Computer Assignment - 02 - Spring 2019

Submitted By - Sayam Kumar S20180010158 Sec-A

Linear Convolution

Write a matlab code for linear convolution of two signals. Then
1. Generate the causal signals -

$$x1[n] = \{3,1,4,16,2\}$$
$$x2[n] = \{3, -1, 3, -1\}$$
$$h[n] = \{2, -1, -4, 1, -3\}$$

Now, determine the output of the given systems

$$y1[n] = (x1[n] + x2[n]) * h[n]$$
$$y2[n] = x1[n] * h[n] + x2[n] * h[n]$$

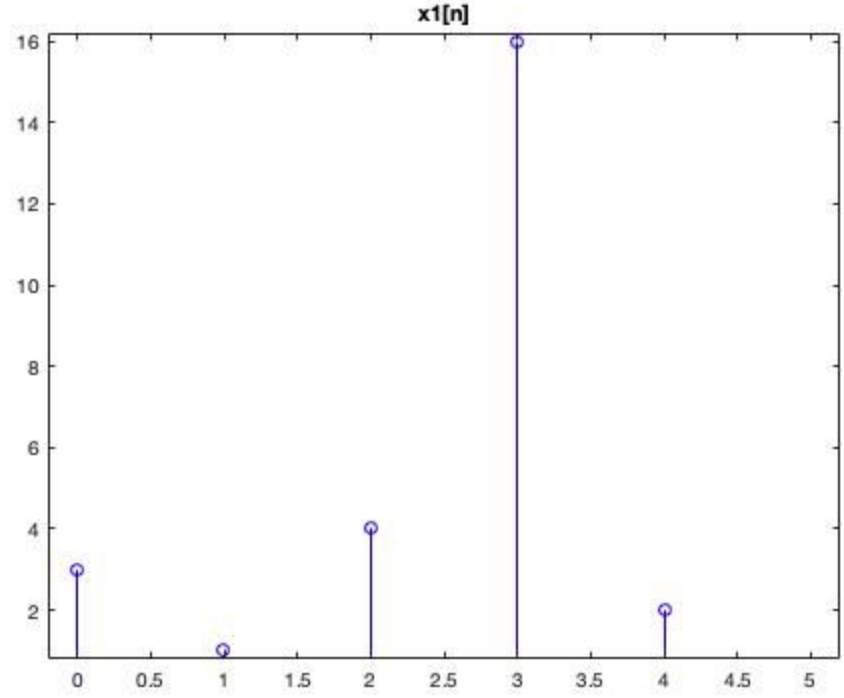
(a) Perform the calculations using your matlab code and verify the results using the inbuilt function conv and on-paper calculations.
(b) Verify if the outputs y1[n] and y2[n] are identical or not.
(c) Using the stem function, plot the signals x1[n], x2[n], h[n], y1[n] and y2 [n].

