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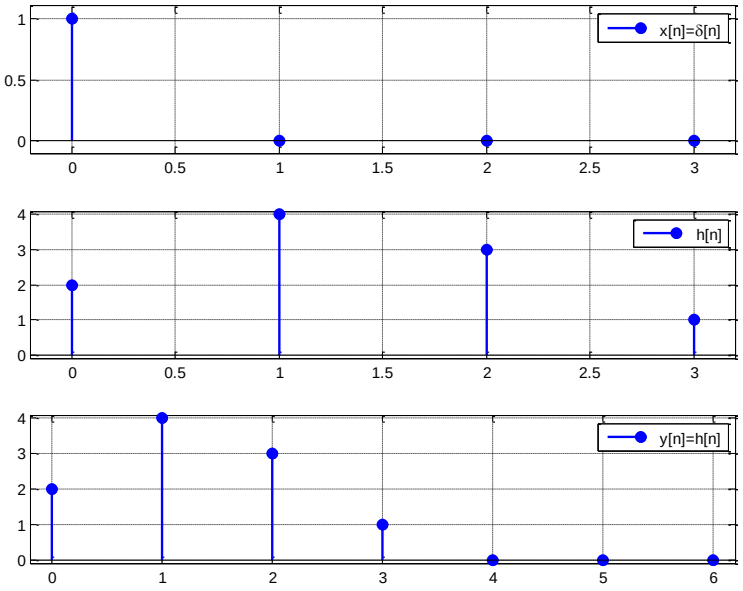
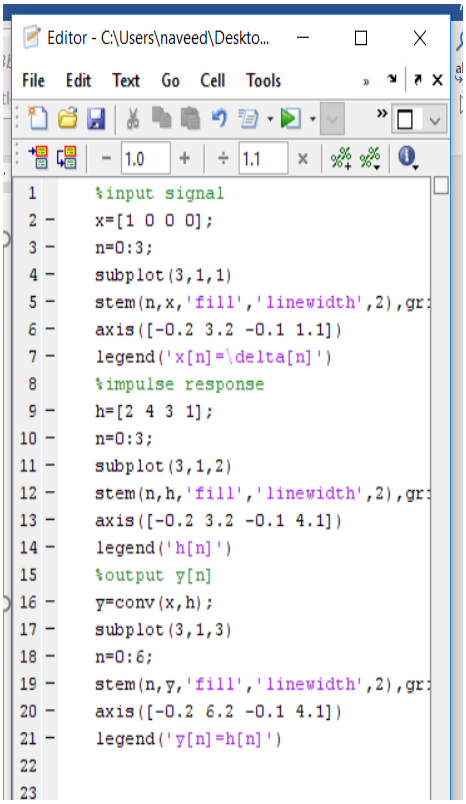
Lab 6

PRE-LAB

The Unit Impulse Sequence as Input to a System:

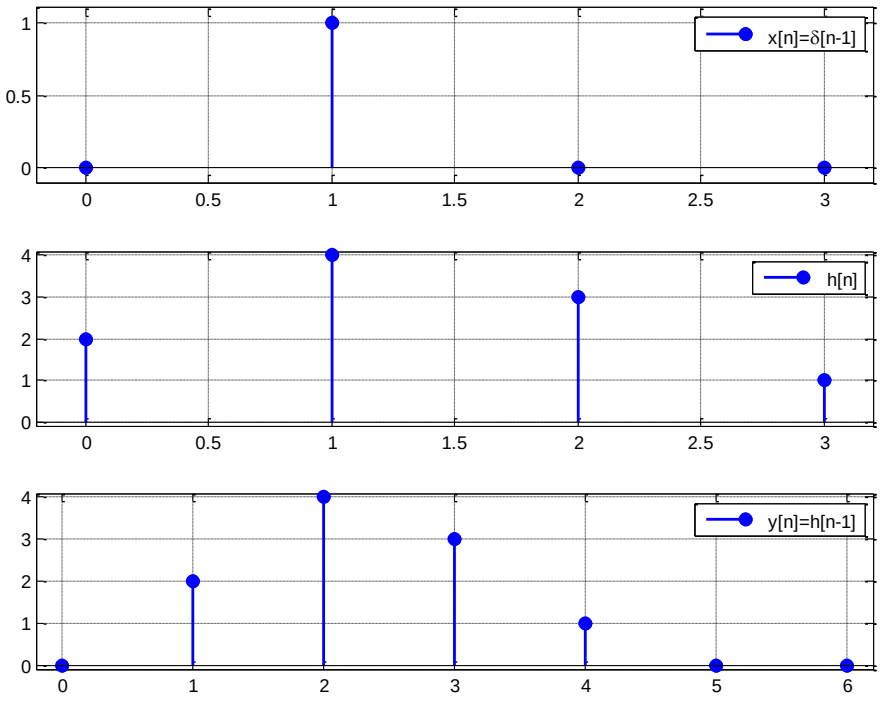
```
%input signal
x=[1 0 0 0];
n=0:3;
subplot(3,1,1)
stem(n,x,'fill','linewidth',2),grid on
axis([-0.2 3.2 -0.1 1.1])
legend('x[n]=\delta[n]')
%impulse response
h=[2 4 3 1];
n=0:3;
subplot(3,1,2)
stem(n,h,'fill','linewidth',2),grid on
axis([-0.2 3.2 -0.1 4.1])
legend('h[n]')
%output y[n]
y=conv(x,h);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

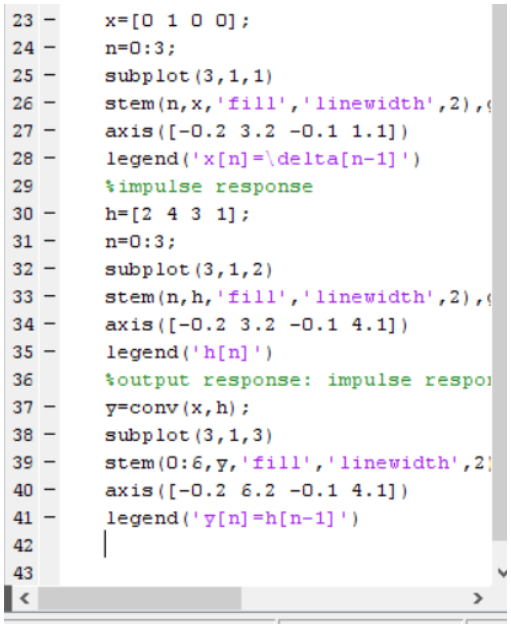




Linear and shift invariant system:

```
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]')
```

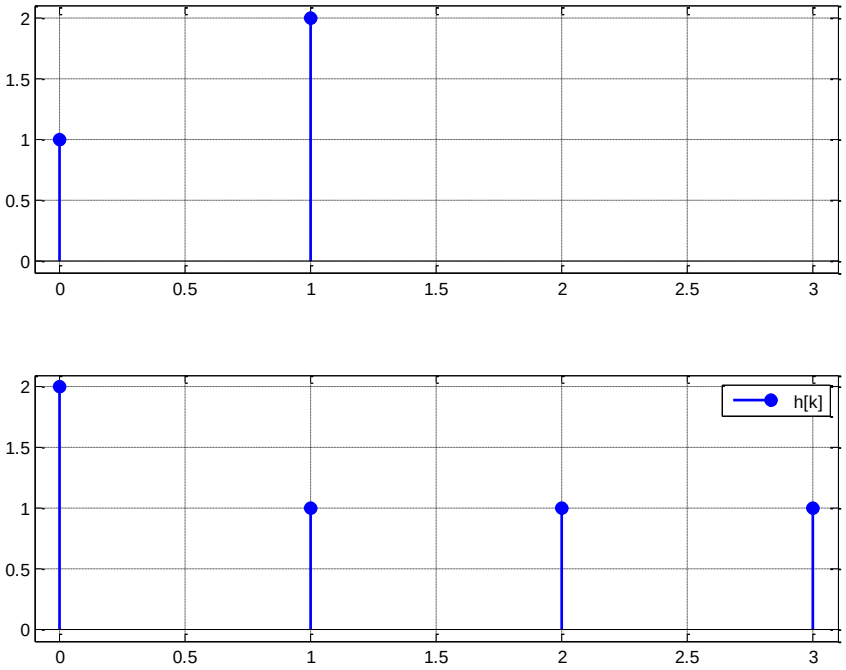




Computation of Discrete Time Convolution:

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]')
```

