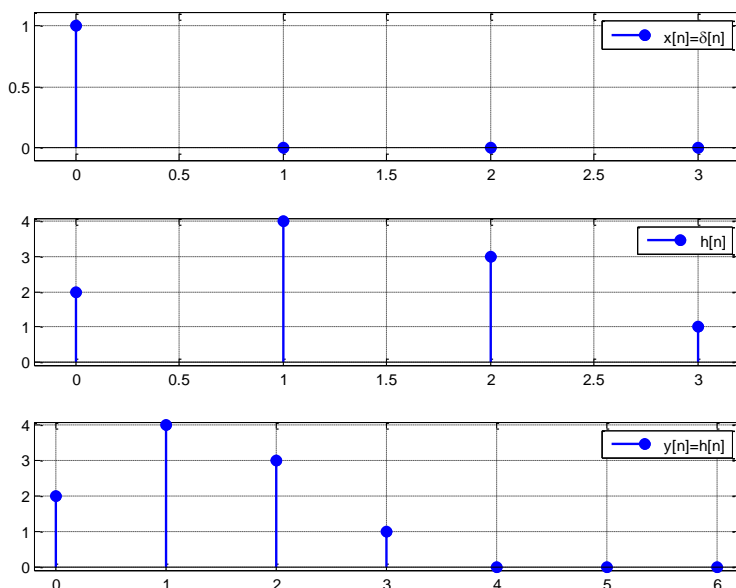


Lab 6

PRE-LAB

The Unit Impulse Sequence as Input to a System:

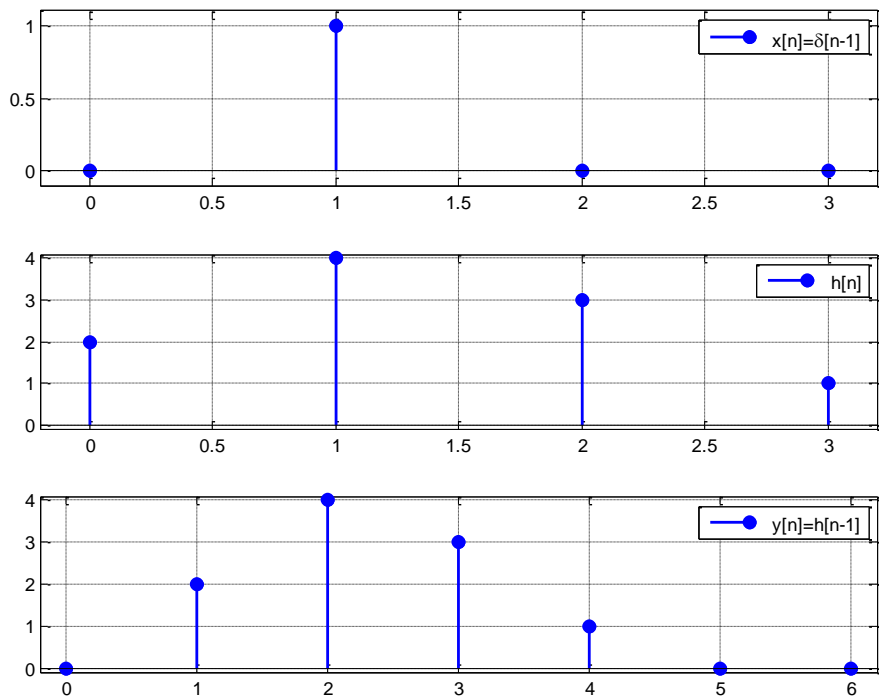
```
%input signal
x=[1 0 0 0];
n=0:3;
subplot(3,1,1)
stem(n,x,'fill','linewidth',2),grid on
axis([-0.2 3.2 -0.1 1.1])
legend('x[n]=\delta[n]')
%impulse response
h=[2 4 3 1];
n=0:3;
subplot(3,1,2)
stem(n,h,'fill','linewidth',2),grid on
axis([-0.2 3.2 -0.1 4.1])
legend('h[n]')
%output y[n]
y=conv(x,h);
subplot(3,1,3)
n=0:6;
stem(n,y,'fill','linewidth',2),grid on
axis([-0.2 6.2 -0.1 4.1])
legend('y[n]=h[n]')
```



```
Editor - C:\Users\ naveed\ Desko...
File Edit Text Go Cell Tools
1 %input signal
2 x=[1 0 0 0];
3 n=0:3;
4 subplot(3,1,1)
5 stem(n,x,'fill','linewidth',2),grid on
6 axis([-0.2 3.2 -0.1 1.1])
7 legend('x[n]=\delta[n]')
8 %impulse response
9 h=[2 4 3 1];
10 n=0:3;
11 subplot(3,1,2)
12 stem(n,h,'fill','linewidth',2),grid on
13 axis([-0.2 3.2 -0.1 4.1])
14 legend('h[n]')
15 %output y[n]
16 y=conv(x,h);
17 subplot(3,1,3)
18 n=0:6;
19 stem(n,y,'fill','linewidth',2),grid on
20 axis([-0.2 6.2 -0.1 4.1])
21 legend('y[n]=h[n]')
22
23
```