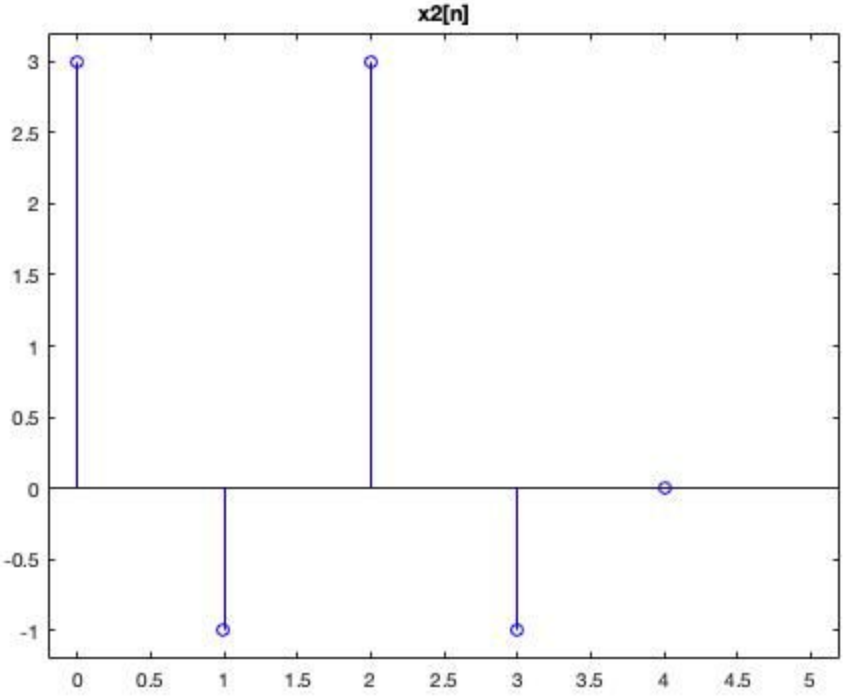
Solution -

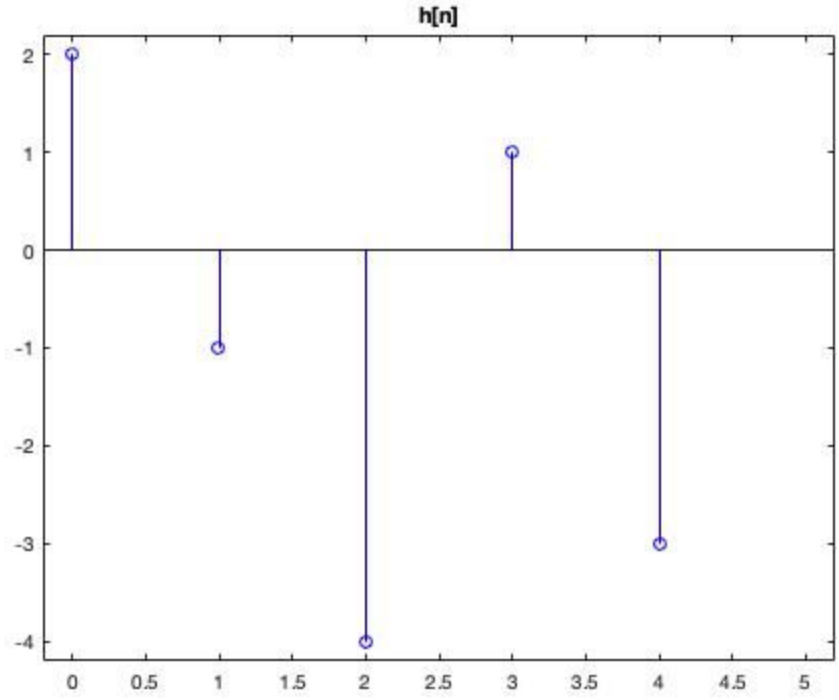
```
function x = x1(n)
    x(n==0) = 3;
    x(n==1) = 1;
    x(n==2) = 4;
    x(n==3) = 16;
    x(n==4) = 2;
end
```

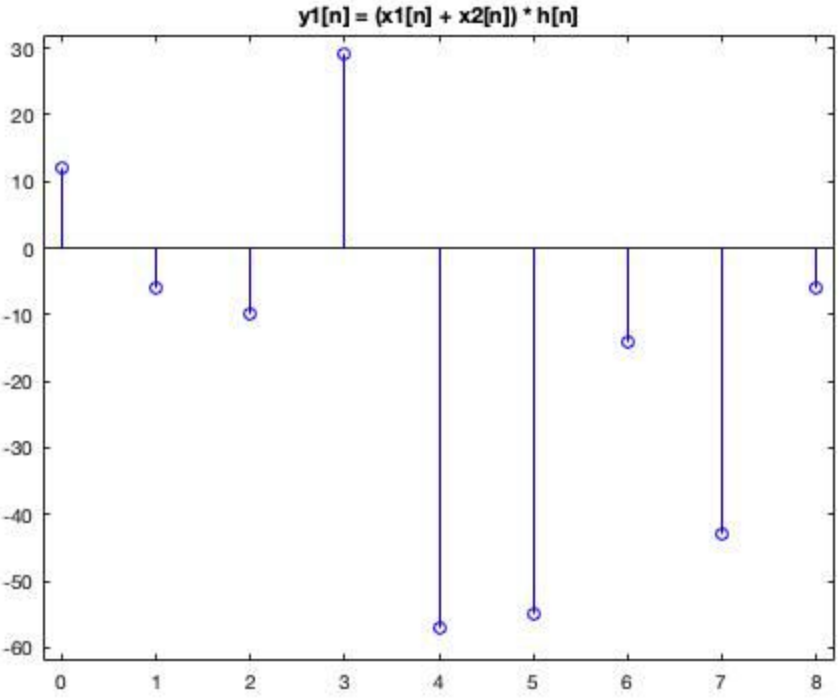
```
function x = x2(n)
    x(n==0) = 3;
    x(n==1) = -1;
    x(n==2) = 3;
    x(n==3) = -1;
end

function x = h1(n)
    x(n==0) = 2;
    x(n==1) = -1;
    x(n==2) = -4;
    x(n==3) = 1;
    x(n==4) = -3;
end

function y = convolve(x,h)
    m = length(x);
    n = length(h);
    l = m+n-1;
    xe = zeros(size(1:l));
    xe(1:m) = x(1:m);
    he = zeros(size(1:l));
    he(1:n) = h(1:n);
    y = zeros(size(l));
    for i = 1:l
        y(i) = 0;
        for k = 1:i
            y(i) = y(i) + he(k)*xe(i-k+1);
        end
    end
end
```