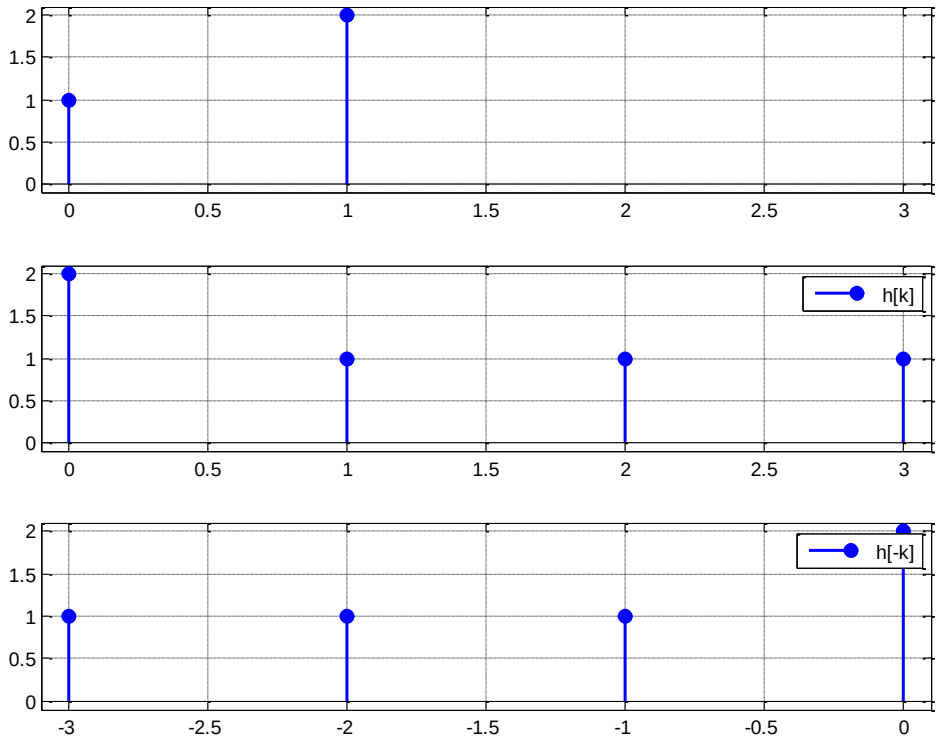



```
43    %input signal x[k]
44 -  kx=[0 1];
45 -  x=[1 2];
46 -  subplot(2,1,1)
47 -  stem(kx,x,'fill','linewidth',2),
48 -  axis([-0.1 3.1 -0.1 2.1])
49    %impulse response signal h[k]
50 -  kh=0:3;
51 -  h=[2 1 1 1];
52 -  subplot(2,1,2)
53 -  stem(kh,h,'fill','linewidth',2),
54 -  axis([-0.1 3.1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



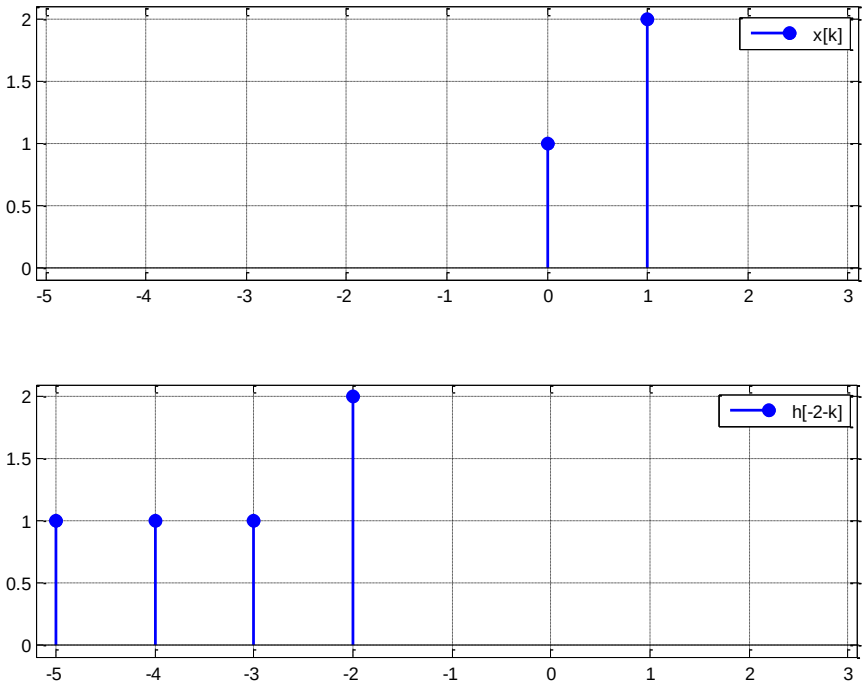

