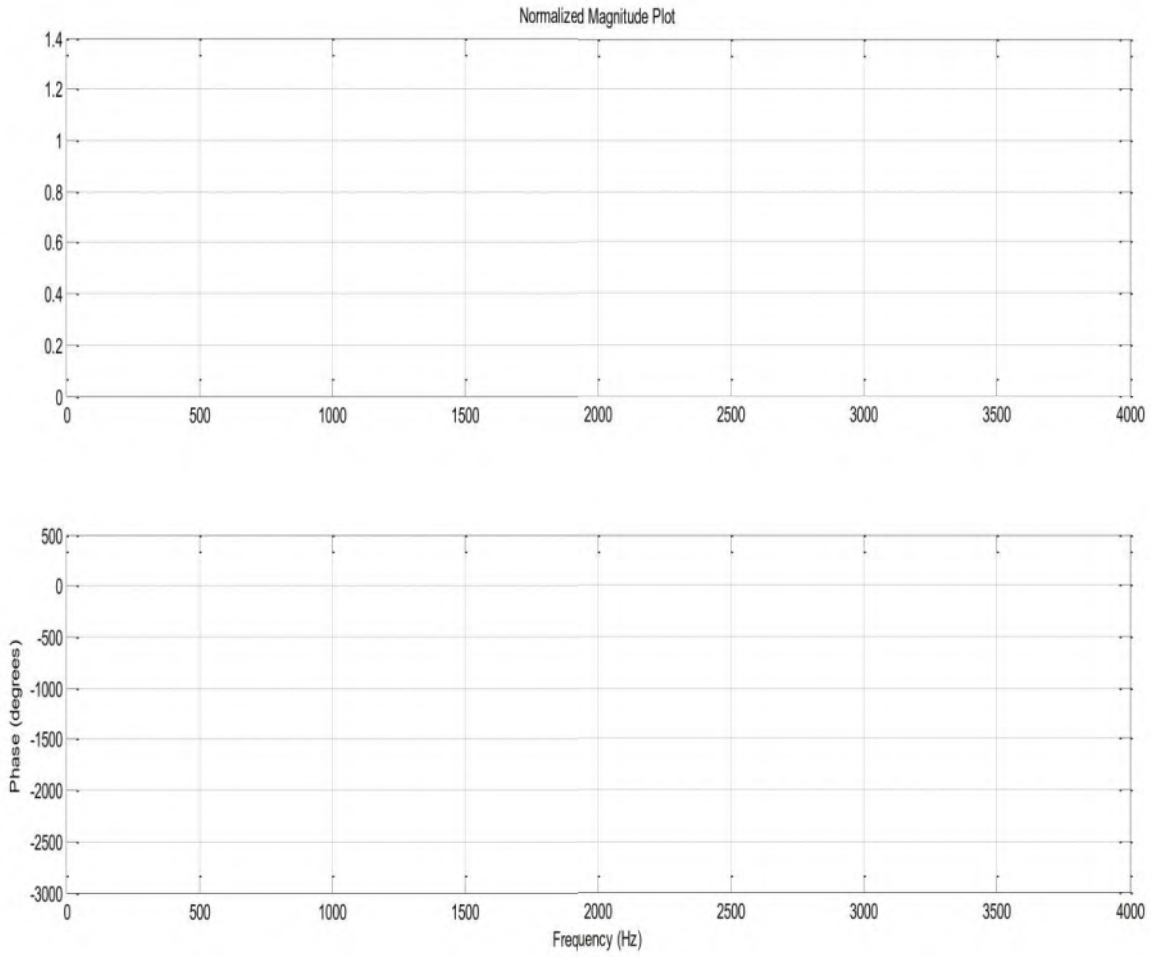
OUTPUT:



QUESTION 6: **Design a 64-tap FIR High Pass filter with a cutoff frequency of 2400 Hz and a sampling rate of 8000 Hz using the Blackman Window method.**