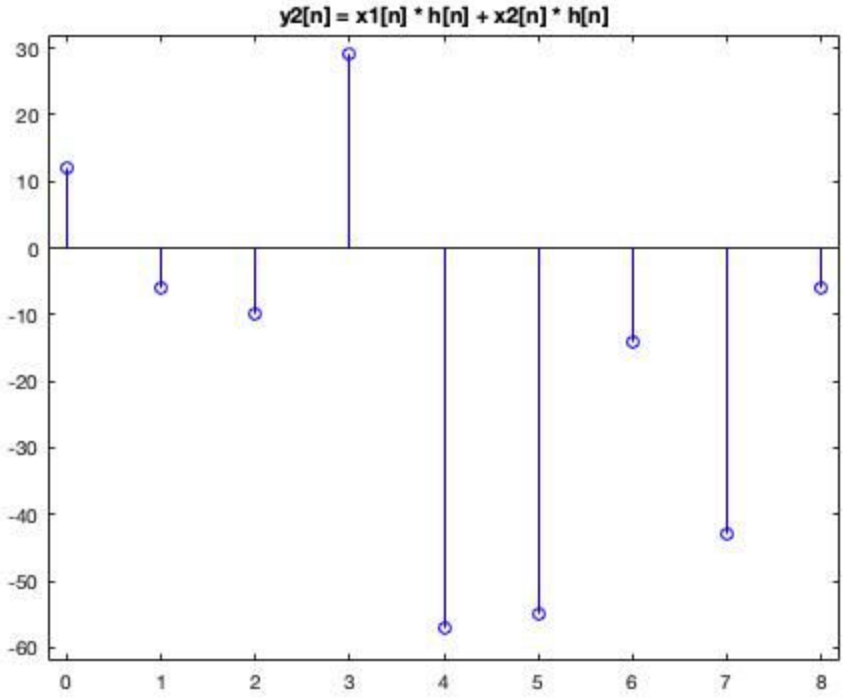
```
%live-script
n = 0:8;
xa = x1(n);
xb = x2(n);
h = h1(n);
xb(1:length(xa)) = [xb, zeros(size(length(xa)-length(xb)))];
y1 = convolve(xa+xb,h);
y2 = convolve(xa,h)+convolve(xb,h);

stem(0:(length(xa)-1),xa,'blue')
xlim([-0.2 5.2])
ylim([0.8 16.2])
title('x1[n]')

stem(0:(length(xb)-1),xb,'blue')
xlim([-0.2 5.2])
ylim([-1.2 3.2])
title('x2[n]')

stem(0:(length(h)-1),h,'blue')
xlim([-0.2 5.2])
ylim([-4.2 2.2])
title('h[n]')

stem(n,y1,'blue')
xlim([-0.2 8.2])
ylim([-62 32])
title('y1[n] = (x1[n] + x2[n]) * h[n]')

stem(n,y2,'blue')
xlim([-0.2 8.2])
ylim([-62 32])
title('y2[n] = x1[n] * h[n] + x2[n] * h[n]')
```


x1[n]
16
14
12
10
8
6
4
2
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


x2[n]
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


h[n]
2
1
0
-1
-2
-3
-4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


y1[n] = (x1[n] + x2[n]) * h[n]
30
20
10
0
-10
-20
-30
-40
-50
-60
0
1
2
3
4
5
6
7
8



a) Yes, all the outputs are verified using the conv function.
b) Yes, y1[n] and y2[n] are identical.