Linear and shift invariant system:

```
x=[0 1 0 0];
n=0:3;
subplot(3,1,1)
stem(n,x,'fill','linewidth',2),grid on
axis([-0.2 3.2 -0.1 1.1])
legend('x[n]=\delta[n-1]')
%impulse response
h=[2 4 3 1];
n=0:3;
subplot(3,1,2)
stem(n,h,'fill','linewidth',2),grid on
axis([-0.2 3.2 -0.1 4.1])
legend('h[n]')
%output response: impulse response shifted by 1 unit to the right
y=conv(x,h);
subplot(3,1,3)
stem(0:6,y,'fill','linewidth',2),grid on
axis([-0.2 6.2 -0.1 4.1])
legend('y[n]=h[n-1]')
```

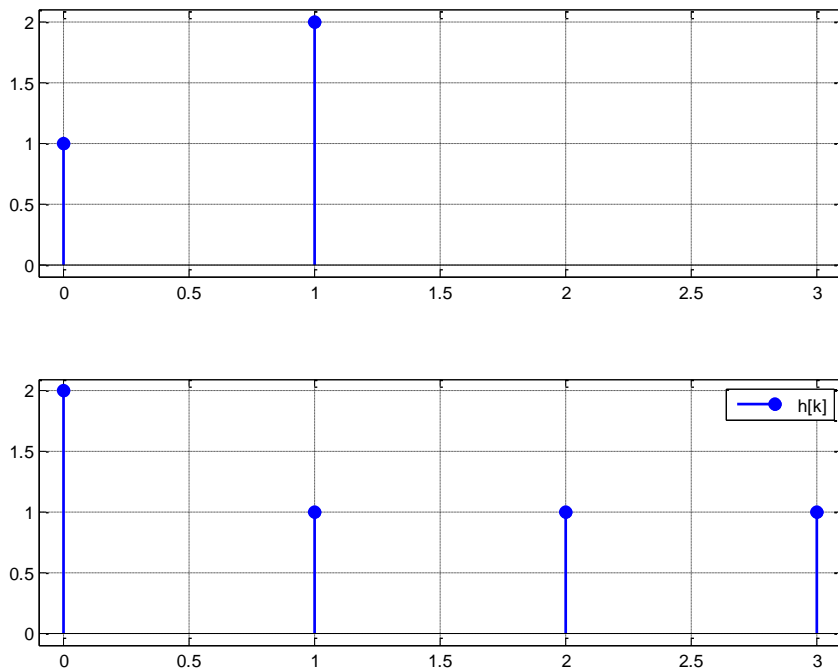


```
23 - x=[0 1 0 0];
24 - n=0:3;
25 - subplot(3,1,1)
26 - stem(n,x,'fill','linewidth',2),grid on
27 - axis([-0.2 3.2 -0.1 1.1])
28 - legend('x[n]=\delta[n-1]')
29 - %impulse response
30 - h=[2 4 3 1];
31 - n=0:3;
32 - subplot(3,1,2)
33 - stem(n,h,'fill','linewidth',2),grid on
34 - axis([-0.2 3.2 -0.1 4.1])
35 - legend('h[n]')
36 - %output response: impulse response shifted by 1 unit to the right
37 - y=conv(x,h);
38 - subplot(3,1,3)
39 - stem(0:6,y,'fill','linewidth',2),grid on
40 - axis([-0.2 6.2 -0.1 4.1])
41 - legend('y[n]=h[n-1]')
42 -
43 -
```

Computation of Discrete Time Convolution:

Step 1: The two signals are plotted at the k -axis.

```
%input signal x[k]
kx=[0 1];
x=[1 2];
subplot(2,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-0.1 3.1 -0.1 2.1])
%impulse response signal h[k]
kh=0:3;
h=[2 1 1 1];
subplot(2,1,2)
stem(kh,h,'fill','linewidth',2),grid on
axis([-0.1 3.1 -0.1 2.1])
legend('h[k]')
```



```
43 %input signal x[k]
44 kx=[0 1];
45 x=[1 2];
46 subplot(2,1,1)
47 stem(kx,x,'fill','linewidth',2),
48 axis([-0.1 3.1 -0.1 2.1])
49 %impulse response signal h[k]
50 kh=0:3;
51 h=[2 1 1 1];
52 subplot(2,1,2)
53 stem(kh,h,'fill','linewidth',2),
54 axis([-0.1 3.1 -0.1 2.1])
55 legend('h[k]')
56
```