```
%input signal x[k]
kx=[0 1];
x=[1 2];
subplot(3,1,1)
stem(kx,x,'fill','linewidth',2),
axis([-0.1 3.1 -0.1 2.1])
%impulse response signal h[k]
kh=0:3;
h=[2 1 1 1];
subplot(3,1,2)
stem(kh,h,'fill','linewidth',2),
axis([-0.1 3.1 -0.1 2.1])
legend('h[k]')
%The reflected signal h[-k]
subplot(3,1,3)
stem(-kh,h,'fill','linewidth',2)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

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]')
```



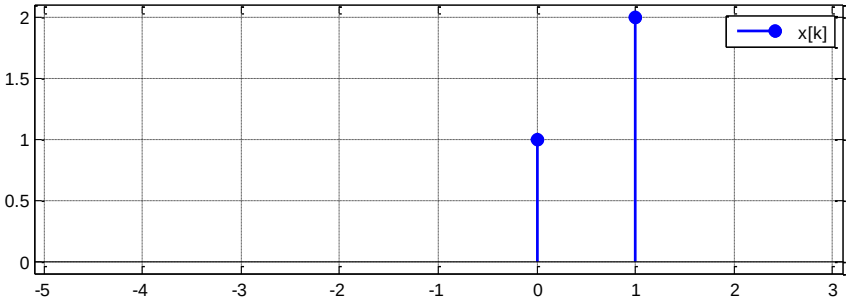

```
63 -  kx=[0 1];
64 -  x=[1 2];
65 -  kh=0:3;
66 -  h=[2 1 1 1];
67    %input signal x[k]
68 -  subplot(2,1,1)
69 -  stem(kx,x,'fill','linewidth',2),grid on
70 -  axis([-5.1 3.1 -0.1 2.1])
71 -  legend('x[k]')
72    %impulse response signal h[n-k] for n=-2
73 -  n=-2;
74 -  subplot(2,1,2)
75 -  stem(-kh+n,h,'fill','linewidth',2),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

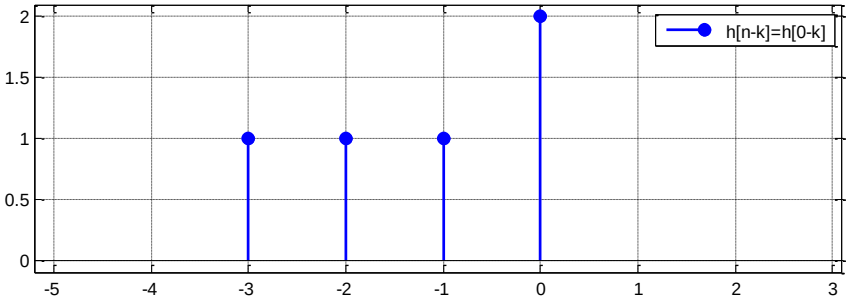
- Second Stage: Overlap. The signals $x[n]$ and $h[n-k]$ overlap for $0 \le n \le 4$.

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;




```
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
```