2. Next, generate the signals

$x[n] = \{-3, -2, 0, 1, 2, 3\}$

$h[n] = \{3,1,1,3,1,1\}$

Now, determine the output of the given system

$y[n] = x[n - 3] * h[n]$

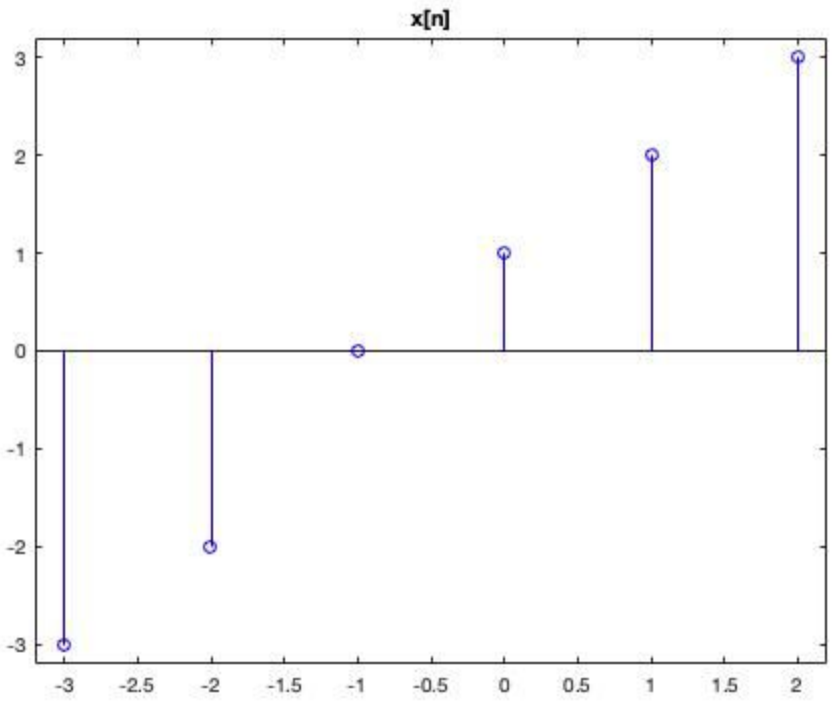
(a) Perform the calculations using your matlab code and verify the results using the inbuilt function conv and on-paper calculations.

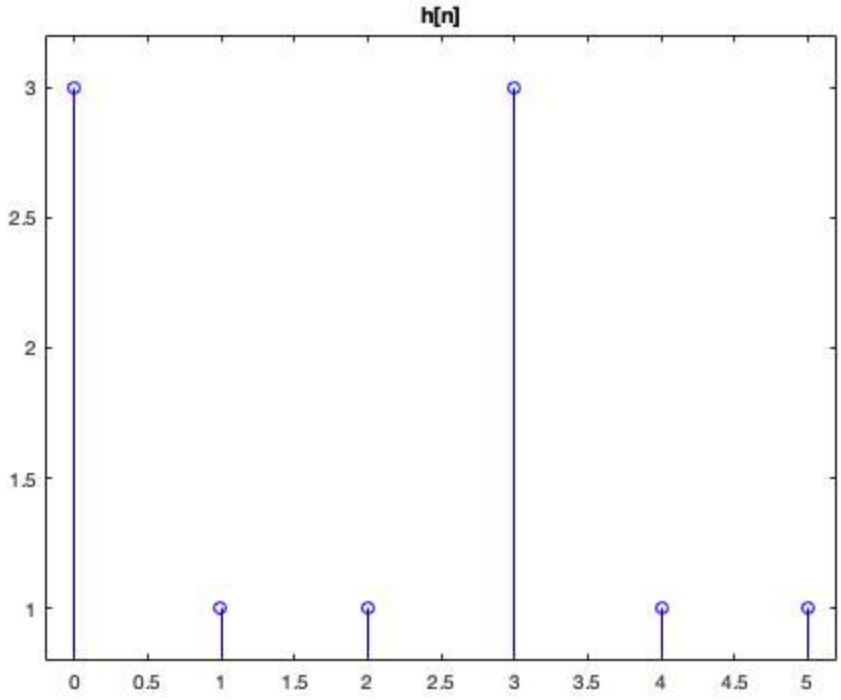
(b) Using the stem function, plot the signals x[n], h[n], and y[n].