MATLAB PROGRAM

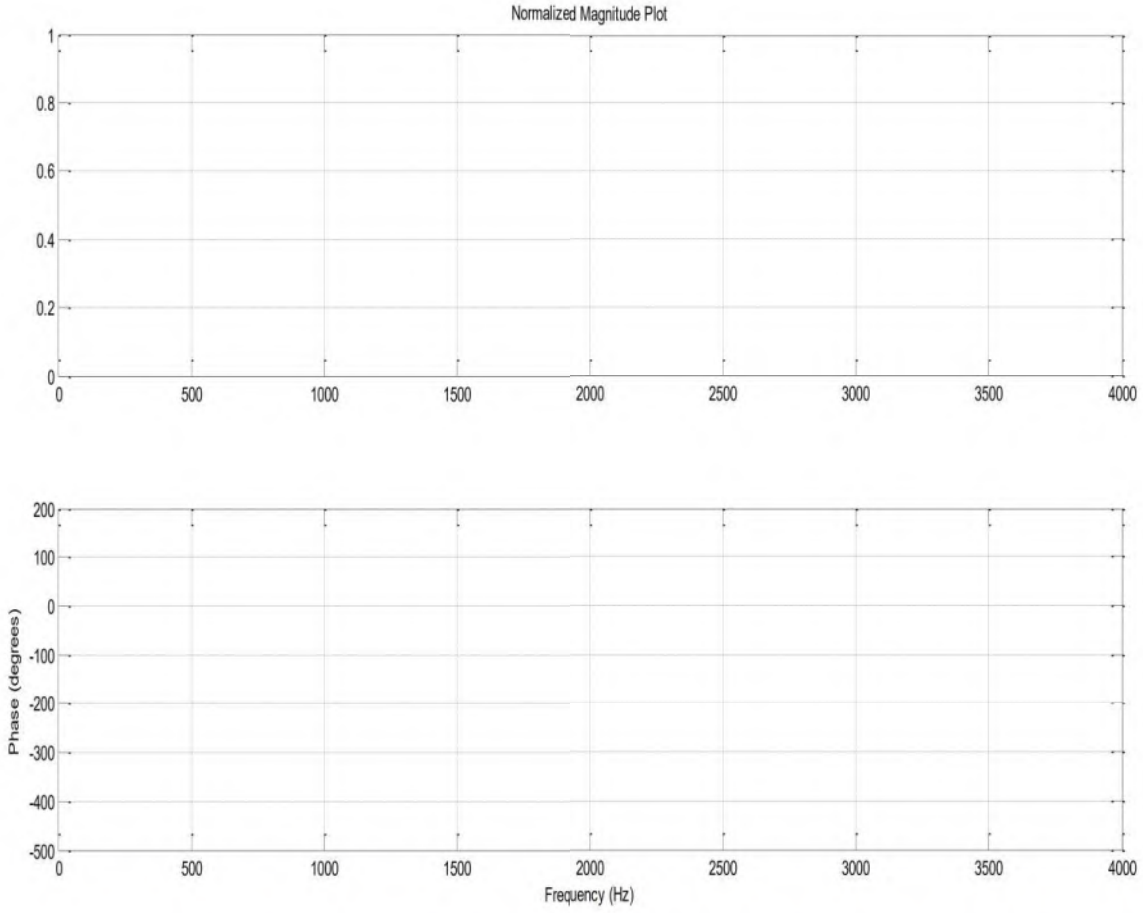
OUTPUT



QUESTION 7: **Design a 40-tap FIR band reject filter with a lower cutoff frequency of 2000 Hz, an upper cutoff frequency of 2400 Hz and a sampling rate of 8000 Hz using the rectangular window method.**

MATLAB PROGRAM:

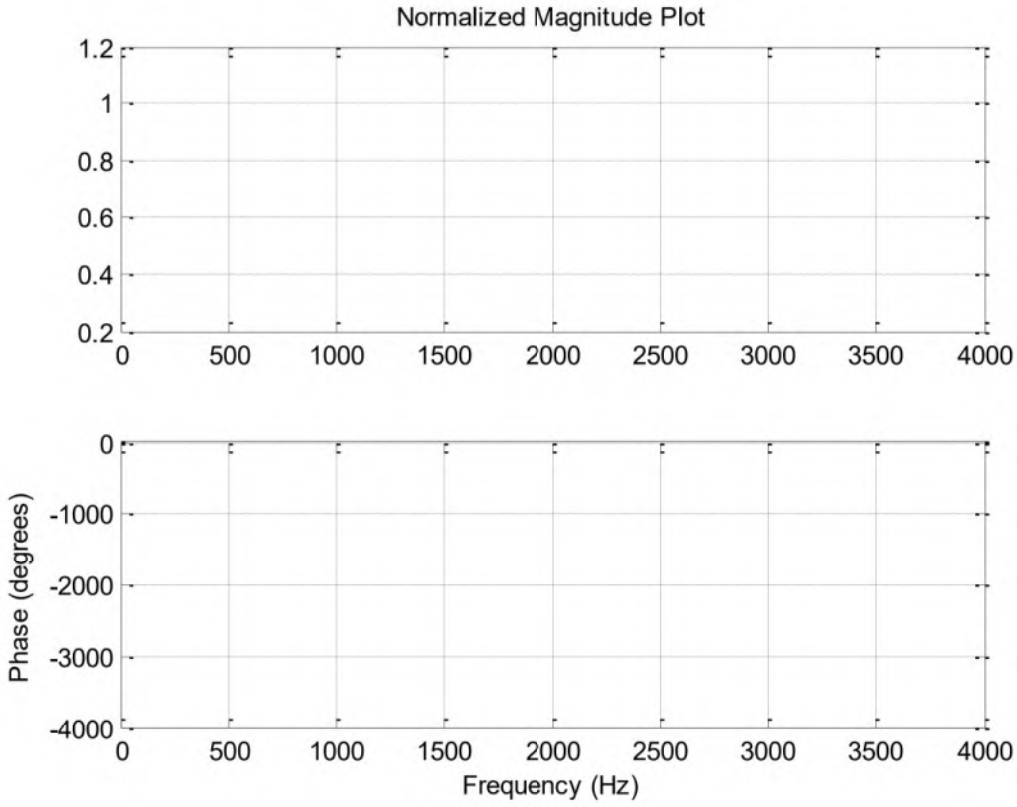
OUTPUT:



QUESTION 8: **Design a 40-tap FIR band reject filter with a lower cutoff frequency of 2000 Hz, an upper cutoff frequency of 2400 Hz and a sampling rate of 8000 Hz using the Triangular window method.**

MATLAB PROGRAM

OUTPUT



Digital Signal Processing

CCE 262

King Khalid University

College of Computer Science
Department of Computer Engineering

Experiment # 12 LAB RECORD

262 CPE

Digital Signal Processing Lab

Student Information

Name: _____ **ID Number:** _____

Lab Day: _____ **Section Number:** _____ **Serial Number:** _____

Experiment #12

Infinite Impulse Response (IIR) filters

Question1: Design a Butterworth Low Pass filter for the following specifications:

Cutoff Frequency = 3400 Hz

Transition Band = 200 Hz (or Stopband frequency = 3600 Hz)

Sampling Frequency = 8000 Hz

Passband Ripple = 1 dB

Stopband Attenuation = 40 dB

```
clc
clear all
close all
fp = input('Enter the passband cut off frequency: ');
fs = input('Enter the Stopband cut off frequency: ');
F = input('Enter the sampling frequency: ');
Rp = input('Enter the Passband Ripple: ');
As = input('Enter the stopband attenuation: ');
wp = 2*pi*fp/F; %Normalized frequency
ws = 2*pi*fs/F;
[N,wn] = buttord(wp/pi,ws/pi,Rp,As);
disp('Order of the Filter = '); disp(N);
[b,a] = butter(N,wn);  %LOW PASS FILTER
disp('Coefficients of the digital filter are =');
disp('Numerator coefficients of the filter are (b) ='); disp(b)
disp('Denominator coefficients of the filter are (a) ='); disp(a)
[Hd,wd] =freqz(b,a);
magd = abs(Hd);
phase = angle(Hd)*180/pi;
subplot(2,1,1); plot(wd/pi,magd); title('Magnitude Plot'); grid
subplot(2,1,2); plot(wd/pi,phase); title('Phase Plot'); grid;
```

OUTPUT:

Enter the passband cut off frequency: 3400

Enter the Stopband cut off frequency: 3600

Enter the sampling frequency: 8000

Enter the Passband Ripple: 1

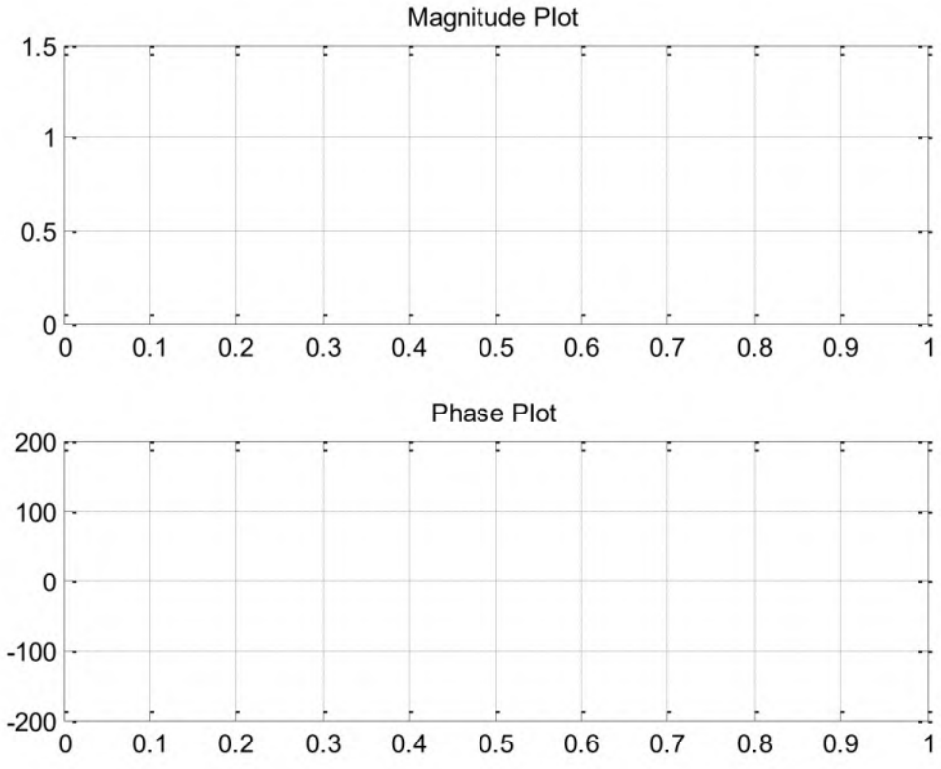
Enter the stopband attenuation: 40

Order of the Filter =

Coefficients of the digital filter are =

b=

a=



Question 2: Design a Butterworth High Pass filter for the below specifications:

Cutoff Frequency = 3400 Hz

Transition Band = 200 Hz (or Stopband frequency = 3200 Hz)

Sampling Frequency = 8000 Hz

Passband Ripple = 1 dB

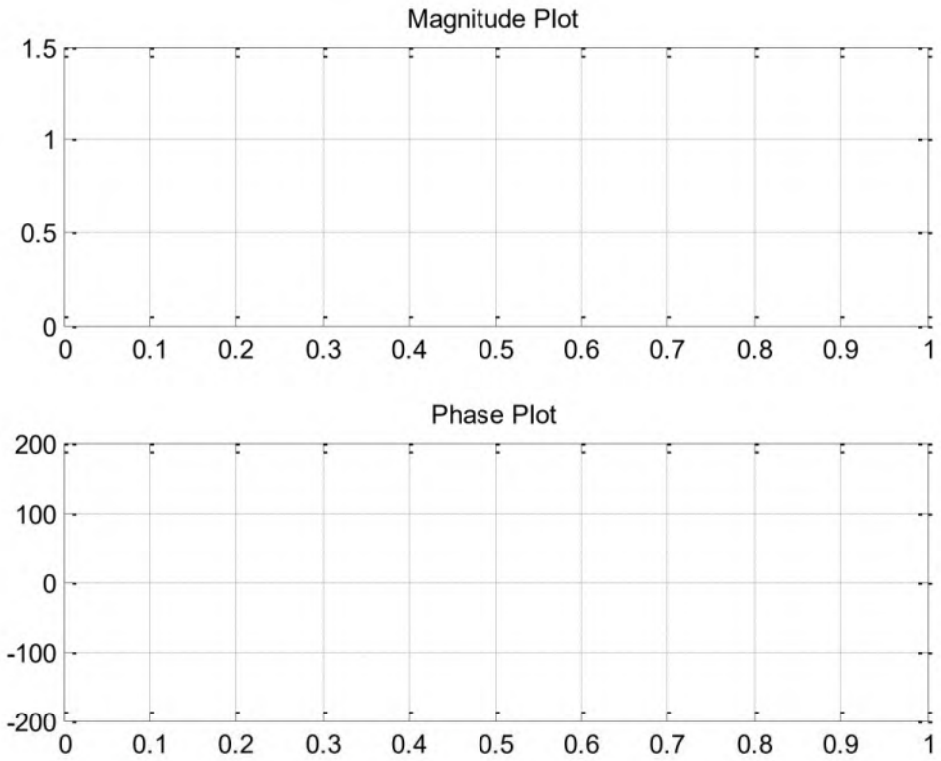
Stopband Attenuation = 40 dB

```
clc
clear all
close all
fp = input('Enter the passband cut off frequency: ');
fs = input('Enter the Stopband cut off frequency: ');
F = input('Enter the sampling frequency: ');
Rp = input('Enter the Passband Ripple: ');
As = input('Enter the stopband attenuation: ');
wp = 2*pi*fp/F; %Normalized frequency
ws = 2*pi*fs/F;
[N,wn] = buttord(wp/pi,ws/pi,Rp,As);
disp('Order of the Filter = '); disp(N);
[b,a] = butter(N,wn,'high');  % HIGH PASS FILTER
disp('Coefficients of the digital filter are =');
disp('Numerator coefficients of the filter are (b) ='); disp(b)
disp('Denominator coefficients of the filter are (a) ='); disp(a)
[Hd,wd] =freqz(b,a);
magd = abs(Hd);
phase = angle(Hd)*180/pi;
subplot(2,1,1);plot(wd/pi,magd);grid
subplot(2,1,2);plot(wd/pi,phase);grid;
```