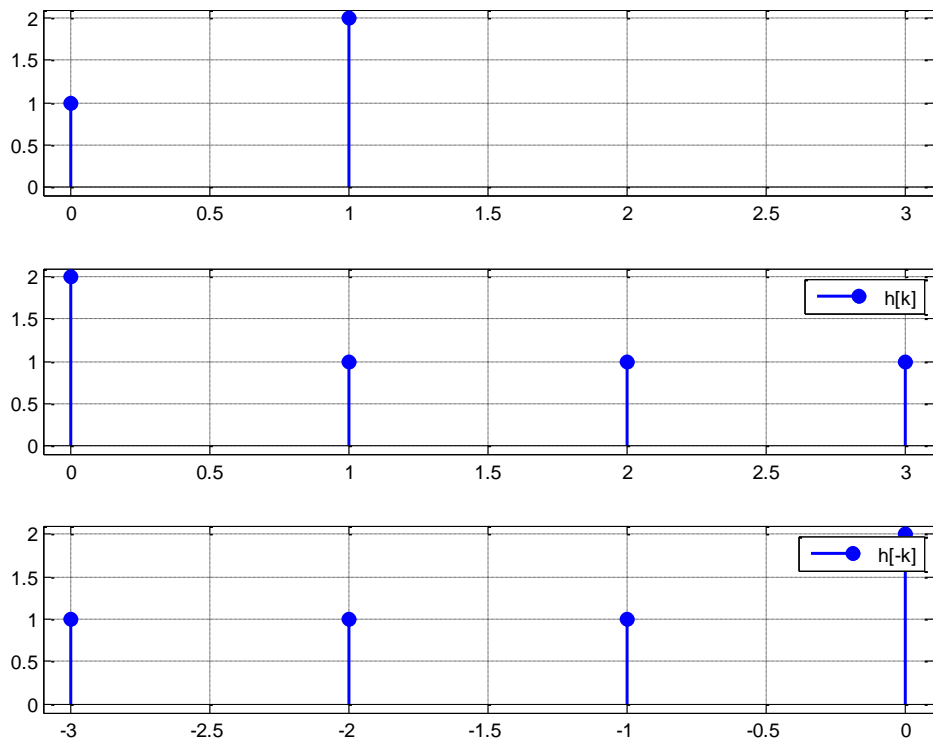
Step 2: The reflected version of $h[k]$, namely, $h[-k]$ is plotted.

```
%input signal x[k]
kx=[0 1];
x=[1 2];
subplot(3,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-0.1 3.1 -0.1 2.1])
```

```

%impulse response signal h[k]
kh=0:3;
h=[2 1 1 1];
subplot(3,1,2)
stem(kh,h,'fill','linewidth',2),grid on
axis([-0.1 3.1 -0.1 2.1])
legend('h[k]')
%The reflected signal h[-k]
subplot(3,1,3)
stem(-kh,h,'fill','linewidth',2) ,grid on
axis([-3.1 0.1 -0.1 2.1])
legend('h[-k]')

```



```

13
14 %input signal x[k]
15 kx=[0 1];
16 x=[1 2];
17 subplot(3,1,1)
18 stem(kx,x,'fill','linewidth',2)
19 axis([-0.1 3.1 -0.1 2.1])
20 %impulse response signal h[k]
21 kh=0:3;
22 h=[2 1 1 1];
23 subplot(3,1,2)
24 stem(kh,h,'fill','linewidth',2)
25 axis([-0.1 3.1 -0.1 2.1])
26 legend('h[k]')
27 %The reflected signal h[-k]
28 subplot(3,1,3)
29 stem(-kh,h,'fill','linewidth',2)
30 axis([-3.1 0.1 -0.1 2.1])
31 legend('h[-k]')
32
33

```

Step 3: The signal $h[n-k]$ is shifted from $-\infty$ to $+\infty$ by changing appropriately the value of n . There are three stages, first there is zero overlap, next there is overlap and finally there is no overlap.