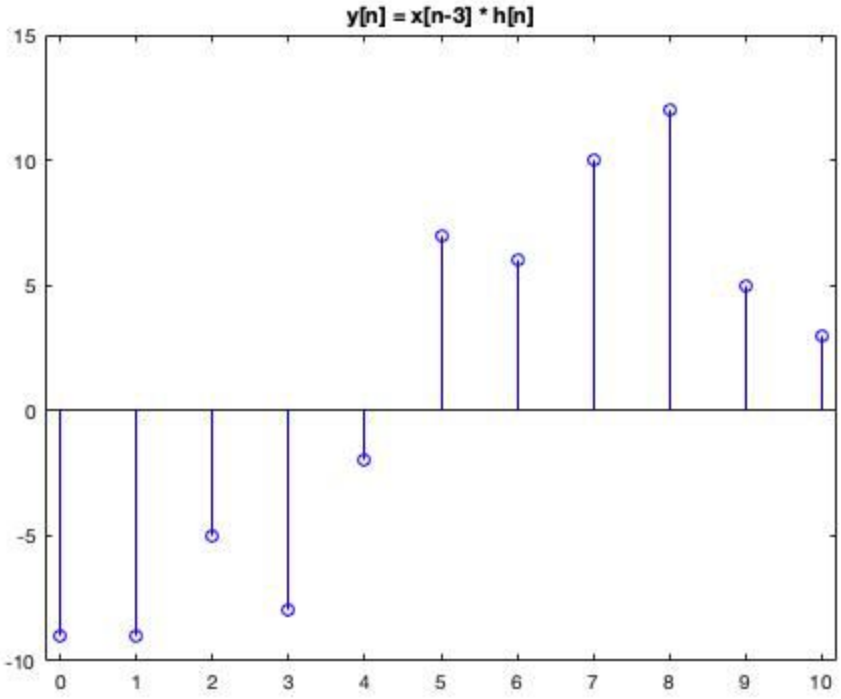
Solution -

```
function x = x1(n)
   x(n==-3) = -3;
   x(n==-2) = -2;
   x(n==-1) = 0;
   x(n==0) = 1;
   x(n==1) = 2;
   x(n==2) = 3;
end

%same convolve function has been used in this code also.
function x = h1(n)
   x(n==0) = 3;
   x(n==1) = 1;
   x(n==2) = 1;
   x(n==3) = 3;
   x(n==4) = 1;
   x(n==5) = 1;
end

%live-script
n = 0:10;
xa = x1(n-3);
h = h1(n);
y = convolve(xa,h);
```

```
stem((0:(length(xa)-1))-3,xa,'blue')
xlim([-3.2 2.2])
ylim([-3.2 3.2])
title('x[n]')

stem(0:(length(h)-1),h,'blue')
xlim([-0.2 5.2])
ylim([0.8 3.2])
title('h[n]')

stem(n,y,'blue')
xlim([-0.2 10.2])
title('y[n] = x[n-3] * h[n]')
```







a) Yes, all the outputs are verified using the conv function.

3. Next generate the causal signals

$x[n] = \{1, 2, -3, 8, -9\}$

$h[n] = \{3,2,1,2,3\}$

Now, compute the output of the given systems

$y1[n] = x[n] * h[1 - n]$, $y2[n] = x[1 - n] * h[n]$

(a) Perform the calculations using your matlab code and verify the results using the inbuilt function conv and on-paper calculations

(b) Using the stem function, plot the signals x[n], h[n], y1[n] and y2[n].

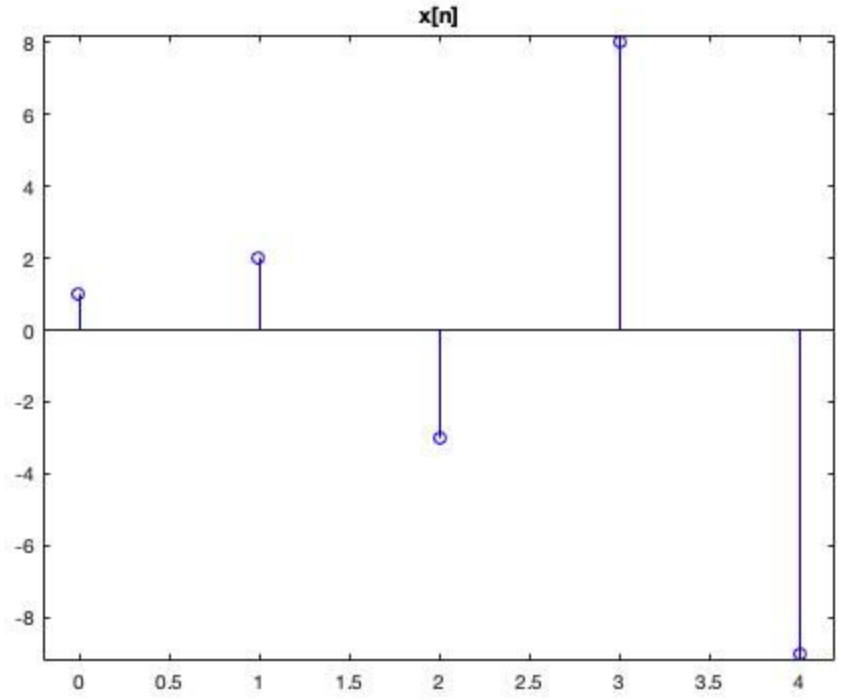
(c) Verify if the outputs y1[n] and y2[n] are identical or not.

