Computer Assignment - 02 - Spring 2019
Signals & Systems

- P . Venkatesh
- S20180010135

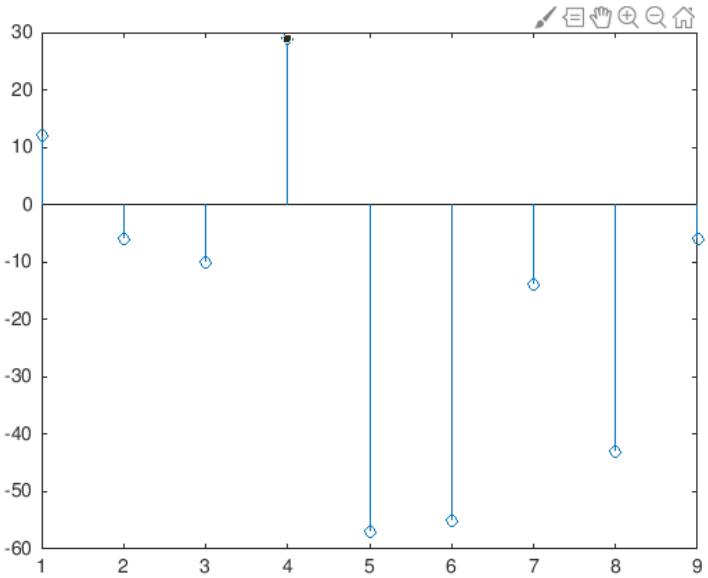
Write a matlab code for linear convolution of two signals. Then
1. Generate the causal signals
x1[n] = {3, 1, 4, 16, 2}
↑
x2[n] = {3, −1, 3, −1}
↑
h[n] = {2, − 1, − 4, 1, − 3}
↑
Now, determine the output of the given systems
y1[n] = (x1[n] + x2[n]) ∗ h[n]
y2[n] = x1[n] ∗ h[n] + x2[n] ∗ h[n]

(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].

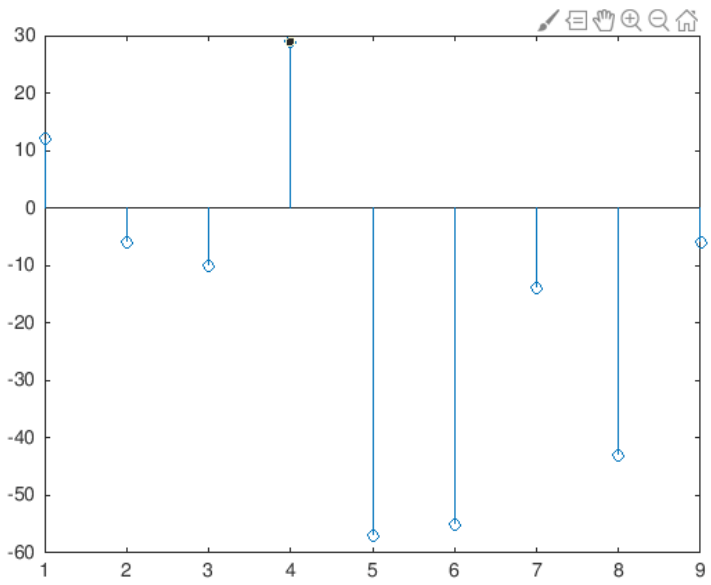
1 solution)

```
x1 = [3 1 4 16 2];
x2 = [3 -1 3 -1];
h = [2 -1 -4 1 -3];
x = x1 + [x2,0];
M = length(x);
N = length(h);
L = M + N - 1;
xc = zeros(1,L);
hc = zeros(1,L);
xc(1:M) = x;
hc(1:N) = h;
for n = 1:L
        y1(n) = 0;
        for k = 1:n
                y1(n) = y1(n) + xc(k)*hc(n-k+1);
        end
end
stem(y1);
y1
```



output:-
y1 = 12 -6 -10 29 -57 -55 -14 -43 -6

```
x1 = [3 1 4 16 2];
h = [2 -1 -4 1 -3];
M1 = length(x1);
N = length(h);
L1 = M1 + N - 1;
xe1 = zeros(1,L);
he1 = zeros(1,L);
xe1(1:M1) = x1;
he1(1:N) = h;
for n = 1:L1
        y1(n) = 0;
        for k=1:n
                y1(n) = y1(n) + xe1(k)*he1(n-
                                                k+1);
        end
end
x2 = [3 -1 3 -1];
M2 = length(x2);
L2 = M2 + N - 1;
xe2 = zeros(L2);
he2 = zeros(L2);
xe2(1:M2) = x2;
he2(1:N) = h;
for n = 1:L2
        y2(n) = 0;
        for k = 1:n
                y2(n) = y2(n) + xe2(n)*he2(n-k+1);
        end
end
y = y1 + [y2,0];
stem(y);
y
```