- First Stage: Zero Overlap. The stage occurs for $n \leq -1$.

```

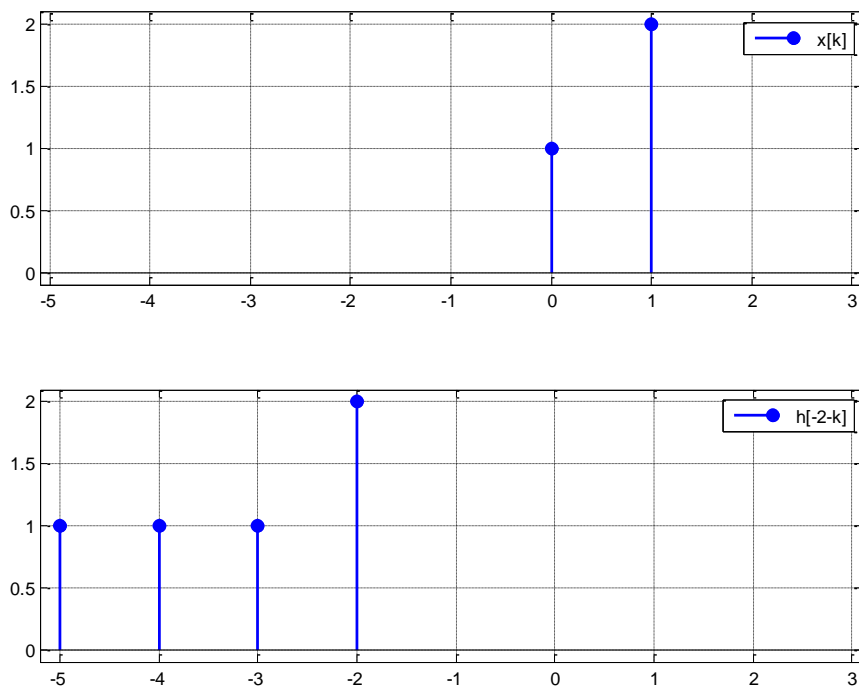
kx=[0 1];
x=[1 2];
kh=0:3;

```

```

h=[2 1 1 1];
%input signal x[k]
subplot(2,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-5.1 3.1 -0.1 2.1])
legend('x[k]')
%impulse response signal h[n-k] for n=-2
n=-2;
subplot(2,1,2)
stem(-kh+n,h,'fill','linewidth',2), grid on
axis([-5.2 3.1 -0.1 2.1])
legend('h[-2-k]')

```



```

62 -
63 - kx=[0 1];
64 - x=[1 2];
65 - kh=0:3;
66 - h=[2 1 1 1];
67 - %input signal x[k]
68 - subplot(2,1,1)
69 - stem(kx,x,'fill','linewidth',2),grid on
70 - axis([-5.1 3.1 -0.1 2.1])
71 - legend('x[k]')
72 - %impulse response signal h[n-k] for n=-2
73 - n=-2;
74 - subplot(2,1,2)
75 - stem(-kh+n,h,'fill','linewidth',2), grid on
76 - axis([-5.2 3.1 -0.1 2.1])
77 - legend('h[-2-k]')
78 -
79 -

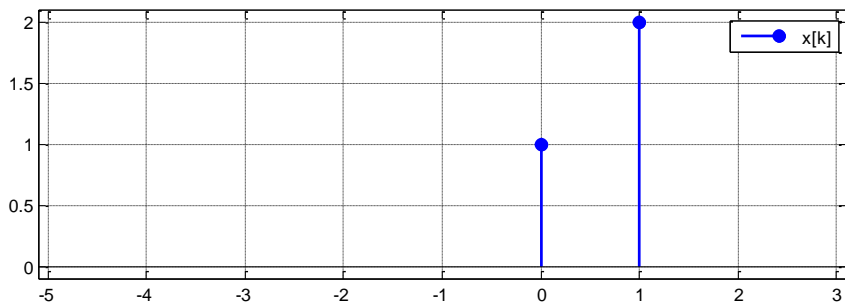
```

Obviously the two signals do not overlap. Thus the output is $y[n] = 0, n \leq -1$.

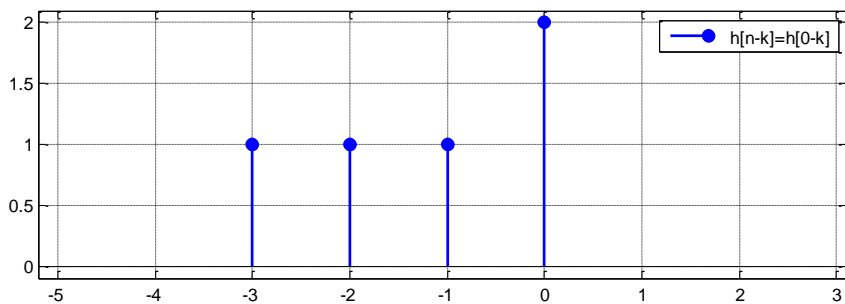
- Second Stage: Overlap. The signals $x[n]$ and $h[n-k]$ overlap for $0 \leq n \leq 4$.