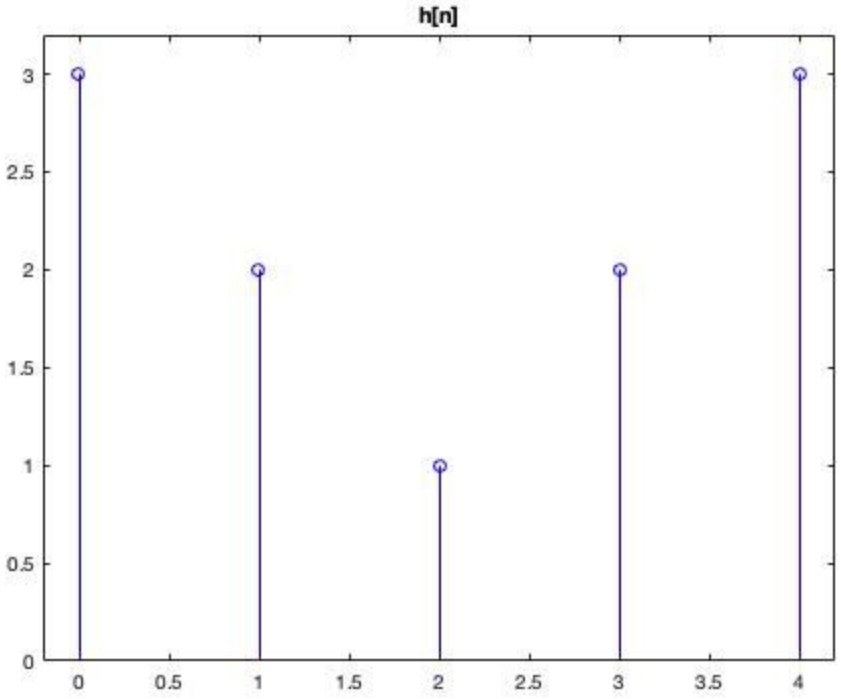
Solution -

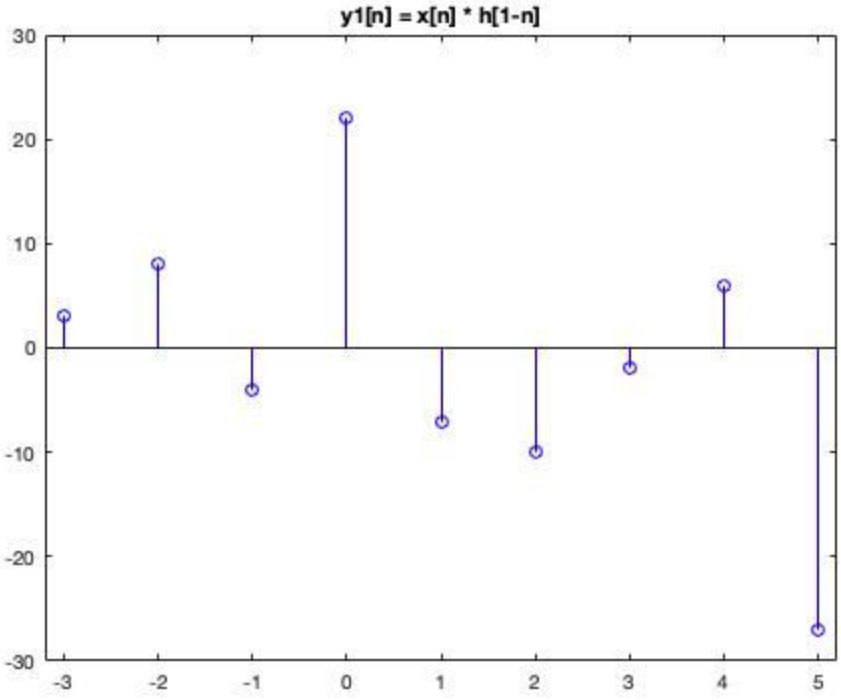
```
function x = x1(n)
   x(n==0) = 1;
   x(n==1) = 2;
   x(n==2) = -3;
   x(n==3) = 8;
   x(n==4) = -9;
end

%same convolve function has been used in this code also.
function x = h1(n)
   x(n==0) = 3;
   x(n==1) = 2;
   x(n==2) = 1;
   x(n==3) = 2;
   x(n==4) = 3;
end

%live-script
n = -3:5;
xa = x1(n);
h = h1(1-n);
xb = x1(1-n);
```