output:-

y = 12 -6 -10 29 -57 -55 -14 -43 -6

code for convulation the convulation using inbuilt functions

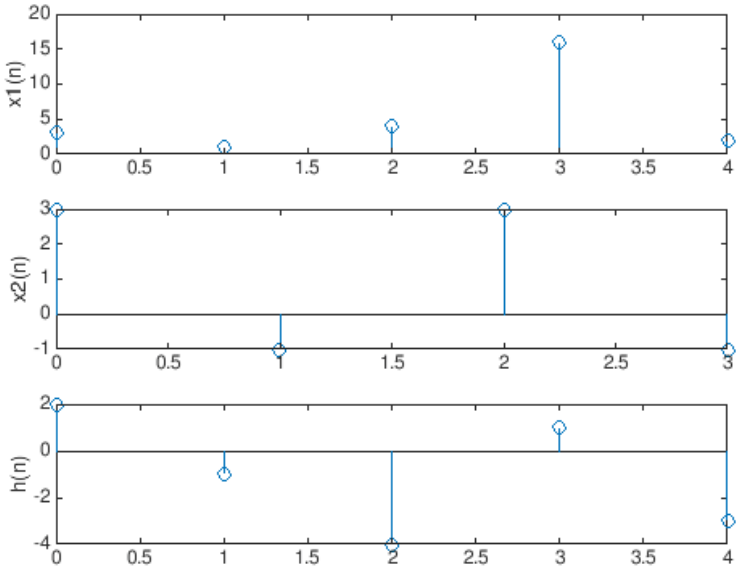
```
x1 = [3 1 4 16 2];
x2 = [3 -1 3 -1];
h = [2 -1 -4 1 -3];
y1 = conv(x1,h);
y2 = conv(x2,h);
y = y1 + [y2,0];
y
y1
```

output after verifying with convulation inbuilt function:-

y =12 -6 -10 29 -57 -55 -14 -43 -6

y1 =12 -6 -10 29 -57 -55 -14 -43 -6

```
x1 = [3 1 4 16 2];
x2 = [3 -1 3 -1];
h = [2 -1 -4 1 -3];
l=0:1:4;
subplot(311);
stem(l,x1);
m=0:1:3;
ylabel('x1(n)');
subplot(312);
stem(m,x2);
ylabel('x2(n)');
subplot(313);
stem(l,h);
ylabel('h(n)');
```



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]

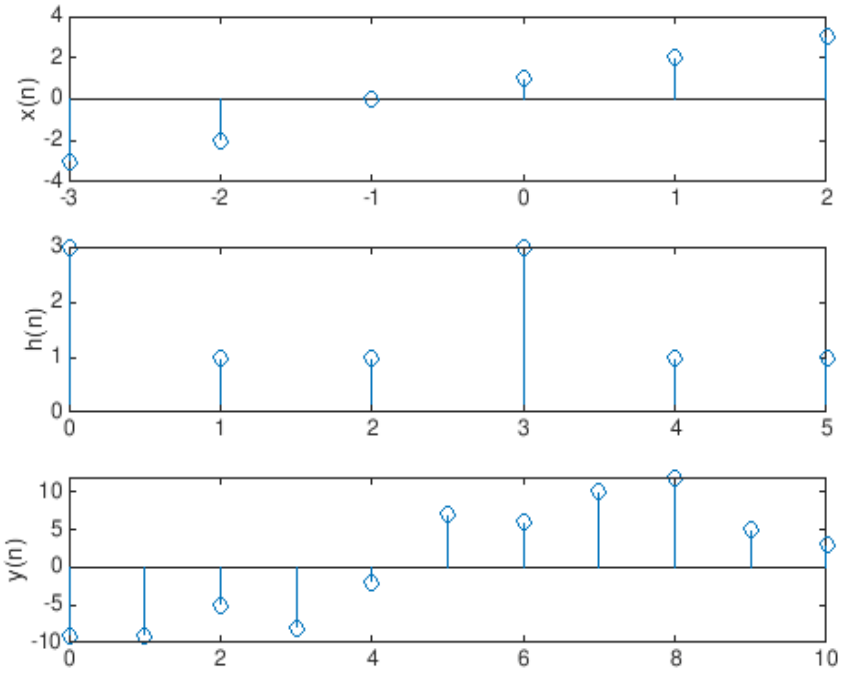
1(a) Perform the calculations using your matlab code and verify the results using the inbuilt function conv and on-paper calculations.

