Cairo University
Faculty of Engineering
Electronics and Communications
dep.

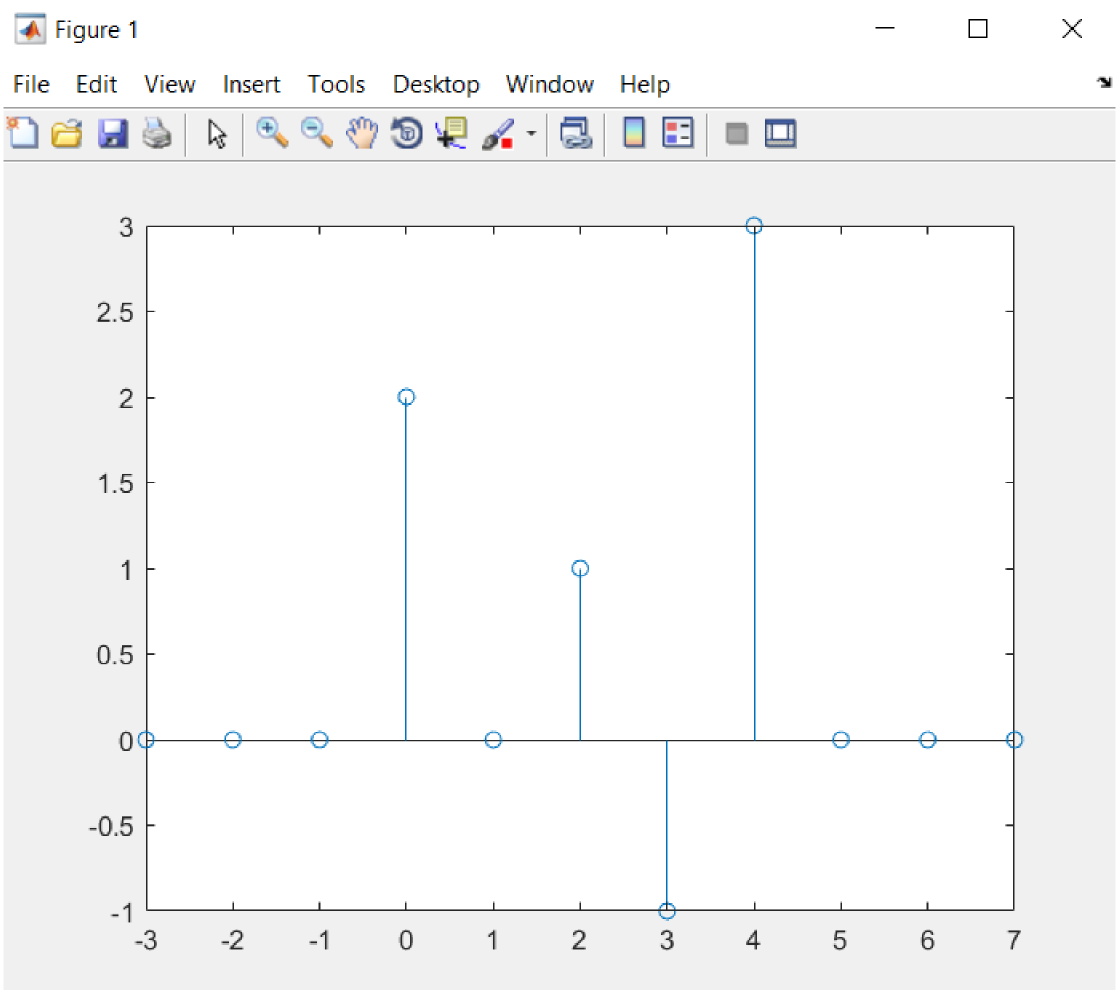
Experiment (1)

Name: Norhan Reda Abd El-wahed Ahmed	**Sec: 2**	**B. N. 30**

Experiment 1 Results sheet:

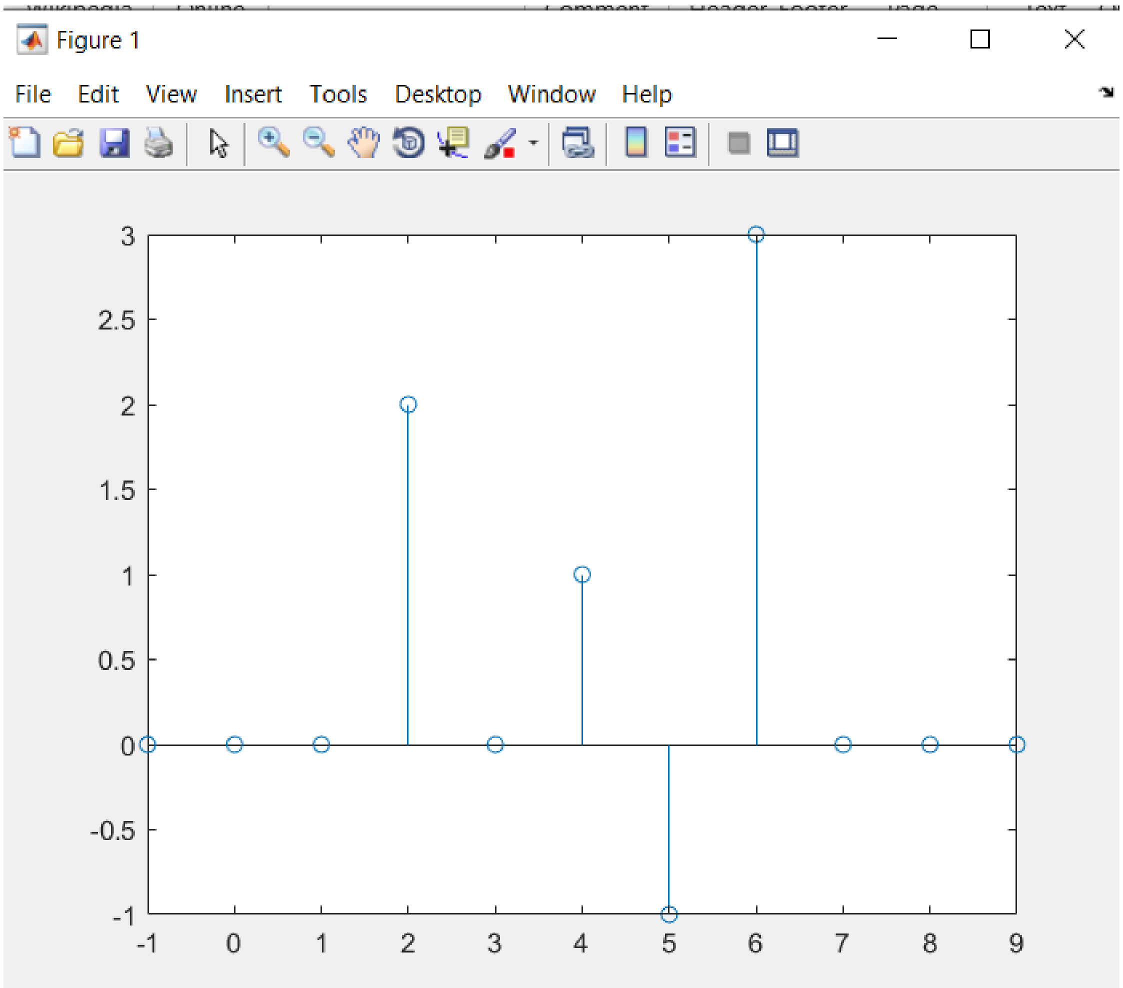
1- a) Code and plot for x[n]

```
>> n=[-3:7];
>> x=zeros(length(n),1);
>> x=[0 0 0 2 0 1 -1 3 0 0 0];
>> stem(n,x);
```