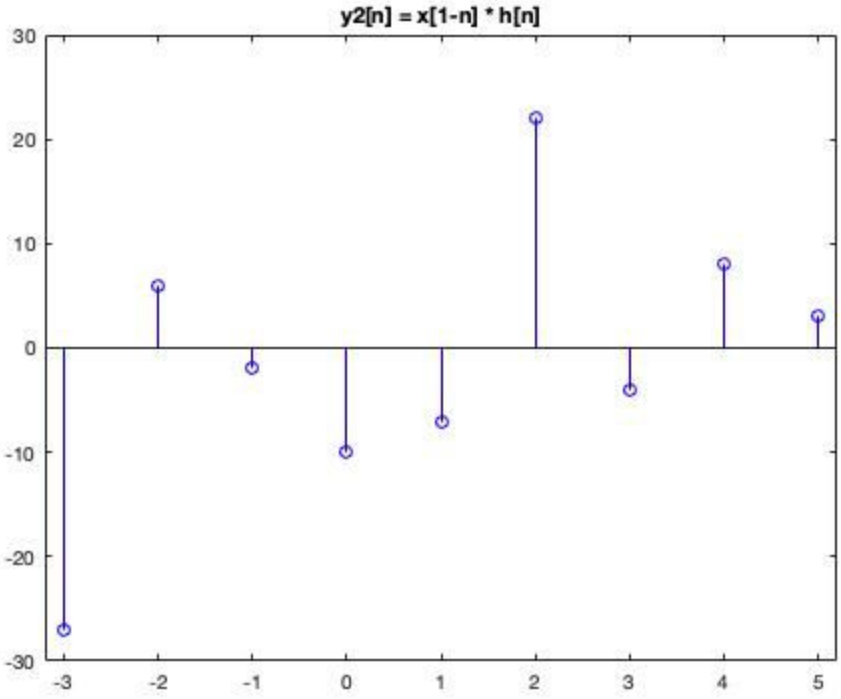
```
hb = h1(n);
y1 = convolve(xa,h);
y2 = convolve(xb,hb);

stem((0:(length(xa)-1))-3,xa,'blue')
xlim([-0.2 4.2])
ylim([-9.2 8.2])
title('x[n]')

stem(0:(length(h)-1),h,'blue')
xlim([-0.2 4.2])
ylim([0 3.2])
title('h[n]')

y1 = y1(length(y1)-length(n)+1:length(y1));
y2 = y2(length(y2)-length(n)+1:length(y2));
stem(n,y1,'blue')
xlim([-3.2 5.2])
title('y1[n] = x[n] * h[1-n]')

stem(n,y2,'blue')
xlim([-3.2 5.2])
title('y2[n] = x[1-n] * h[n]')
```

a) Yes, all the outputs are verified using the conv function.