OUTPUT:

Enter the passband cut off frequency: 3400
Enter the Stopband cut off frequency: 3200
Enter the sampling frequency: 8000
Enter the Passband Ripple: 1
Enter the stopband attenuation: 40
Order of the Filter =
Coefficients of the digital filter are =

Denominator coefficients of the filter are (a) =



Question 3: Design a Chebyshev Low Pass filter for the below specifications:

Cutoff Frequency = 3400 Hz
Transition Band = 200 Hz (or Stopband frequency = 3600 Hz)
Sample Frequency = 8000 Hz
Passband Ripple = 1 dB
Stopband Attenuation = 40 dB

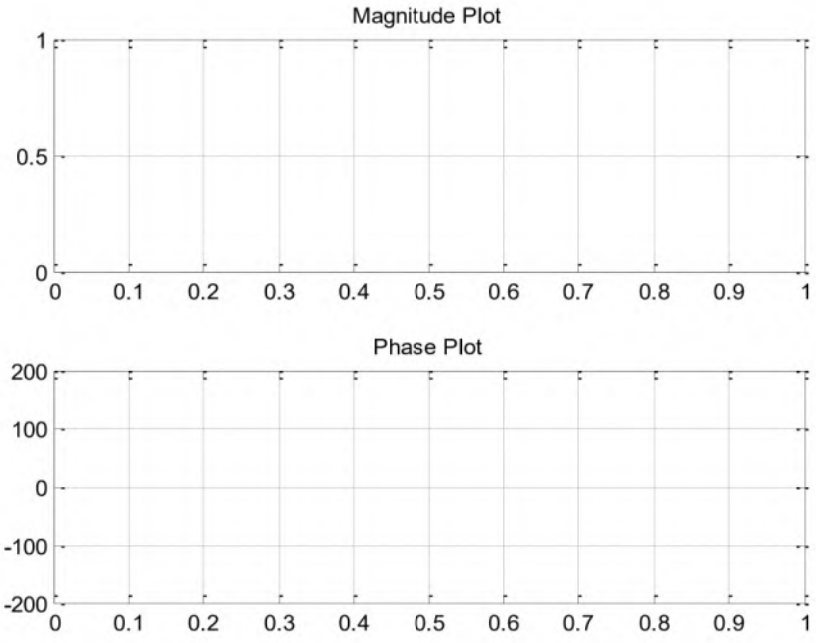
```
clc
clear all
close all
fp = input('Enter the passband cut off frequency: ');
fs = input('Enter the Stopband cut off frequency: ');
F = input('Enter the sampling frequency: ');
Rp = input('Enter the Passband Ripple: ');
As = input('Enter the stopband attenuation: ');
wp = 2*pi*fp/F; %Normalized frequency
```

```
ws = 2*pi*fs/F;
[N,wn] = cheb1ord(wp/pi,ws/pi,Rp,As);
disp('Order of the Filter = '); disp(N);
[b,a] = cheby1(N, Rp, wn);
disp('Coefficients of the digital filter are =')
disp('b='); disp(b)
disp('a='); disp(a)
[Hd,wd] =freqz(b,a);
magd = abs(Hd);
phase = angle(Hd)*180/pi;
subplot(2,1,1);plot(wd/pi,magd);title('Magnitude Plot');grid
subplot(2,1,2);plot(wd/pi,phase);title('Phase Plot');grid;
```