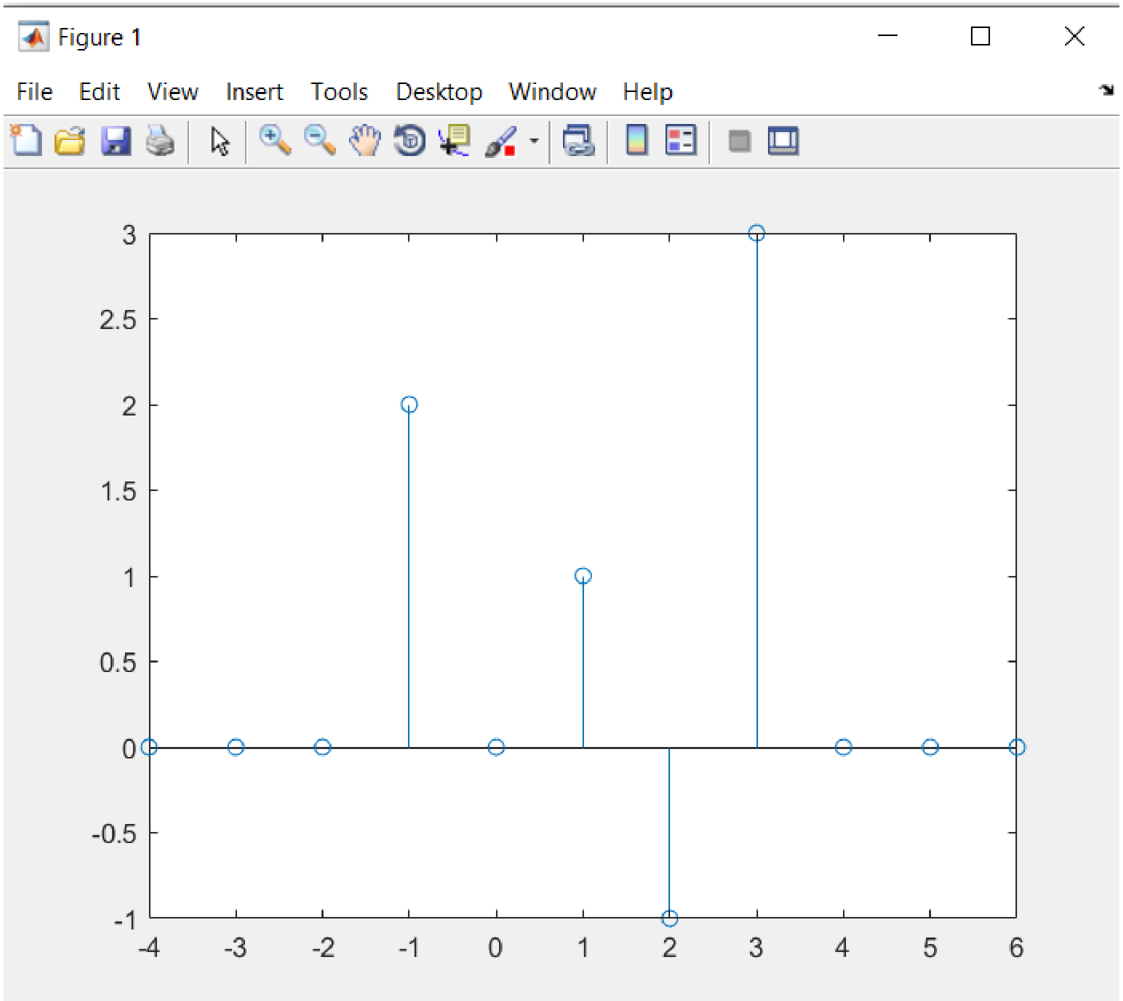


b) Write the definition of the new axis and plot the signal in the table below:

Y1
(n+2)
>> stem(n+2,x);



Y2
(n-1)
stem(n-1,x);



Y3
(-n)
stem(-n,x);

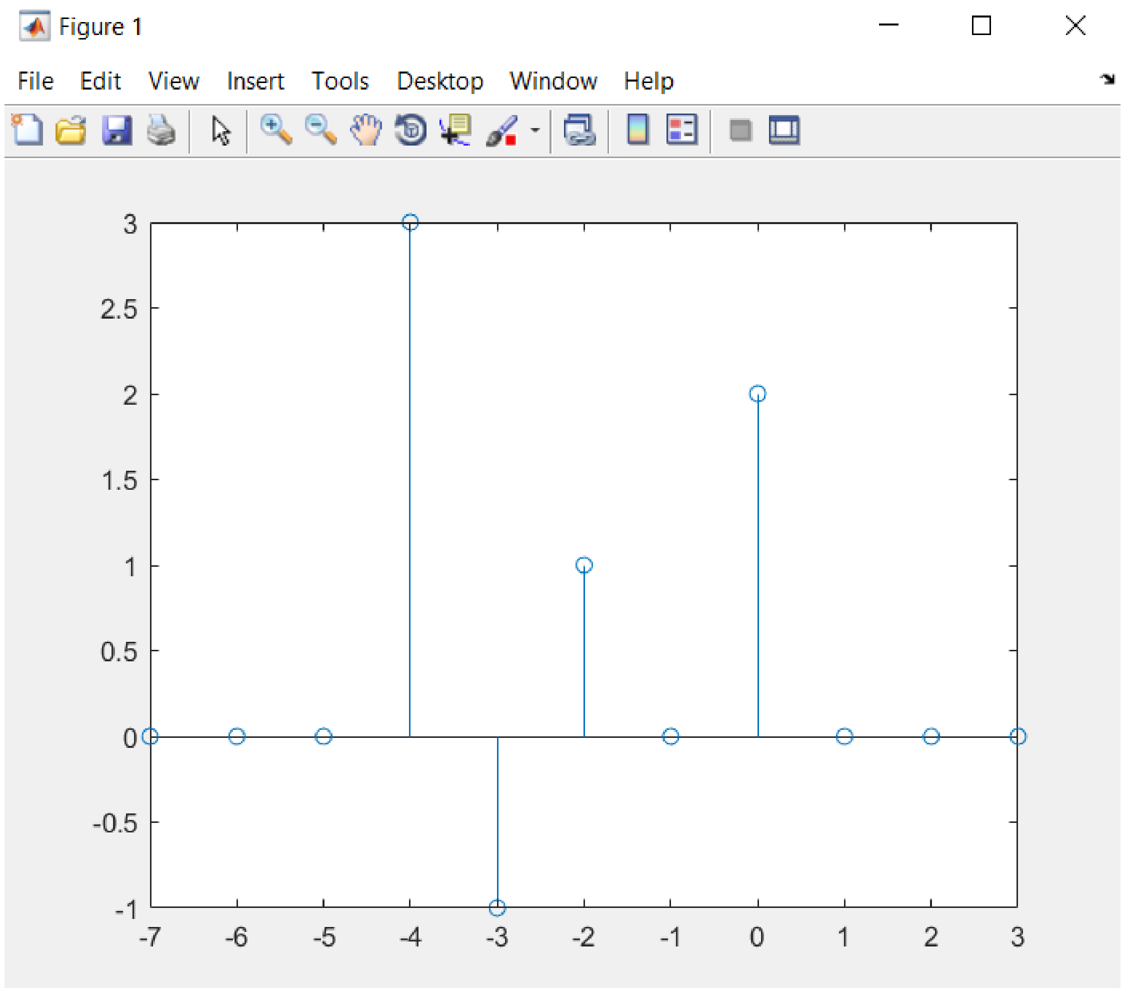
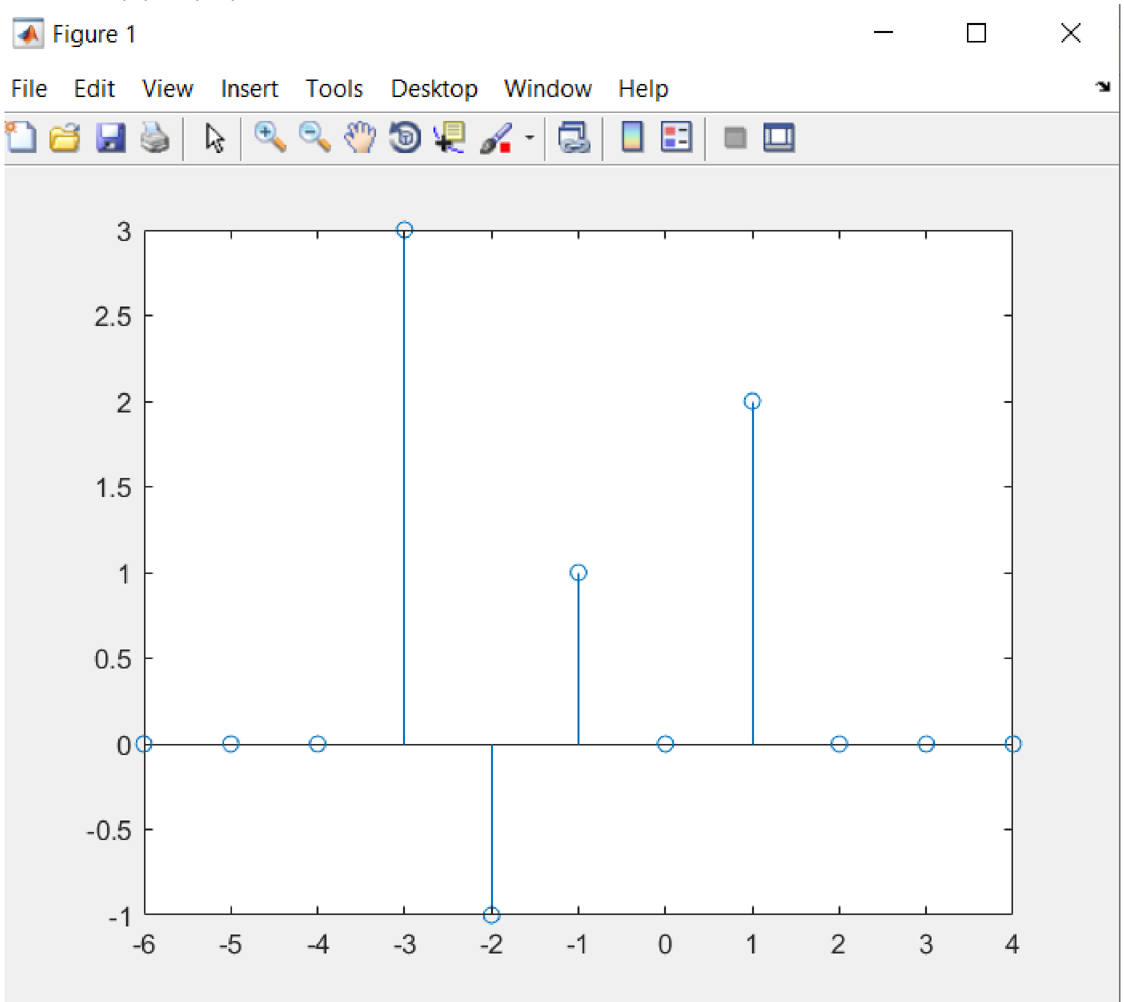
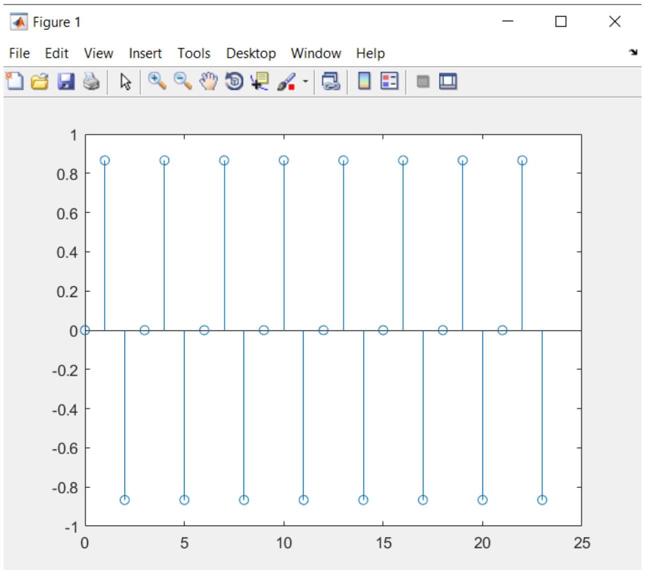
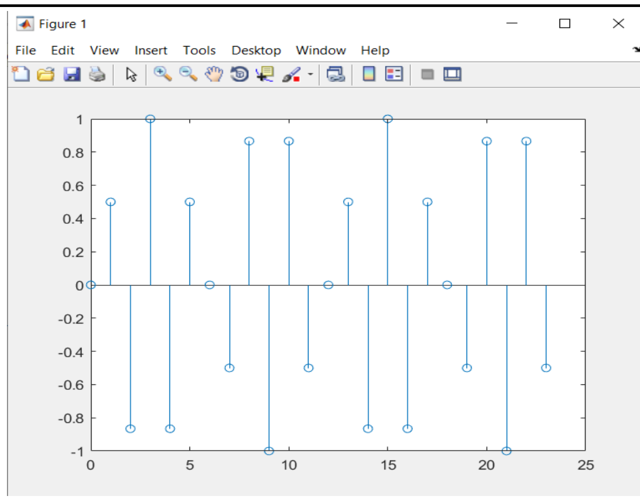
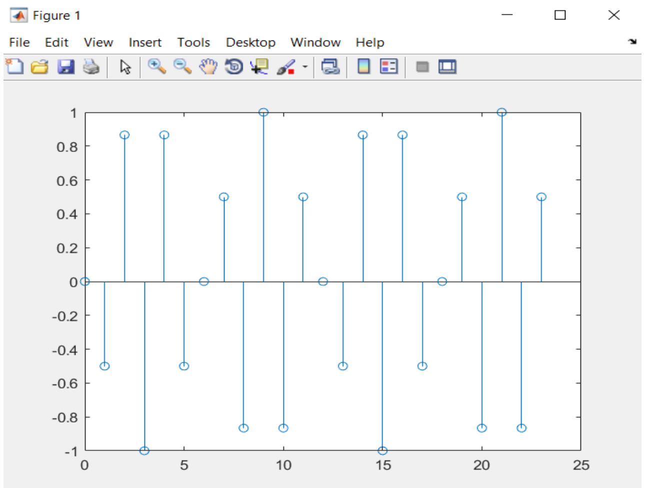