For n=0:

```
kx=[0 1];
x=[1 2];
kh=0:3;
h=[2 1 1 1];
subplot(2,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-5.1 3.1 -0.1 2.1])
legend('x[k]')
n=0;
subplot(2,1,2)
stem(-kh+n,h,'fill','linewidth',2),grid on
axis([-5.2 3.1 -0.1 2.1])
legend('h[n-k]=h[0-k]')
```



$X[k]=1;$



$h[n-k]=2$

$y[0] = (1)(2) = 2$

```
8
9 - kx=[0 1];
0 - x=[1 2];
1 - kh=0:3;
2 - h=[2 1 1 1];
3 - subplot(2,1,1)
4 - stem(kx,x,'fill','linewidth',2),grid on
5 - axis([-5.1 3.1 -0.1 2.1])
6 - legend('x[k]')
7 - n=0;
8 - subplot(2,1,2)
9 - stem(-kh+n,h,'fill','linewidth',2),grid
0 - axis([-5.2 3.1 -0.1 2.1])
1 - legend('h[n-k]=h[0-k]')
2
3
4
```

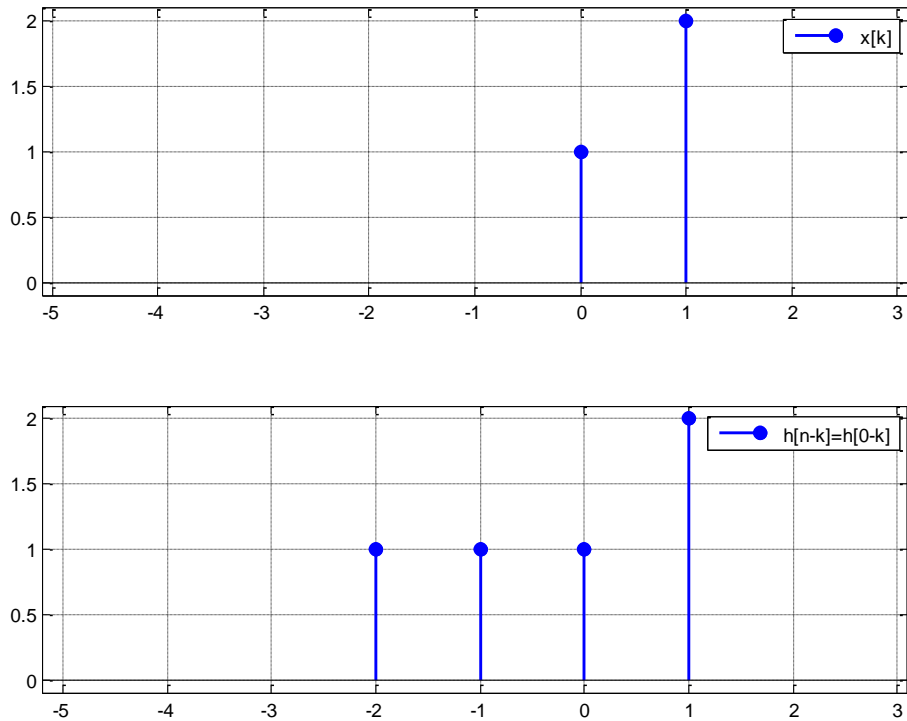
For n=1:

```
kx=[0 1];
x=[1 2];
kh=0:3;
h=[2 1 1 1];
subplot(2,1,1)
```

```

stem(kx,x,'fill','linewidth',2),grid on
axis([-5.1 3.1 -0.1 2.1])
legend('x[k]')
n=1;
subplot(2,1,2)
stem(-kh+n,h,'fill','linewidth',2),grid on
axis([-5.2 3.1 -0.1 2.1])
legend('h[n-k]=h[0-k]')

```



```

78
79 -   kx=[0 1];
80 -   x=[1 2];
81 -   kh=0:3;
82 -   h=[2 1 1 1];
83 -   subplot(2,1,1)
84 -   stem(kx,x,'fill','linewidth',2),grid on
85 -   axis([-5.1 3.1 -0.1 2.1])
86 -   legend('x[k]')
87 -   n=1;
88 -   subplot(2,1,2)
89 -   stem(-kh+n,h,'fill','linewidth',2),grid on
90 -   axis([-5.2 3.1 -0.1 2.1])
91 -   legend('h[n-k]=h[0-k]')
92
93