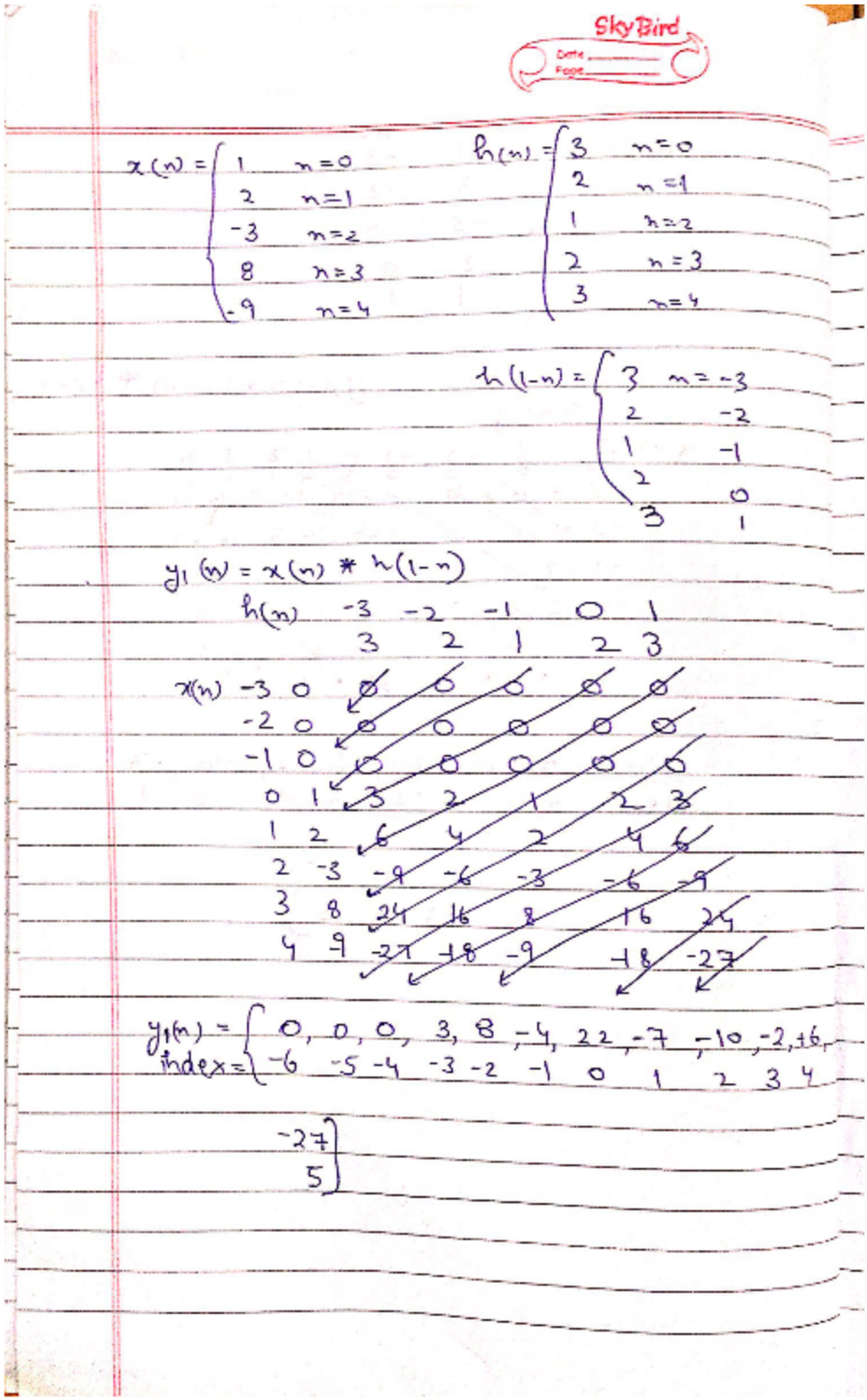

x[n]
8
6
4
2
0
-2
-4
-6
-8
0
0.5
1
1.5
2
2.5
3
3.5
4


h[n]
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
3.5
4





c) y1[n] and y2[n] are not identical. On paper calculations are on the next page.



$x(1-n) = \begin{cases} -9 & -3 \\ 8 & -2 \\ -3 & -1 \\ 2 & 0 \\ 1 & 1 \end{cases}$ (n =)

$y_2(n) = x(1-n) * h(n)$

h(n) ↓

x(n) →	-3	-2	-1	0	1	2	3	4
	0	0	0	3	2	1	2	3
-3 -9	0	0	0	-27	-18	-9	-18	-27
-2 8	0	0	0	24	16	8	16	24
-1 -3	0	0	0	-9	-6	-3	-6	-9
0 2	0	0	0	6	4	2	4	6
1 1	0	0	0	3	2	1	2	3

$y_2(n) = \{0, 0, 0, -27, +6, -2, -10, -7$

index $= \{-6\ -5\ -4\ -3\ -2\ -1\ 0\ 1$

$22, -4, 8, 3\}$

$2\ \ 3\ 4\ 5$

Thank You !!