OUTPUT:

Enter the passband cut off frequency: 3400
Enter the Stopband cut off frequency: 3600
Enter the sampling frequency: 8000
Enter the Passband Ripple: 1
Enter the stopband attenuation: 40
Order of the Filter = _____
Coefficients of the digital filter are =
b= _____

a= _____



Question 4: Design a Chebyshev High Pass filter for the below specifications:

Cutoff Frequency = 3400 Hz
Transition Band = 200 Hz (or Stopband frequency = 3200 Hz)
Sample Frequency = 8000 Hz
Passband Ripple = 1 dB
Stopband Attenuation = 40 dB

```
clc
clear all
close all
fp = input('Enter the passband cut off frequency: ');
fs = input('Enter the Stopband cut off frequency: ');
F = input('Enter the sampling frequency: ');
Rp = input('Enter the Passband Ripple: ');
As = input('Enter the stopband attenuation: ');
wp = 2*pi*fp/F; %Normalized frequency
ws = 2*pi*fs/F;
[N,wn] = cheb1ord(wp/pi,ws/pi,Rp,As);
disp('Order of the Filter = '); disp(N);
[b,a] = cheby1(N, Rp, wn, 'high');
disp('Coefficients of the digital filter are =')
disp('b='); disp(b)
disp('a='); disp(a)
[Hd,wd] =freqz(b,a);
magd = abs(Hd);
phase = angle(Hd)*180/pi;
subplot(2,1,1);plot(wd/pi,magd);title('Magnitude Plot');grid
subplot(2,1,2);plot(wd/pi,phase);title('Phase Plot');grid;
```

OUTPUT

Enter the passband cut off frequency: 3400
Enter the Stopband cut off frequency: 3200
Enter the sampling frequency: 8000
Enter the Passband Ripple: 1
Enter the stopband attenuation: 40
Order of the Filter = _____
Coefficients of the digital filter are =
b=

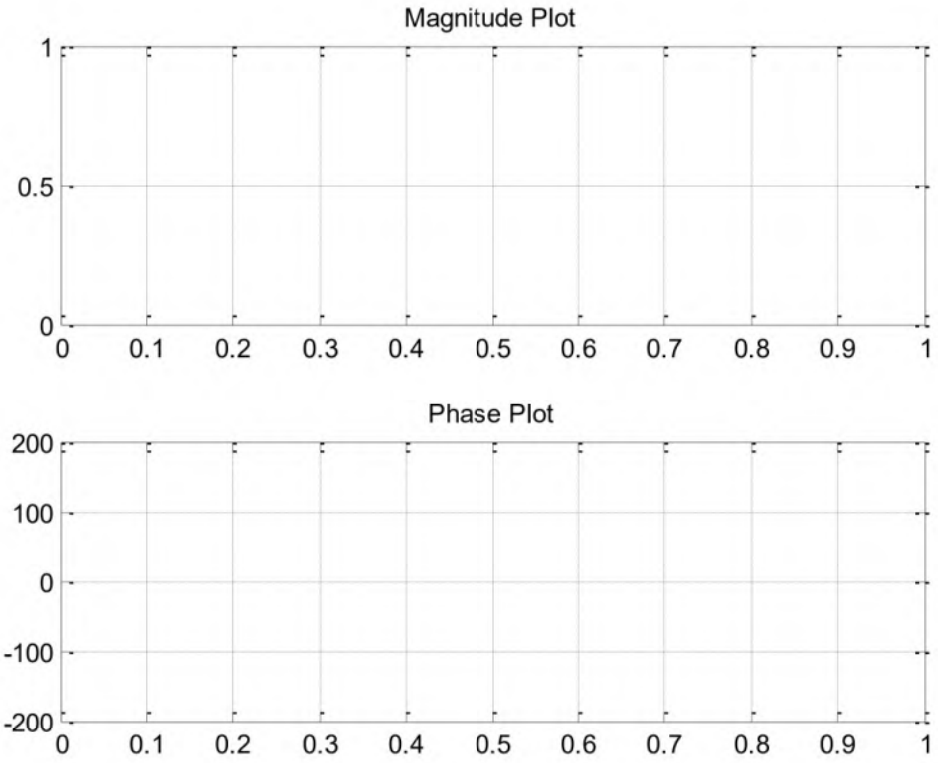
_____

_____

a=

_____

_____


Magnitude Plot
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Phase Plot
200
100
0
-100
-200
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