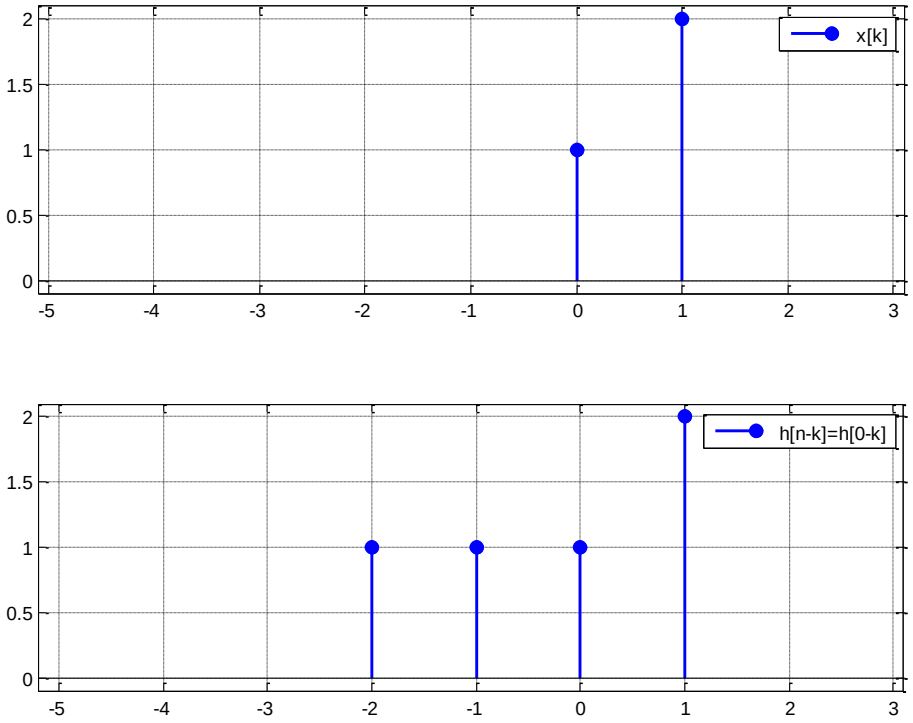
h[n-k]=2

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

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]')
```



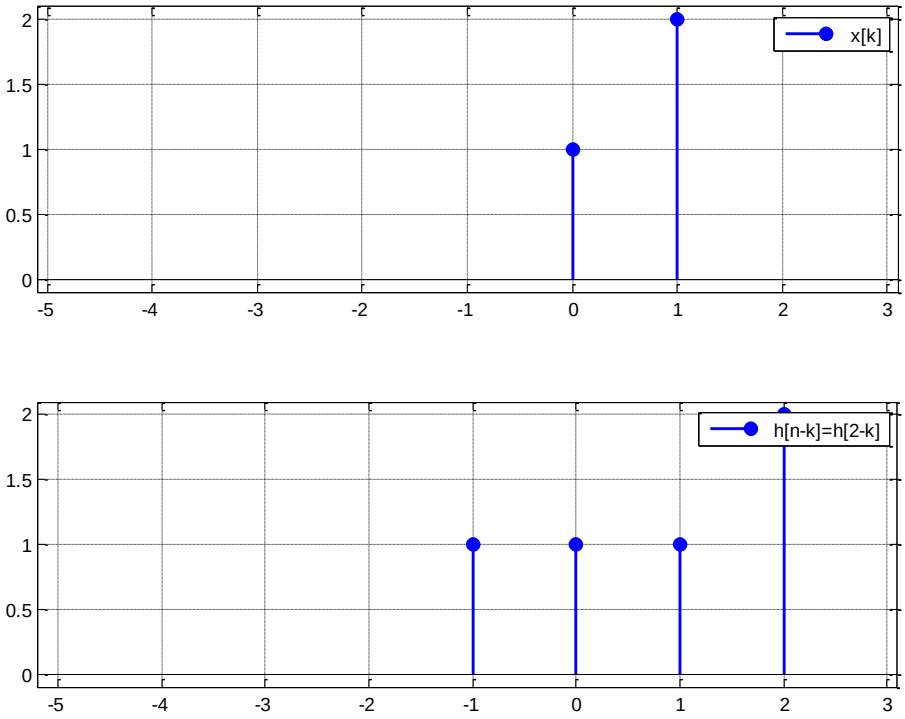

```
78
79 -    kx=[0 1];
80 -    x=[1 2];
81 -    kh=0:3;
82 -    h=[2 1 1 1];
83 -    subplot(2,1,1)
84 -    stem(kx,x,'fill','linewidth',2),grid or
85 -    axis([-5.1 3.1 -0.1 2.1])
86 -    legend('x[k]')
87 -    n=1;
88 -    subplot(2,1,2)
89 -    stem(-kh+n,h,'fill','linewidth',2),grid
90 -    axis([-5.2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