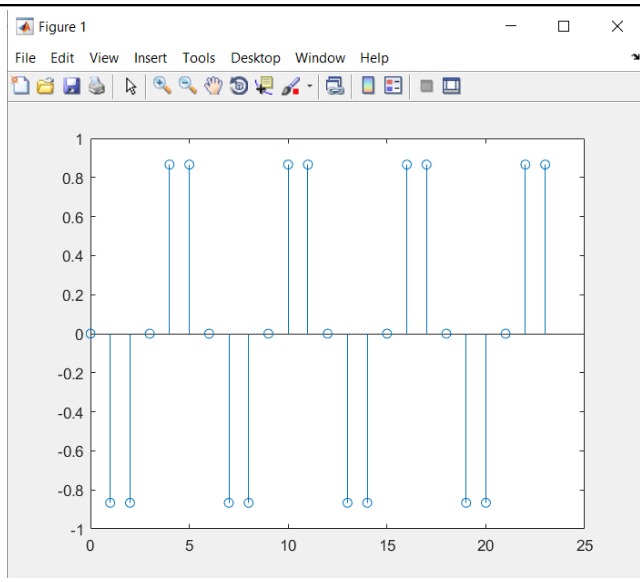
Figure 1
File Edit View Insert Tools Desktop Window Help
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-7 -6 -5 -4 -3 -2 -1 0 1 2 3

Y4
(-(n-1))=(-n+1)
```
>> stem(-(n-1),x);
```


2- a)

M	Plotting	Fundamental period
4		3
5		12

<table>
<tr>
<td>7</td>
<td>


</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>


</td>
<td>6</td>
</tr>
</table>

(2)

(a)

$x_M[n] = \sin(2*pi*M*n/N)$

$\Omega = \frac{2*pi*M}{N}$

$N_0 = \frac{2*pi}{\Omega} K$

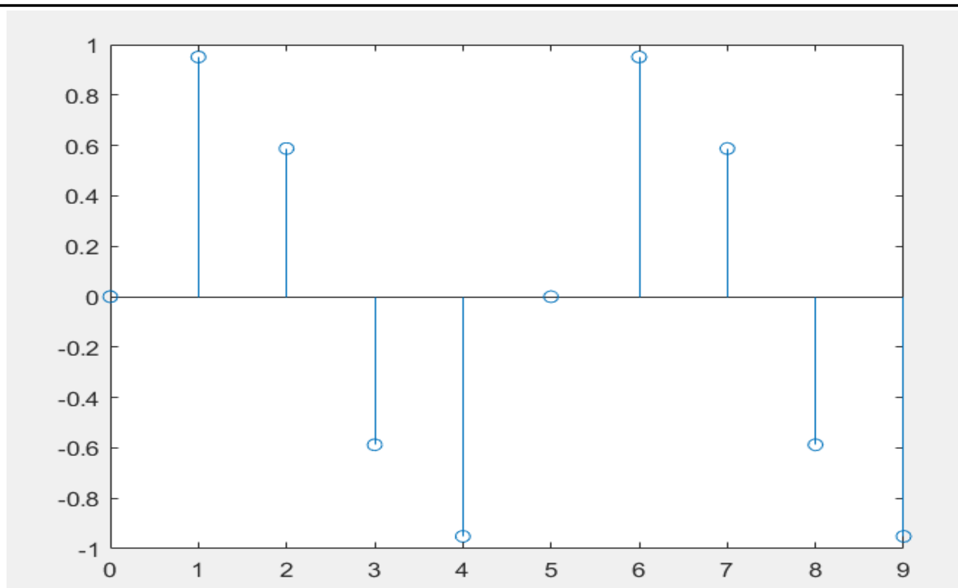
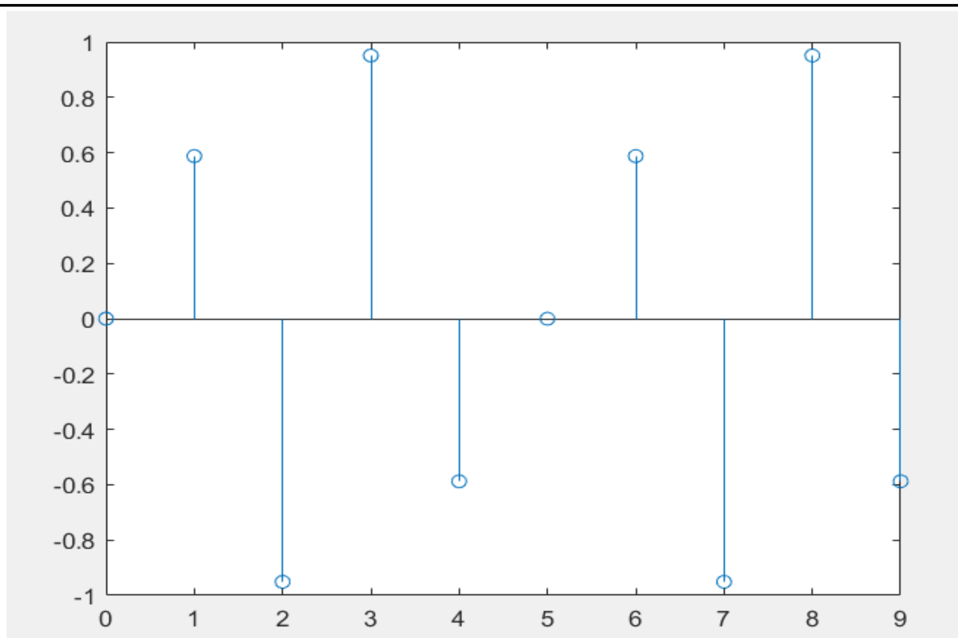
the fundamental period