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

2 solution)

```
x = [-3 -2 0 1 2 3];
h = [3 1 1 3 1 1];
M = length(x);
N = length(h);
L = M + N - 1;
xe = zeros(1,L);
```

```
he = zeros(1,L);
xe(1:M) = x;
he(1:N) = h;
for n=1:L
y(n) = 0;
        for k = 1:n
                y(n) = y(n) + xe(k)*he(n - k + 1);
        end
end
l=0:1:10;
m=-3:1:2;
n=0:1:5;
subplot(311);
stem(m,x);
ylabel('x(n)');
subplot(312);
stem(n,h);
ylabel('h(n)');
subplot(313);
stem(l,y);
ylabel('y(n)');
y
```



output:-

y = -9 -9 -5 -8 -2 7 6 10 12 5 3

3. Next generate the causal signals

x[n] = {1, 2, − 3, 8, − 9}

↑

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

↑

Now, compute the ouput of the given systems

y1[n] = x[n] ∗ h[1 − n]

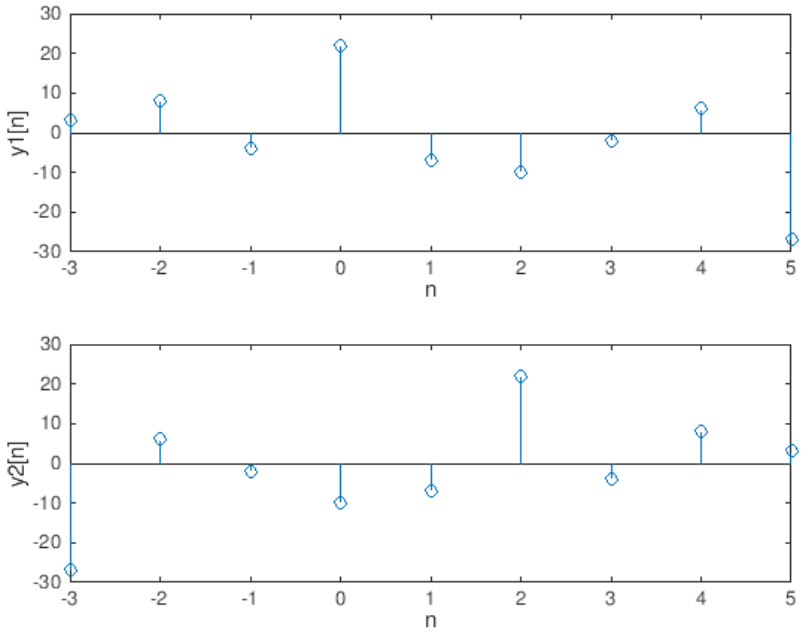
y2[n] = x[1 − n] ∗ h[n]

(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.

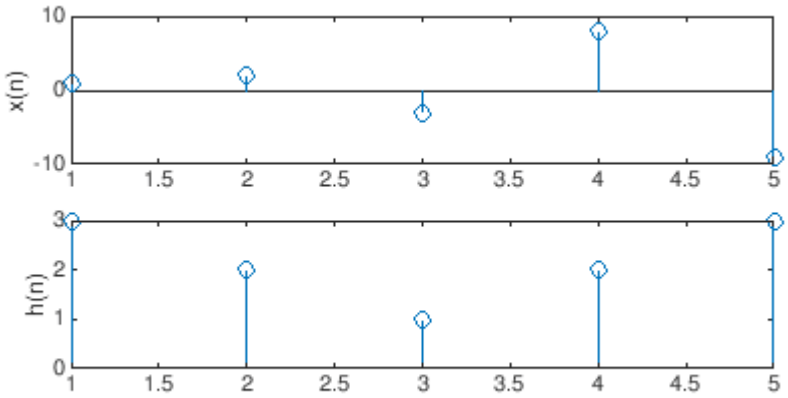
```
x = [1 2 -3 8 -9];
h = [3 2 1 2 3];
hf = fliplr(h);
xf = fliplr(x);
nk = -3:5;
M1 = length(x);
M2 = length(xf);
N1 = length(h);
N2 = length(hf);
L1 = M1 + N2 - 1;
L2 = M2 + N1 - 1;
xc1 = zeros(1,L1);
hc1 = zeros(1,L1);
xc1(1:M1) = x;
hc1(1:N2) = hf;
for n = 1:L1
        y1(n) = 0;
        for k = 1:n
                y1(n) = y1(n) + xc1(k)*hc1(n-k+1);
        end
end
xc2 = zeros(1,L2);
hc2 = zeros(1,L2);
xc2(1:M2) = xf;
hc2(1:N1) = h;
for n = 1:L2
        y2(n) = 0;
        for k = 1:n
                y2(n) = y2(n) + xc2(k)*hc2(n-k+1);
        end
end
subplot(211)
stem(nk,y1);
xlabel('n');
ylabel('y1[n]')
subplot(212)
stem(nk,y2);
xlabel('n');
ylabel('y2[n]')
y1
y2
```