LAB ACTIVITY - EXERCISE

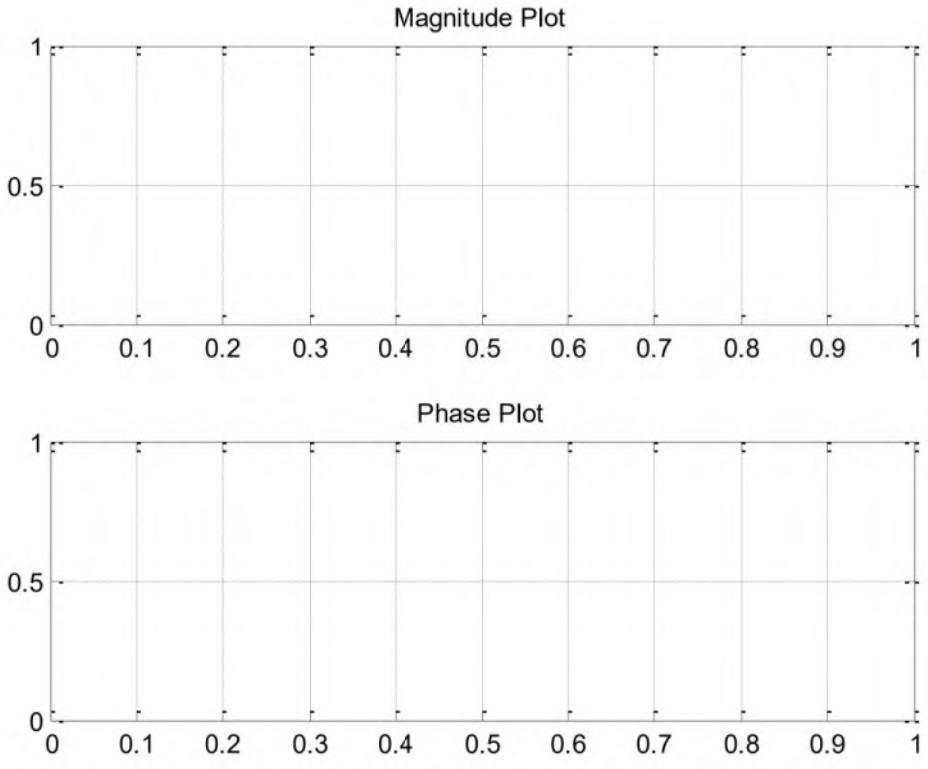
QUESTION 5: **Design a Butterworth Band Pass filter for the following specifications:**

Digital Normalized Pass Band Cutoff Frequencies = [0.4π 0.6π]

Digital Normalized Stop Band Cutoff Frequencies = [0.3π 0.75π]

Passband Ripple = 0.5 dB

Stopband Attenuation = 20 dB



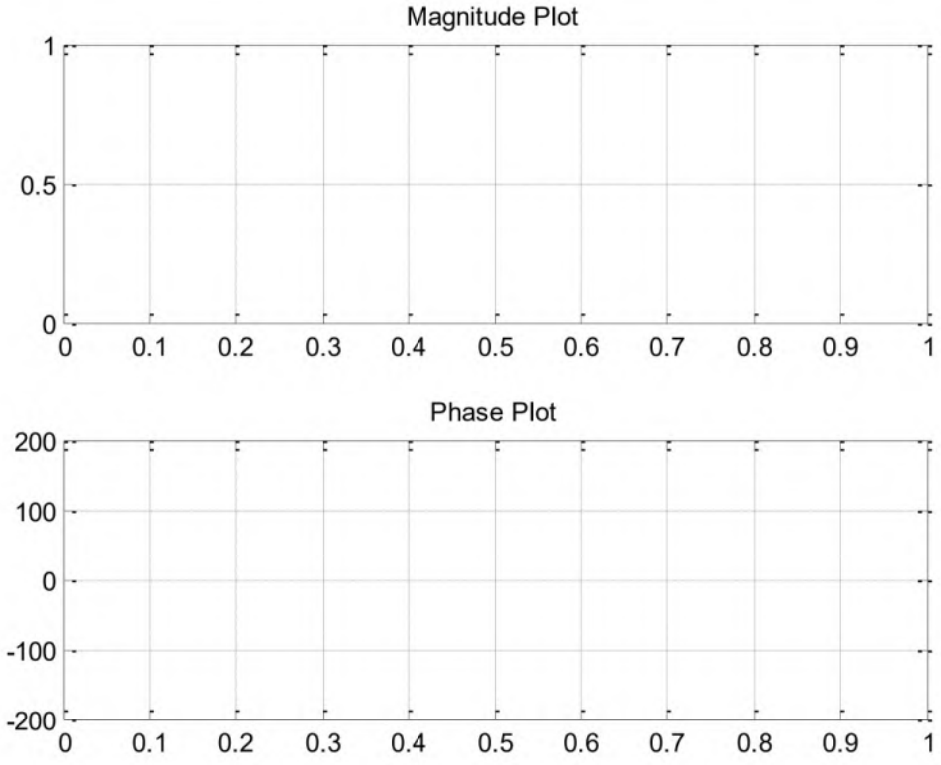
QUESTION 6: **Design a Butterworth Band Stop filter for the following specifications:**