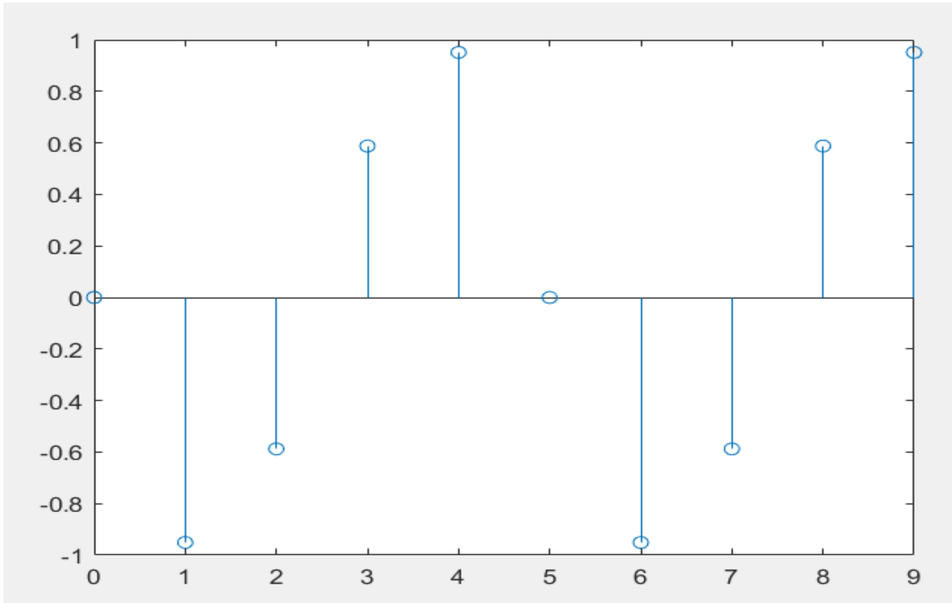
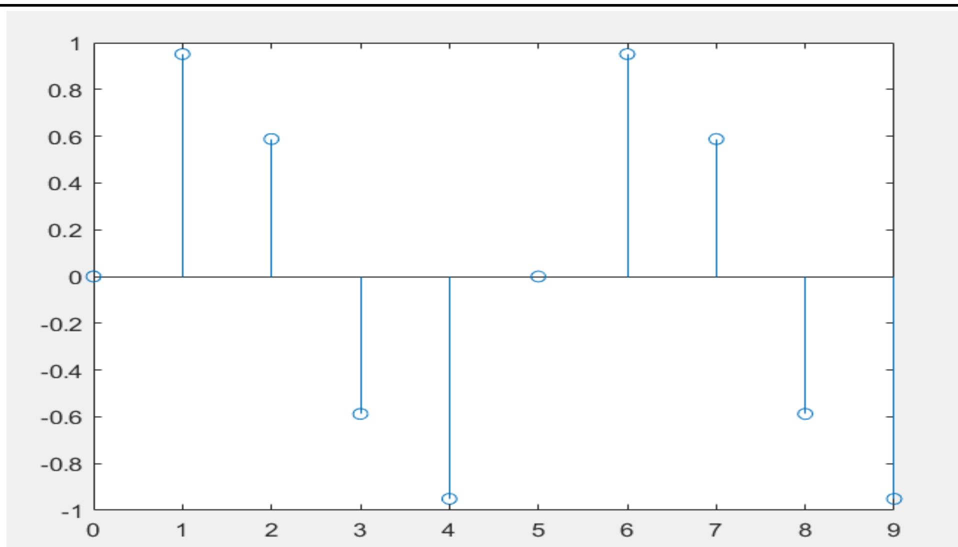
where K is the smallest integer such that N_0 is positive integer

$N_0 = \frac{2*pi*K}{\frac{2*pi*M}{N}} = \frac{N}{M} * K$

where K is a positive integer to make N_0 is a positive integer

2- b)

K	Stem of x
1	
2	

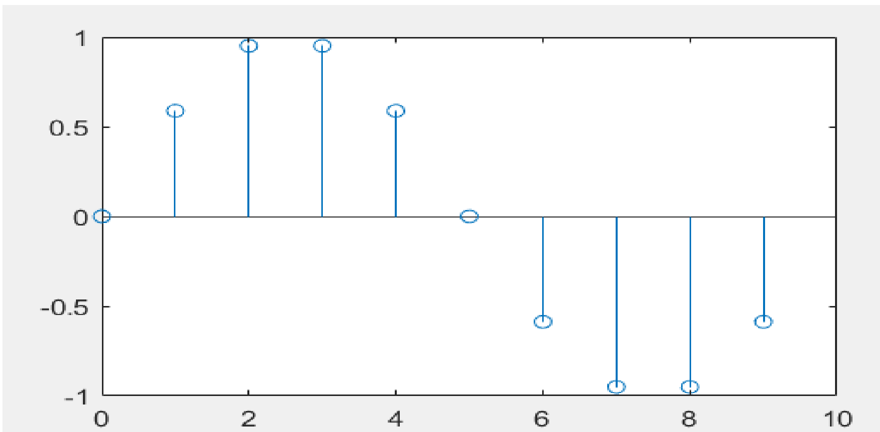
<table>
<tr><td>4</td><td>
</td></tr>
<tr><td>6</td><td>
</td></tr>
</table>

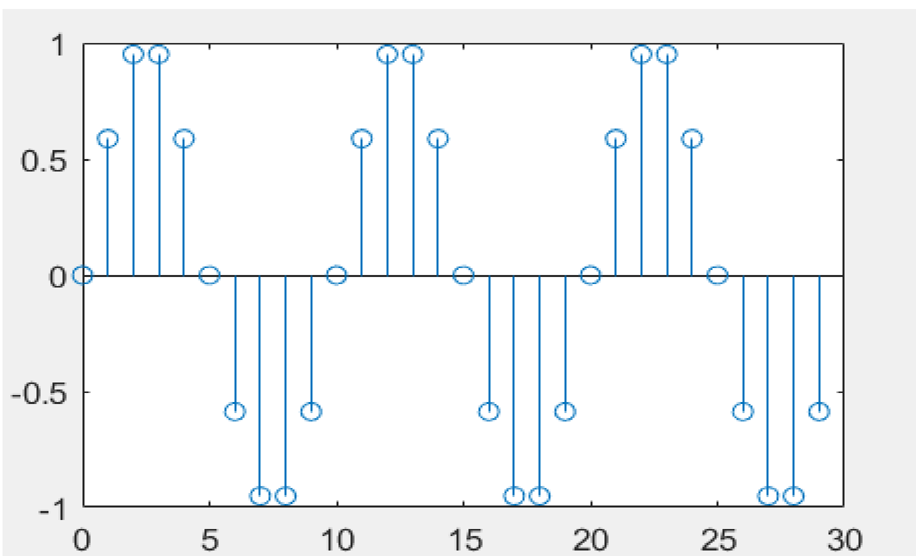
There are three unique plots because at k=1 and k=6 have the same plot .
Period is five and difference between k=1 and k=6 is one period so k=6 is the same signal as k=1 but after one period

3)