output:-

y1 = 3 8 -4 22 -7 -10 -2 6 -27
y2 = -27 6 -2 -10 -7 22 -4 8 3

```
clc
clear all
close all
%%
x = [1 2 -3 8 -9];
h = [3 2 1 2 3];
subplot(311);
stem(x);
ylabel('x(n)');
subplot(312);
stem(h);
ylabel('h(n)');
```



verifying using inbuilt conv function:

```
x = [1 2 -3 8 -9];
h = [3 2 1 2 3];
hf= fliplr(h);
xf= fliplr(x);
y = conv(x,hf);
y1 = conv(xf,h);
y
y1
```

output when using convulation inbuilt function:-

y = 3 8 -4 22 -7 -10 -2 6 -27
y1 = -27 6 -2 -10 -7 22 -4 8 3

solution for all the questions (rough work)

1) $x_1[n] = \{3, 1, 4, 16, 2\}$ $\quad x_2[n] = \{3, -1, 3, -1\}$

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

$x_1[n] * h[n] =$

	3	1	4	16	2
2	6	2	8	32	4
-1	-3	-1	-4	-16	-2
-4	-12	-4	-16	-64	-8
1	3	1	4	16	2
-3	-9	-3	-12	-48	-6

$= \{6, -1, -5, 27, -36, -65, -4, -46, -6\}$

$x_2[n] * h[n] =$

	3	-1	3	-1
2	6	-2	6	-2
-1	-3	1	-3	1
-4	-12	4	-12	4
1	3	-1	3	-1
-3	-9	3	-9	3

$= \{6, -5, -5, 2, -21, 10, -10, 3\}$

$x[n] = x_1[n] + x_2[n] = \{6, 0, 7, 15, 2\}$

(*) $y_1[n] = (x_1[n] + x_2[n]) * h[n]$

$= x[n] * h[n]$

	6	0	7	15	2
2	12	0	14	30	4
-1	-6	0	-7	15	-2
-4	-24	0	-28	-60	-8
1	6	0	7	-15	2
-3	-18	0	-21	-45	-6

$= \{12, -6, -10, 29, -57, -55, -14, -43, -6\}$

(*) $y_2[n] = x_1[n] * h[n] + x_2[n] * h[n]$

$= \{12, -6, -10, 29, -57, -55, -14, -43, -6\}$

2) $x[n] = \{-3, -2, 0, \underset{\uparrow}{1}, 2, 3\} \Rightarrow x[n-3] = \{\underset{\uparrow}{-3}, -2, 0, 1, 2, 3\}$

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

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

	-3	-2	0	1	2	3
3	-9	-6	0	3	6	9
1	-3	-2	0	1	2	3
1	-3	-2	0	1	2	3
3	-9	-6	0	3	6	9
1	-3	-2	0	1	2	3
1	-3	-2	0	1	2	3

$y[n] = \{\underset{\uparrow}{-9}, -9, -5, -8, -2, 7, 6, 10, 12, 5, 3\}$

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

$h[n] = \{\underset{\uparrow}{3}, 2, 1, 2, 3\} \longrightarrow h[1-n] = \{3, 2, 1, 2, \underset{\uparrow}{3}\}$

$y_1[n] = x[n] * h[1-n]$

	1	2	-3	8	-9
3	3	6	-9	24	-27
2	2	4	-6	16	-18
1	1	2	-3	8	-9
2	2	4	-6	16	-18
3	3	6	-9	24	-27

$y_1[n] = \{3, 8, -4, \underset{\uparrow}{22}, -7, -10, -2, 6, -27\}$

$y_2[n] = x[1-n] * h[n]$

	-9	8	-3	2	1
3	-27	24	-9	6	3
2	-18	16	-6	4	2
1	-9	8	-3	2	1
2	-18	16	-6	4	2
3	-27	24	-9	6	3

$y_2[n] = \{-27, 6, -2, \underset{\uparrow}{-10}, -7, 22, -4, 8, 3\}$

here $y_1[n] \neq y_2[n]$