```

$$y[1] = (2)(2) + (1)(1) = 5$$

For n=2:

```

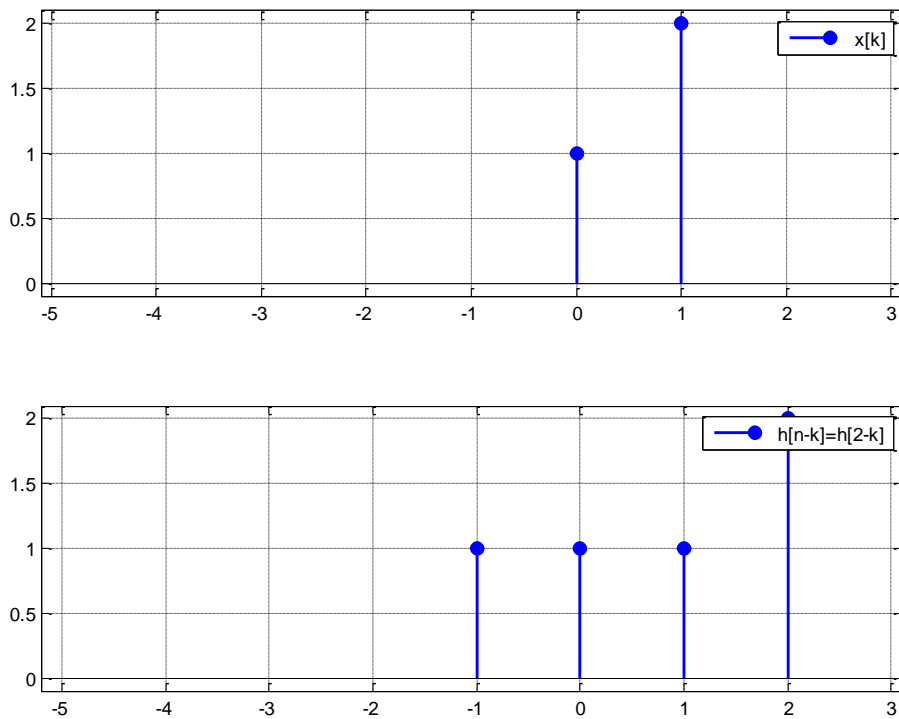
kx=[0 1];
x=[1 2];
kh=0:3;

```

```

h=[2 1 1 1];
subplot(2,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-5.1 3.1 -0.1 2.1])
legend('x[k]')
n=2;
subplot(2,1,2)
stem(-kh+n,h,'fill','linewidth',2),grid on
axis([-5.2 3.1 -0.1 2.1])
legend('h[n-k]=h[2-k]')

```



```

70
79 - kx=[0 1];
80 - x=[1 2];
81 - kh=0:3;
82 - h=[2 1 1 1];
83 - subplot(2,1,1)
84 - stem(kx,x,'fill','linewidth',2),grid on
85 - axis([-5.1 3.1 -0.1 2.1])
86 - legend('x[k]')
87 - n=2;
88 - subplot(2,1,2)
89 - stem(-kh+n,h,'fill','linewidth',2),grid on
90 - axis([-5.2 3.1 -0.1 2.1])
91 - legend('h[n-k]=h[2-k]')
92
93
94
95

```

$$y[2] = (2)(1) + (1)(1) = 3$$

For n=3:

```

kx=[0 1];
x=[1 2];

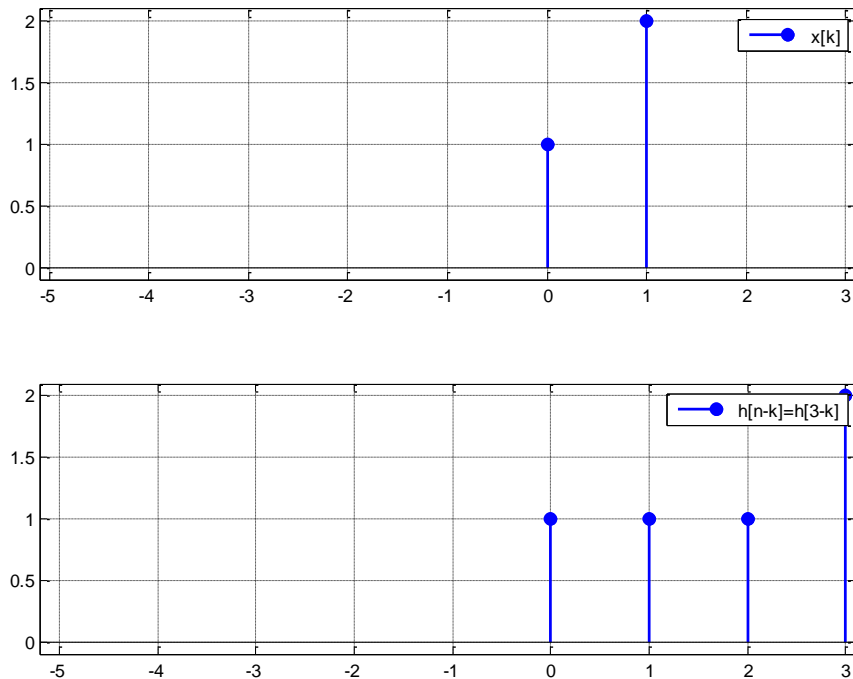
```



```

kh=0:3;
h=[2 1 1 1];
subplot(2,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-5.1 3.1 -0.1 2.1])
legend('x[k]')
n=3;
subplot(2,1,2)
stem(-kh+n,h,'fill','linewidth',2),grid on
axis([-5.2 3.1 -0.1 2.1])
legend('h[n-k]=h[3-k]')