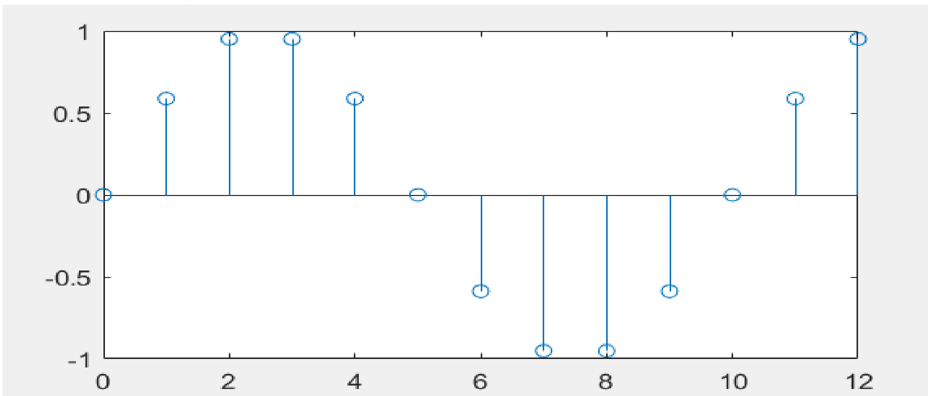
a

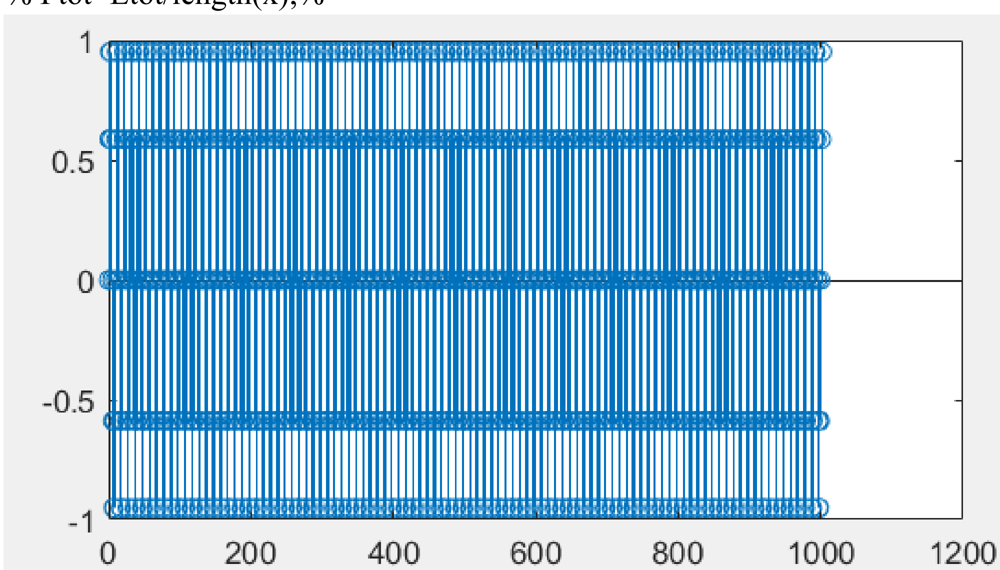
```
n=[0:9];
 x=sin(2*pi*1/10*n);
stem(n,x);
Etot=sum(x.^2);
Ptot=Etot/length(x);
```





Eoneperiod= 5.000000000000001
Ptotal= 0.500000000000000
Etotal for periodic function = inf

<table>
<tr>
<td>B</td>
<td>
n=[0:12];
x=sin(2*pi*1/10*n);
stem(n,x);
Etot=sum(x.^2);


Etotal= 6.250000000000000
Ptotal=0 (aperiodic)
</td>
</tr>
<tr>
<td>C</td>
<td>
n=[0:1002];
x=sin(2*pi*1/10*n);
stem(n,x);
Etot=sum(x.^2);
% Ptot=Etot/length(x);%


Etotal= 501.2500
Ptotal=0 (aperiodic)
</td>
</tr>
</table>

Comments

For b and c they are aperiodic signals because the are on a specific interval in which they aren't periodic so the total power is zero according to the relation

- Power over an infinite interval (total)

$$P_{\infty} = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x[n]|^2$$

And they have a finite energy

Codes

1-

a-

```
>> nx=[-3:7];
>> x=zeros(length(nx),1);
>> x=[0 0 0 2 0 1 -1 3 0 0 0];
>> stem(nx,x);
```

b-

Y1

```
>> nx=[-3:7];
>> x=zeros(length(nx),1);
>> x=[0 0 0 2 0 1 -1 3 0 0 0];
>> stem(nx+2,x);
```

Y2

```
>> nx=[-3:7];
>> x=zeros(length(nx),1);
>> x=[0 0 0 2 0 1 -1 3 0 0 0];
>>stem(nx-1,x);
```

Y3

```
>> nx=[-3:7];
>> x=zeros(length(nx),1);
>> x=[0 0 0 2 0 1 -1 3 0 0 0];
>>stem(-nx,x);
```

Y4

```
>> nx=[-3:7];
>> x=zeros(length(nx),1);
>> x=[0 0 0 2 0 1 -1 3 0 0 0];
>> stem(-(nx-1),x);
```

2-

a-

```
 N=12;
 M=4;
n = [0:2*N - 1];
x=sin(2*pi*M*n/N);
stem(n,x);
```

////////////////////////////

```
N=12;
 M=5;
n = [0:2*N - 1];
x=sin(2*pi*M*n/N);
stem(n,x);
```

///////////////////////////

```
N=12;
 M=7;
n = [0:2*N - 1];
x=sin(2*pi*M*n/N);
stem(n,x);
```

//////////////////////////////

```
N=12;
 M=10;
n = [0:2*N - 1];
x=sin(2*pi*M*n/N);
stem(n,x);
```

//////////////////////////////

b-

```
n=[0:9];
w=2*pi /5;
k=1;
x=sin(w*k*n);
stem(n,x);

///////////////
n=[0:9];
w=2*pi /5;
k=2;
x=sin(w*k*n);
stem(n,x);
////////////////
n=[0:9];
w=2*pi /5;
k=4;
x=sin(w*k*n);
stem(n,x);
/////////////////
n=[0:9];
w=2*pi /5;
k=6;
x=sin(w*k*n);
stem(n,x);
```

3-

a-

```
n=[0:9];
  x=sin(2*pi*1/10*n);
 stem(n,x);
 Etot=sum(x.^2);
 Ptot=Etot/length(x);
```

b-

```
n=[0:12];
 x=sin(2*pi*1/10*n);
 stem(n,x);
 Etot=sum(x.^2);
```

c-

```
n=[0:1002];
 x=sin(2*pi*1/10*n);
 stem(n,x);
 Etot=sum(x.^2);
```

Cairo University
Faculty of Engineering
Electronics and Communications dep.

Signals and Systems Labs
Second year

Experiment (2)
Systems Properties and Convolution

1) Linearity and time invariance:

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Experiment 2 –Part 1 Results sheet:

1- Analytical solution to discover time invariance and linearity of the systems:

a)

Subject موضوع الدرس Date التاريخ

(a) Check linarity

let

step 1

$$x_1[n] \rightarrow y_1[n] = x_1[n] - x_1[n-1] - x_1[n-2]$$

$$x_2[n] \rightarrow y_2[n] = x_2[n] - x_2[n-1] - x_2[n-2]$$

step 2

$$A y_1[n] + B y_2[n] = A x_1[n] - A x_1[n-1] - A x_1[n-2] + B x_2[n] - B x_2[n-1] - B x_2[n-2] \rightarrow (1)$$

step 3

$$x_3[n] = A x_1[n] + B x_2[n] \rightarrow y_3[n]$$

$$y_3[n] = A x_1[n] + B x_2[n] - [A x_1[n-1] + B x_1[n-1]] - [A x_1[n-2] + B x_2[n-2]] \rightarrow (2)$$

from (1), (2)

$$y_3[n] = A y_1[n] + B y_2[n]$$

$\therefore$ the system is linear

(a) Check time invariance

Step 1

$x_1[n] \rightarrow y_1[n] = x_1[n] - x_1[n-1] - x_1[n-2]$

$\rightarrow y_1[n-n_0] = x_1[n-n_0] - x_1[n-n_0-1] - x_1[n-n_0-2] \rightarrow (1)$

Step 2

$x_2[n] = x_1[n-n_0] \rightarrow y_2[n] = x_1[n-n_0] - x_1[n-1-n_0] - x_1[n-2-n_0] \rightarrow (2)$

$y_2[n] = y_1[n-n_0]$

$\therefore$ the system is time invariant b)

(1b) linearity

step 1

$x_1[n] \rightarrow y_1[n] = \cos[x_1[n]]$

$x_2[n] \rightarrow y_2[n] = \cos[x_2[n]]$

step 2

$A y_1[n] + B y_2[n] = A \cos[x_1[n]] + B \cos[x_2[n]]$

step 3

$x_3[n] = A x_1[n] + B x_2[n] \rightarrow y_3[n]$

$y_3[n] = \cos[A x_1[n] + B x_2[n]]$

$A y_1[n] + B y_2[n] \neq y_3[n]$

$\therefore$ not linear

time invarient

(b)

step 1

$x_1[n] \rightarrow y_1[n] = \cos(x_1[n]) \rightarrow y_1[n-n_0] = \cos[x_1[n-n_0]]$

step 2

$x_2[n] = x_1[n-n_0] \rightarrow y_2[n] = \cos[x_1[n-n_0]]$

$y_1[n-n_0] = y_2[n]$

$\rightarrow$ time invarient

c)