Digital Normalized Stop Band Cutoff Frequencies = [0.4π 0.6π]

Digital Normalized Pass Band Cutoff Frequencies = [0.3π 0.75π]

Passband Ripple = 0.5 dB

Stopband Attenuation = 20 dB



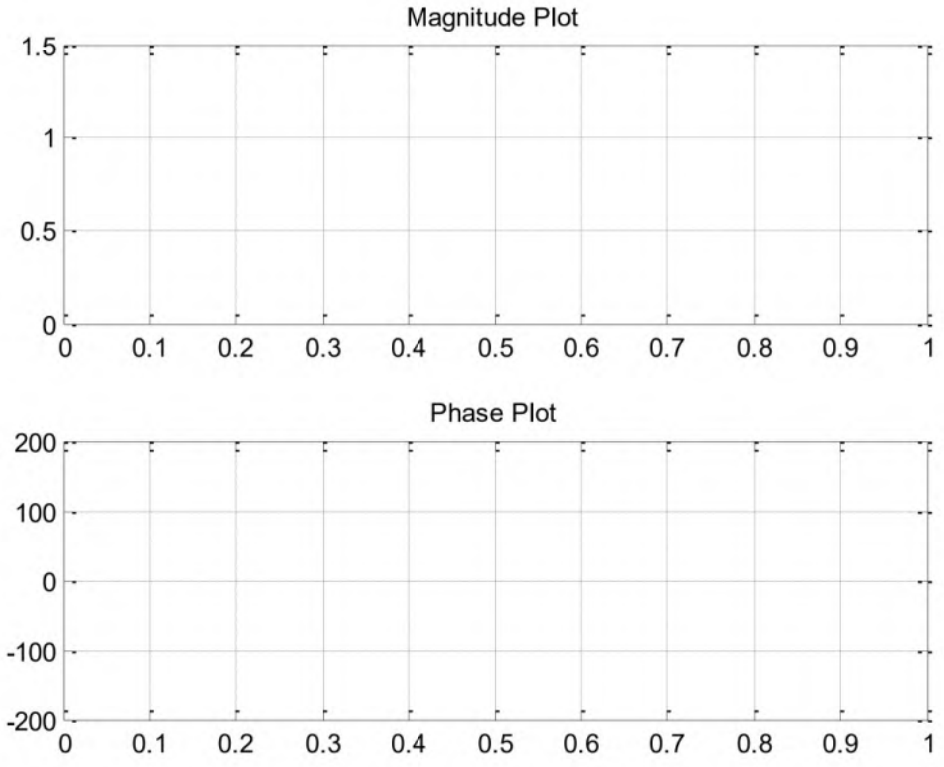
QUESTION 7: **Design a Chebyshev Band Pass filter for the following specifications:**

Digital Normalized Pass Band Cutoff Frequencies = [0.4π 0.6π]

Digital Normalized Stop Band Cutoff Frequencies = [0.3π 0.75π]

Passband Ripple = 0.5 dB

Stopband Attenuation = 20 dB



QUESTION 8: **Design a Chebyshev Band Pass filter for the following specifications:**

Digital Normalized Stop Band Cutoff Frequencies = [0.4π 0.6π]

Digital Normalized Pass Band Cutoff Frequencies = [0.3π 0.75π]

Passband Ripple = 0.5 dB

Stopband Attenuation = 20 dB