```



```

78
79 -   kx=[0 1];
80 -   x=[1 2];
81 -   kh=0:3;
82 -   h=[2 1 1 1];
83 -   subplot(2,1,1)
84 -   stem(kx,x,'fill','linewidth',2),grid on
85 -   axis([-5.1 3.1 -0.1 2.1])
86 -   legend('x[k]')
87 -   n=3;
88 -   subplot(2,1,2)
89 -   stem(-kh+n,h,'fill','linewidth',2),grid on
90 -   axis([-5.2 3.1 -0.1 2.1])
91 -   legend('h[n-k]=h[3-k]')
92
93
94

```

$$y[3] = (2)(1) + (1)(1) = 3.$$

For n=4:

```

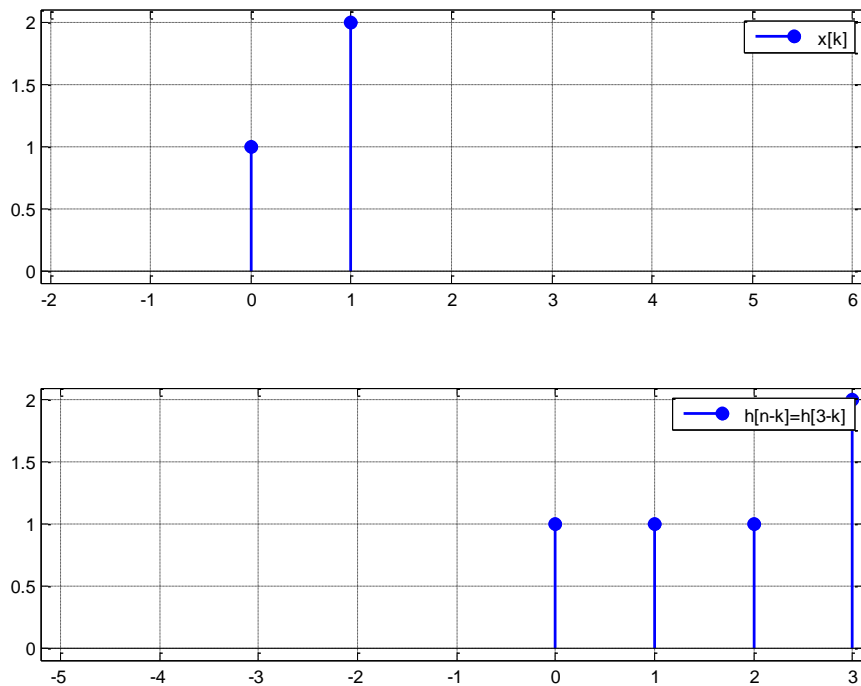
kx=[0 1];
x=[1 2];
kh=0:3;
h=[2 1 1 1];

```

```

subplot(2,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-2.1 6.1 -0.1 2.1])
legend('x[k]')
n=4;
subplot(2,1,2)
stem(-kh+n,h,'fill','linewidth',2),grid on
axis([-2.1 6.1 -0.1 2.1])
legend('h[n-k]=h[4-k]')

```



```

78
79 -   kx=[0 1];
80 -   x=[1 2];
81 -   kh=0:3;
82 -   h=[2 1 1 1];
83 -   subplot(2,1,1)
84 -   stem(kx,x,'fill','linewidth',2),grid on
85 -   axis([-2.1 6.1 -0.1 2.1])
86 -   legend('x[k]')
87 -   n=4;
88 -   subplot(2,1,2)
89 -   stem(-kh+n,h,'fill','linewidth',2),grid on
90 -   axis([-2.1 6.1 -0.1 2.1])
91 -   legend('h[n-k]=h[4-k]')
92
93
94
95
96
97
--

```

- Third Stage: Zero

Overlap. For $n \geq 5$, the input and impulse response signals do not overlap, hence $y[n] = 0, n \geq 5$.