(c)

check linearity

Step 1

$x_1[n] \rightarrow y_1[n] = n\, x_1[n]$

$x_2[n] \rightarrow y_2[n] = n\, x_2[n]$

Step 2

$A\, y_1[n] + B\, y_2[n] = A\, n\, x_1[n] + B\, n\, x_2[n]$

Step 3

$x_3[n] = A\, x_1[n] + B\, x_2[n] \rightarrow y_3[n] = \cancel{[A\, x_1[n] + B\, x_2[n]]}$

$y_3[n] = n\, [A\, x_1[n] + B\, x_2[n]]$

$y_3[n] = A\, y_1[n] + B\, y_2[n]$

$\therefore$ linear

(5) Check time invariance

Step 1

$x_1[n] \rightarrow y_1[n] = n\,x_1[n] \rightarrow y_1[n-n_0] = (n-n_0)\,x_1[n-n_0]$

Step 2

$x_2[n] = x_1[n-n_0] \rightarrow y_2[n] = n\,x_1[n-n_0]$

$y_2[n] \neq y_1[n-n_0]$

$\rightsquigarrow$ Time Varient

Write the code used to input the first signal to the three systems

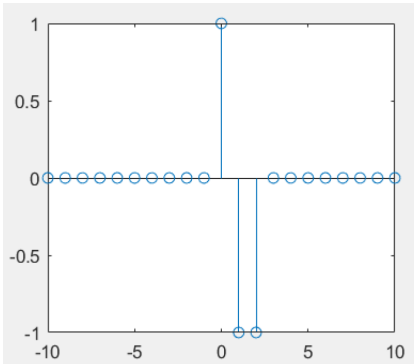
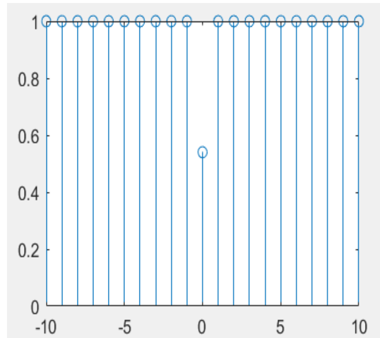
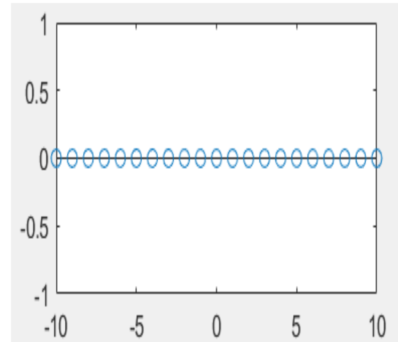
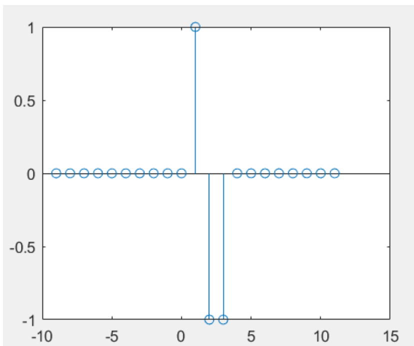
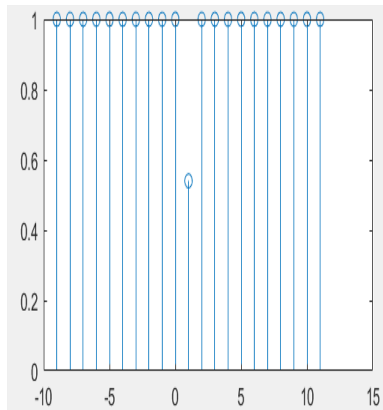
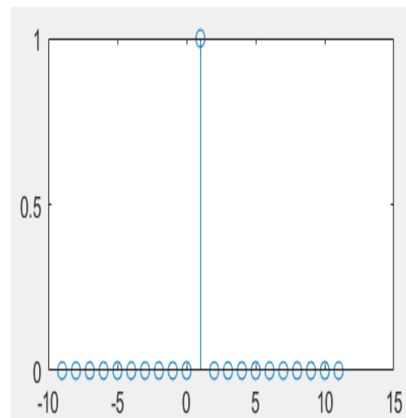
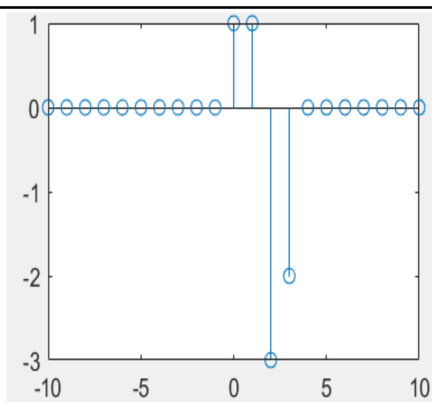
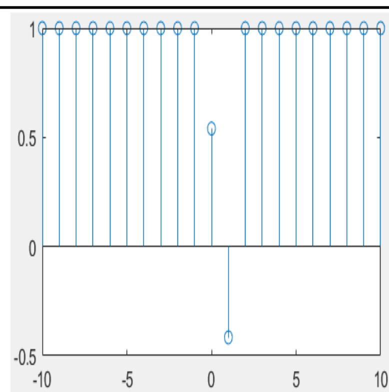
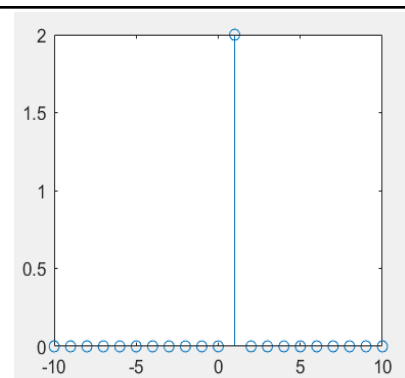
System	Code

a	Input 1
	n1=[-10:10];
	x1=[zeros(1,10) 1 zeros(1,10)];
	x2=[zeros(1,11) 1 zeros(1,9)];
	x3=[zeros(1,12) 1 zeros(1,8)];
	y=x1-x2-x3;
	stem(n1,y);
	
	input 2
	n2=[-9:11];
	x1=[zeros(1,10) 1 zeros(1,10)];
	x2=[zeros(1,11) 1 zeros(1,9)];
	x3=[zeros(1,12) 1 zeros(1,8)];
	y=x1-x2-x3;
	stem(n2,y);
	
	input3
	n=[-10:10];
	x1=[zeros(1,10) 1 zeros(1,10)];
	x2=[zeros(1,11) 1 zeros(1,9)];
	x3=[zeros(1,12) 1 zeros(1,8)];
	x11=[zeros(1,11) 1 zeros(1,9)];
	x22=[zeros(1,12) 1 zeros(1,8)];
	x33=[zeros(1,13) 1 zeros(1,7)];
	
	y=(x1+2.*x11)-(x2+2.*x22)-(x3+2.*x33);
	stem(n,y);

b	Input 1
	n=[-10:10];
	x=[zeros(1,10) 1 zeros(1,10)];
	y= cos(x);
	stem(n,y);
	input 2
	n=[-9:11];
	x=[zeros(1,10) 1 zeros(1,10)];
	y= cos(x);
	stem(n,y);
	input3
	n=[-10:10];
	x1=[zeros(1,10) 1 zeros(1,10)];
	x2=[zeros(1,11) 1 zeros(1,9)];
	y= cos(x1+2.*x2);
	stem(n,y);

c	Input 1
	n=[-10:10];
	x=[zeros(1,10) 1 zeros(1,10)];
	y= n.*x;
	stem(n,y);
	input 2
	n=[-9:11];
	x=[zeros(1,10) 1 zeros(1,10)];
	y= n.*x;
	stem(n,y);
	
	input3
	n=[-10:10];
	x1=[zeros(1,10) 1 zeros(1,10)];
	x2=[zeros(1,11) 1 zeros(1,9)];
	y= n.*(x1+2.*x2);
	stem(n,y);

Plotting for the responses of the systems to the three inputs:

	System (1)	System (2)	System (3)
Input(1)			
Input(2)			
Input(3)			
Comment	Linear: when multiplying inputs by factors and adding them output is also multiplied and added time invariant :when shifting input output is also the same but shifted	Not linear : when multiplying inputs by factors and adding them output is not multiplied and added time invariant: when shifting input output is also the same but shifted	Linear : when multiplying inputs by factors and adding them output is also multiplied and added not time invariant: when shifting input output is not shifted version from original output

Part 2:

1) Discrete time convolution:

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Experiment 2- Part 2 Results sheet:

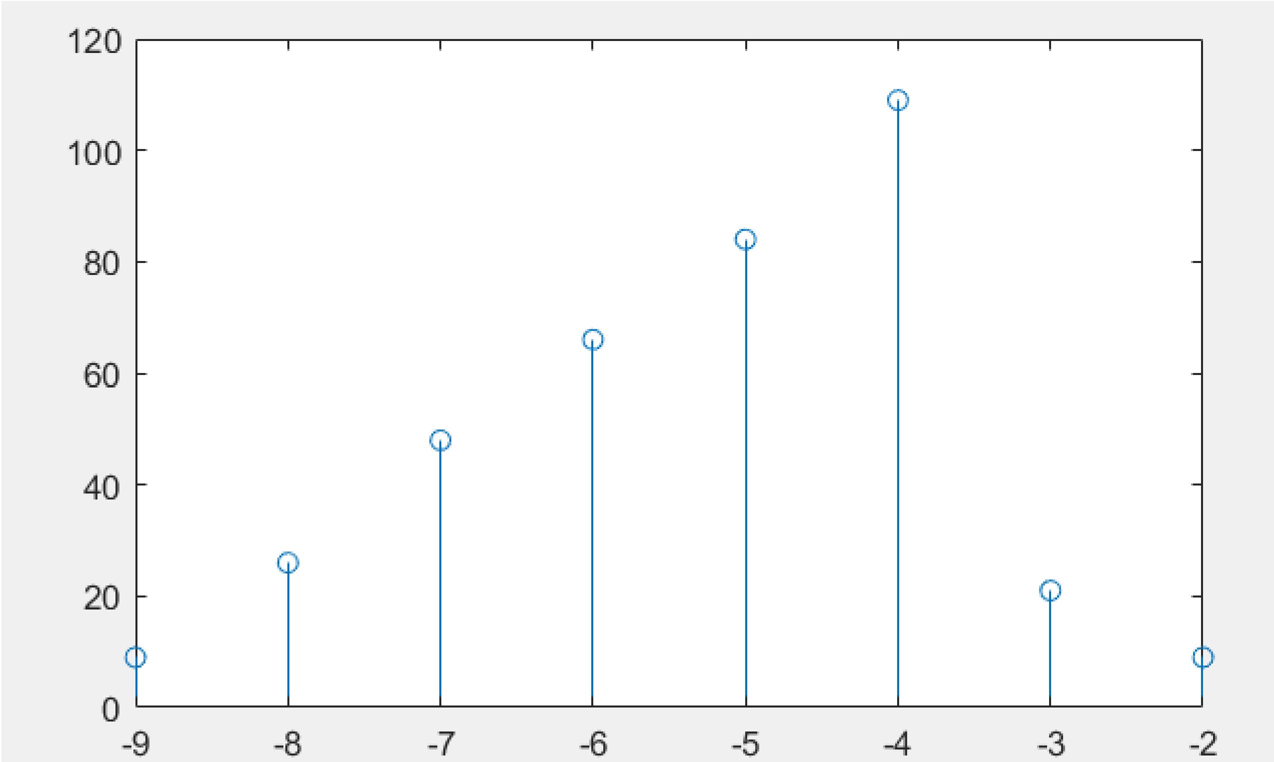
a) Convolution complete code (1)

```
nx=[-3 -2 -1];
x =[1 2 3];
nh=[-6 -5 -4 -3 -2 -1];
h =[9 8 5 32 5 3];


M=length(x);
N=length(h);
ny= nx(1)+nh(1):nx(end)+nh(end);

y=zeros(1,length(ny));
for u=1:length(h)
    x1=h(u)*[zeros(1,u-1) x zeros(1,N-u)];
    y=y+x1;
end
stem(ny,y);
```

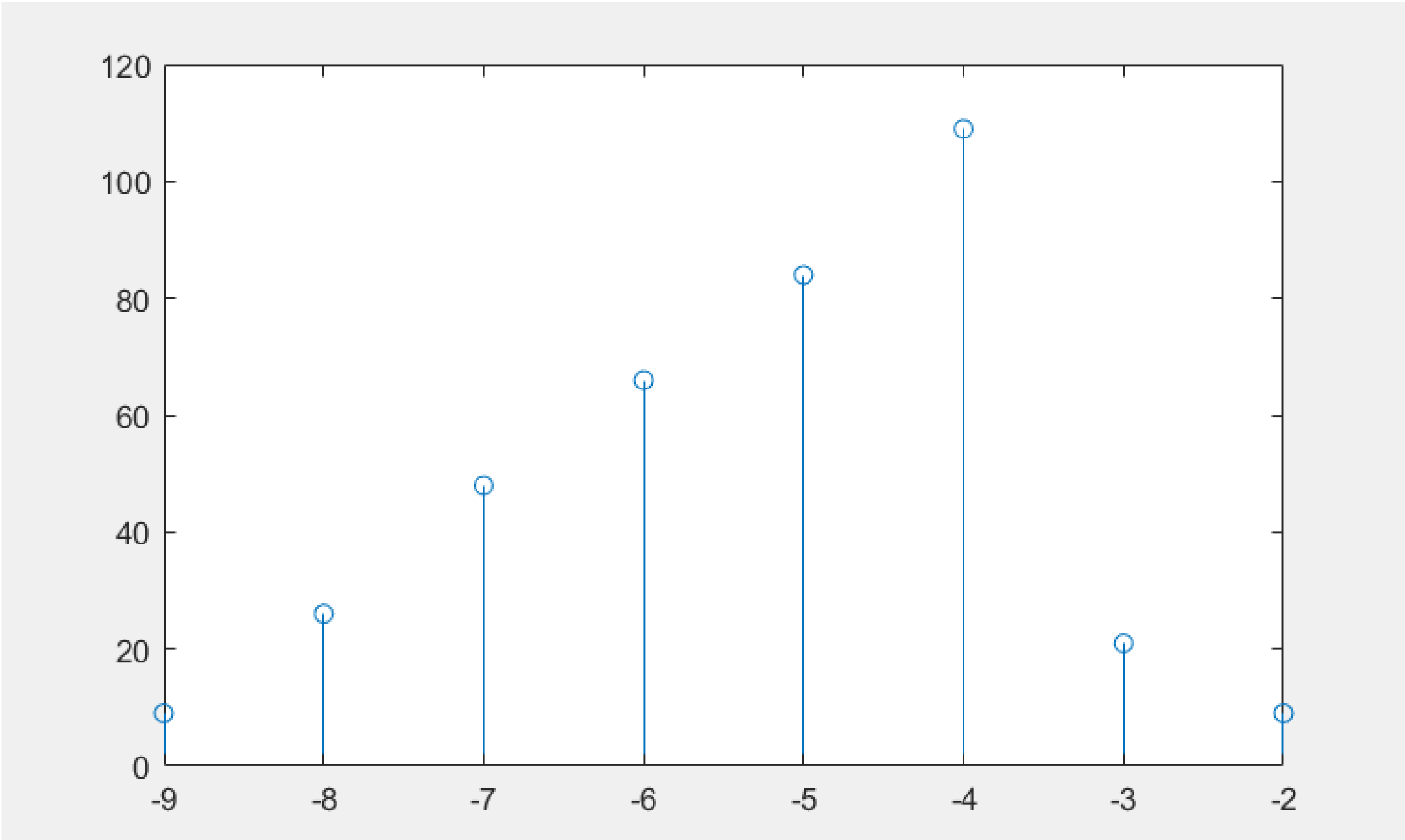
Using stem function to plot the final output y.



b) The conv command:

```
nx=[-3 -2 -1];
x =[1 2 3];
nh=[-6 -5 -4 -3 -2 -1];
h =[9 8 5 32 5 3];
>> y=conv(x,h);
>> n_c= nx(1)+nh(1):nx(end)+nh(end);
>> stem(n_c,y);
```

Using stem function to plot its final output y.