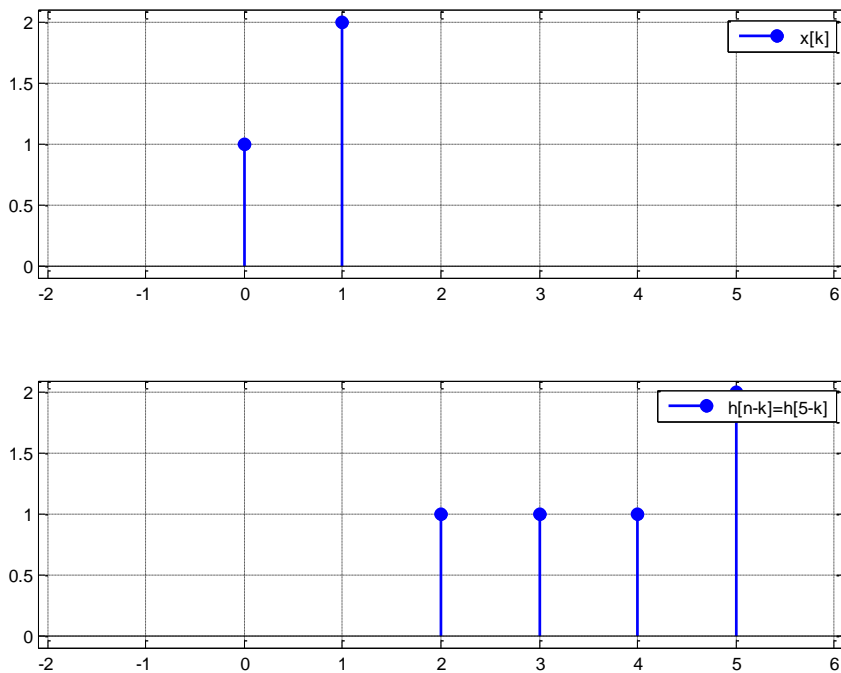
For n=5:

```

kx=[0 1];
x=[1 2];
kh=0:3;
h=[2 1 1 1];
subplot(2,1,1)
stem(kx,x,'fill','linewidth',2),grid on
axis([-2.1 6.1 -0.1 2.1])
legend('x[k]')
n=5;
subplot(2,1,2)
stem(-kh+n,h,'fill','linewidth',2),grid on
axis([-2.1 6.1 -0.1 2.1])

```

```
legend('h[n-k]=h[5-k]')
```



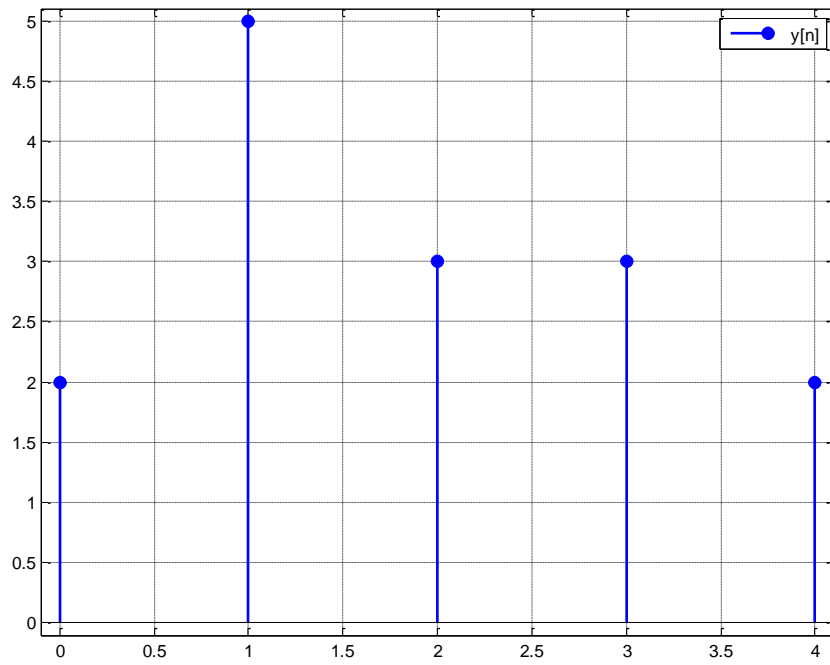
```
78
79 -   kx=[0 1];
80 -   x=[1 2];
81 -   kh=0:3;
82 -   h=[2 1 1 1];
83 -   subplot(2,1,1)
84 -   stem(kx,x,'fill','linewidth',2),grid on
85 -   axis([-2.1 6.1 -0.1 2.1])
86 -   legend('x[k]')
87 -   n=5;
88 -   subplot(2,1,2)
89 -   stem(-kh+n,h,'fill','linewidth',2),grid on
90 -   axis([-2.1 6.1 -0.1 2.1])
91 -   legend('h[n-k]=h[5-k]')
```

Combining the derived results we conclude that the response of the system with impulse response $h[n]=[2 \ 1 \ 1 \ 1]$, $0 \leq n \leq 3$ to the input signal $x[n]=[1 \ 2]$, $0 \leq n \leq 1$ is $y[n]=[2 \ 5 \ 3 \ 3 \ 2]$, $0 \leq n \leq 4$.

Output:

```
n=0:4;
y=[2 5 3 3 2];
stem(n,y,'fill','linewidth',2),grid on
axis([-0.1 4.1 -0.1 5.1])
```

`legend('y[n]')`



```
93
94 - n=0:4;
95 - y=[2 5 3 3 2];
96 - stem(n,y,'fill','linewidth',2),grid on
97 - axis([-0.1 4.1 -0.1 5.1])
98 - legend('y[n]')
99
100
```

THE END