2) Fourier Series:

Experiment 2 Results sheet:

a)Inverse Fourier Series Code	**N=length(a);** **n=0:N-1;** **for k=0:N-1** **x(k+1)=sum(a.*exp(2*pi*i*k*n/N));** end
b)Fourier series of the three signals:	a- [2.500000000000000 + 0.000000000000000i, -0.500000000000000 + 0.500000000000000i, -0.500000000000000 - 0.000000000000000i, -0.500000000000000 - 0.500000000000000i]
	b- [1.500000000000000 + 0.000000000000000i, -0.250000000000000 -0.250000000000000i, 0.000000000000000e+00 - 3.061616997868382e-17i, -0.250000000000000 + 0.250000000000000i]
	c- [0.000000000000000 + 0.000000000000000i, 0.000000000000000 - 0.850650808352040i, -0.000000000000000 + 0.525731112119134i, 0.000000000000000 - 0.525731112119134i, -0.000000000000000 + 0.850650808352040i] Code **N=length(x);** **n=0:N-1;** **for k=0:N-1** **a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));** end

X signal for the previous Fourier series coefficients	[1.000000000000000 - 0.000000000000001i, 2.000000000000000 - 0.000000000000000i, 3.000000000000000 - 0.000000000000000i, 4.000000000000000 + 0.000000000000000i]
	[1.000000000000000 - 0.000000000000000i, 2.000000000000000 - 0.000000000000000i, 2.000000000000000 + 0.000000000000000i, 1.000000000000000 + 0.000000000000000i]
	[-2.331468351712829e-16 + 1.110223024625157e-16i, 1.000000000000000 + 0.000000000000000i, 2.000000000000000 + 0.000000000000000i, -2.000000000000000 + 0.000000000000000i, -1.000000000000000 + 0.000000000000000i]

c) analytical solution of the three signals:

@ $x[n] = \cos(2\pi n \frac{3}{7})$

$x[n] = \frac{1}{2}\left[e^{2\pi \frac{3}{7} J} + e^{-2\pi \frac{3}{7} J}\right]$

$\Omega_0 = \frac{2\pi}{7}$

$N = 7 \qquad m = 3$

$\therefore a_3 = \frac{1}{2}$

$a_{-3} = \frac{1}{2}$

$a_{-3} = \frac{1}{2}$ is equivalent to

$a_4 = \frac{1}{2}$

because period is 7

and $-3 + 7 = 4$ #

(b) $x[n] = \sin(2\pi n \frac{3}{7})$

$$x[n] = \frac{1}{2J}\left[e^{2\pi\frac{3}{7}J} - e^{-2\pi\frac{3}{7}J}\right]$$

$\Omega_0 = \frac{2\pi}{7}$

$N = 7 \quad m = 3$

$\therefore a_3 = -0.5J$

$a_{-3} = 0.5J$

a_{-3} is equivalent to

a_4 because $N = 7$

~~$a_{-3}=0$~~

$\therefore a_3 = -0.5J$

$a_4 = 0.5J$

	(c) $x[n] = e^{(2\pi n \frac{3}{7} j)}$ $\Omega_0 = \frac{2\pi}{7}$ $N=7 \quad m=3$ $\therefore \ a_3 = 1$

Simulation output of the three signals:	a-
	
	A=
	[2.061842760018148e-16 + 0.000000000000000e+00i,
	-4.758098676964956e-17 + 2.061842760018148e-16i,
	-1.704985359245776e-16 - 1.427429603089487e-16i,
	0.500000000000000 - 0.000000000000000i,
	0.500000000000000 + 0.000000000000001i,
	-8.326672684688674e-16 + 4.758098676964956e-17i,
	1.903239470785983e-16 - 3.806478941571965e-16i]
	
	A0=0 , A1=0 , A2=0 , A3=0.5 , A4=0.5 , A5=0, A6=0
	
	Code
	
	`n=[ 0 ,1,2,3,4,5,6 ];`
	`x=cos(2*pi*n*3/7);`
	` N=length(x);`
	`n=0:N-1;`
	`for k=0:N-1`
	`        a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));`
	`end`

b-

A=
[-8.723180907769087e-17 + 0.000000000000000e+00i,
7.137148015447434e-17 - 1.506731247705569e-16i,
1.962715704248045e-16 + 1.110223024625157e-16i,
0.000000000000000 - 0.500000000000000i,
-0.000000000000000 + 0.500000000000000i,
2.101493582326189e-16 + 1.586032892321652e-17i,
4.599495387732791e-16 + 2.379049338482478e-17i]

A0=0 , A1=0 ,A2=0 ,A3=-0.5j , A4=0.5j, A5=0, A6=0

code

```
n=[ 0 ,1,2,3,4,5,6 ];
x= sin(2*pi*n*3/7);
 N=length(x);
n=0:N-1;
for k=0:N-1
        a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```

c-
A=
[2.061842760018148e-16 - 8.723180907769087e-17i,
8.723180907769087e-17 + 2.696255916946809e-16i,
-2.696255916946809e-16 + 9.516197353929913e-17i,
1.000000000000000 + 0.000000000000000i,
1.586032892321652e-16 + 7.930164461608260e-17i,
-8.326672684688674e-16 + 2.537652627714643e-16i,
1.744636181553817e-16 + 7.930164461608260e-17i]

A0=0 , A1=0 , A2=0 , A3=1, A4=0, A5=0, A6=0

code

```
n=[ 0 ,1,2,3,4,5,6 ];
x= exp(j*2*pi*n*3/7);
 N=length(x);
n=0:N-1;
for k=0:N-1
        a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```

Codes

1) Linearity and time invariance:

Experiment 2 –Part 1 Results sheet:

a-

Input 1

```
n1=[-10:10];
x1=[zeros(1,10) 1 zeros(1,10)];
x2=[zeros(1,11) 1 zeros(1,9)];
x3=[zeros(1,12) 1 zeros(1,8)];
y=x1-x2-x3;
stem(n1,y);
```

input 2

```
n2=[-9:11];
x1=[zeros(1,10) 1 zeros(1,10)];
x2=[zeros(1,11) 1 zeros(1,9)];
x3=[zeros(1,12) 1 zeros(1,8)];
y=x1-x2-x3;
stem(n2,y);
```

input3

```
n=[-10:10];
x1=[zeros(1,10) 1 zeros(1,10)];
x2=[zeros(1,11) 1 zeros(1,9)];
x3=[zeros(1,12) 1 zeros(1,8)];
x11=[zeros(1,11) 1 zeros(1,9)];
x22=[zeros(1,12) 1 zeros(1,8)];
x33=[zeros(1,13) 1 zeros(1,7)];

y=(x1+2.*x11)-(x2+2.*x22)-(x3+2.*x33);
stem(n,y);
```

b-

Input 1
```
n=[-10:10];
x=[zeros(1,10) 1 zeros(1,10)];
y= cos(x);
stem(n,y);
```
input 2
```
n=[-9:11];
x=[zeros(1,10) 1 zeros(1,10)];
y= cos(x);
stem(n,y);
```
input3
```
n=[-10:10];
x1=[zeros(1,10) 1 zeros(1,10)];
x2=[zeros(1,11) 1 zeros(1,9)];
y= cos(x1+2.*x2);
stem(n,y);
```

c-

Input 1
```
n=[-10:10];
x=[zeros(1,10) 1 zeros(1,10)];
y= n.*x;
stem(n,y);
```
input 2
```
n=[-9:11];
x=[zeros(1,10) 1 zeros(1,10)];
y= n.*x;
stem(n,y);
```
input3
```
n=[-10:10];
x1=[zeros(1,10) 1 zeros(1,10)];
x2=[zeros(1,11) 1 zeros(1,9)];
y= n.*(x1+2.*x2);
stem(n,y);
```

Experiment 2- Part 2 Results sheet:

a-

```
nx=[-3 -2 -1];
x =[1 2 3];
nh=[-6 -5 -4 -3 -2 -1];
h =[9 8 5 32 5 3];


M=length(x);
N=length(h);
ny= nx(1)+nh(1):nx(end)+nh(end);

y=zeros(1,length(ny));
for u=1:length(h)
    x1=h(u)*[zeros(1,u-1) x zeros(1,N-u)];
    y=y+x1;
end
stem(ny,y);
```

b-

```
nx=[-3 -2 -1];
x =[1 2 3];
nh=[-6 -5 -4 -3 -2 -1];
h =[9 8 5 32 5 3];
>> y=conv(x,h);
>> n_c= nx(1)+nh(1):nx(end)+nh(end);
>> stem(n_c,y);
```

2) Fourier Series:

Students experiment 1:

a-

```
N=length(a);
n=0:N-1;
for k=0:N-1
x(k+1)=sum(a.*exp(2*pi*i*k*n/N));
end
```

b-

a-
```
x=[1 2 3 4];
N=length(x);
n=0:N-1;
for k=0:N-1
      a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```

b-
```
x=[1 2 2 1]
N=length(x);
n=0:N-1;
for k=0:N-1
      a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```

c-
```
[x=[0 1 2 -2 -1;
N=length(x);
n=0:N-1;
for k=0:N-1
      a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```

c-

a-

```
n=[ 0 ,1,2,3,4,5,6 ];
x=cos(2*pi*n*3/7);
 N=length(x);
n=0:N-1;
for k=0:N-1
        a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```

b-
```
n=[ 0 ,1,2,3,4,5,6 ];
x= sin(2*pi*n*3/7);
 N=length(x);
n=0:N-1;
for k=0:N-1
        a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```

c-

```
n=[ 0 ,1,2,3,4,5,6 ];
x= exp(j*2*pi*n*3/7);
 N=length(x);
n=0:N-1;
for k=0:N-1
	a(k+1)=1/N*sum(x.*exp(-2*pi*i*k*n/N));
end
```