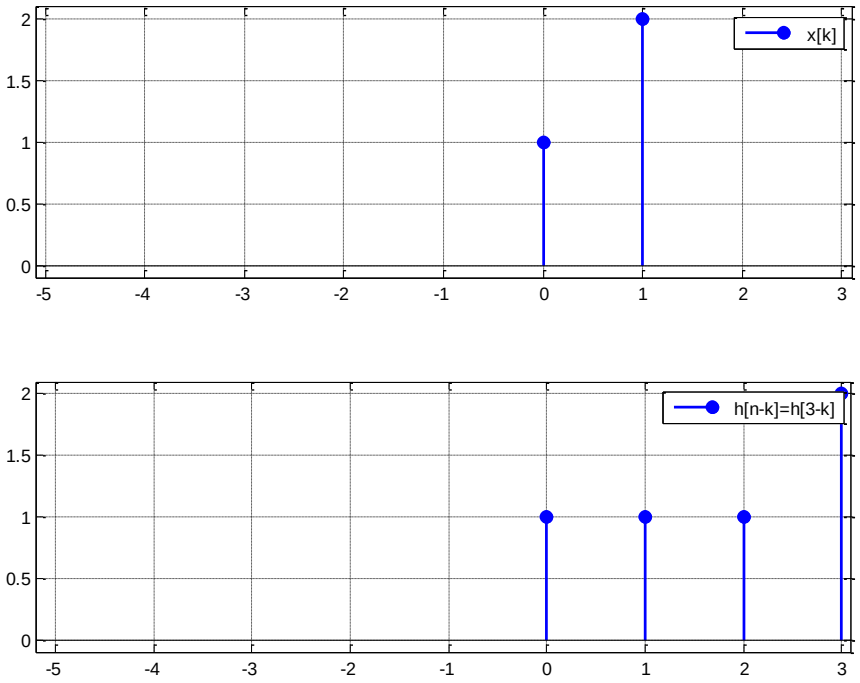

```
79 -  kx=[0 1];
80 -  x=[1 2];
81 -  kh=0:3;
82 -  h=[2 1 1 1];
83 -  subplot(2,1,1)
84 -  stem(kx,x,'fill','linewidth',2),grid or
85 -  axis([-5.1 3.1 -0.1 2.1])
86 -  legend('x[k]')
87 -  n=2;
88 -  subplot(2,1,2)
89 -  stem(-kh+n,h,'fill','linewidth',2),grid
90 -  axis([-5.2 3.1 -0.1 2.1])
91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



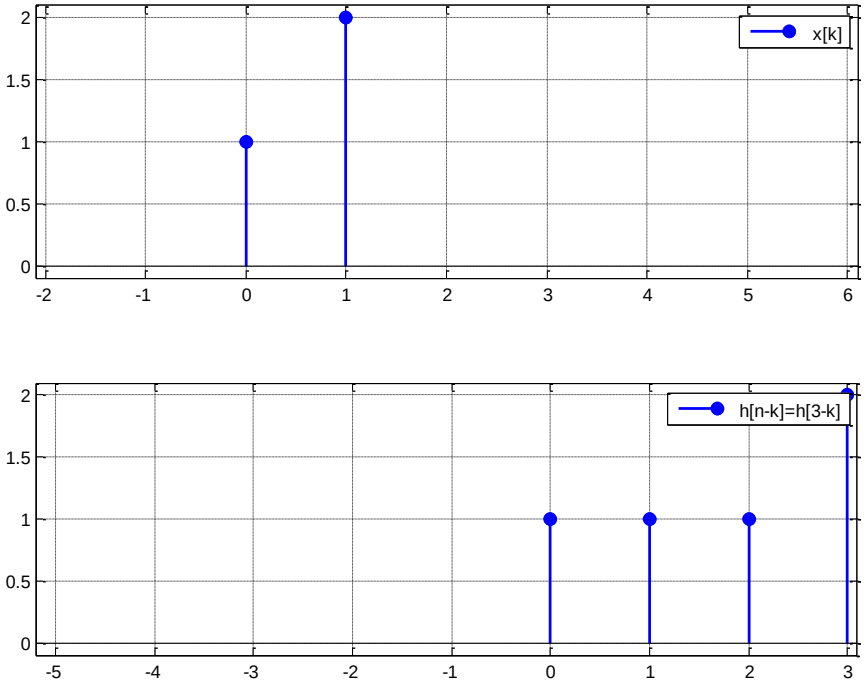

```
78
79 -    kx=[0 1];
80 -    x=[1 2];
81 -    kh=0:3;
82 -    h=[2 1 1 1];
83 -    subplot(2,1,1)
84 -    stem(kx,x,'fill','linewidth',2),grid or
85 -    axis([-5.1 3.1 -0.1 2.1])
86 -    legend('x[k]')
87 -    n=3;
88 -    subplot(2,1,2)
89 -    stem(-kh+n,h,'fill','linewidth',2),grid
90 -    axis([-5.2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



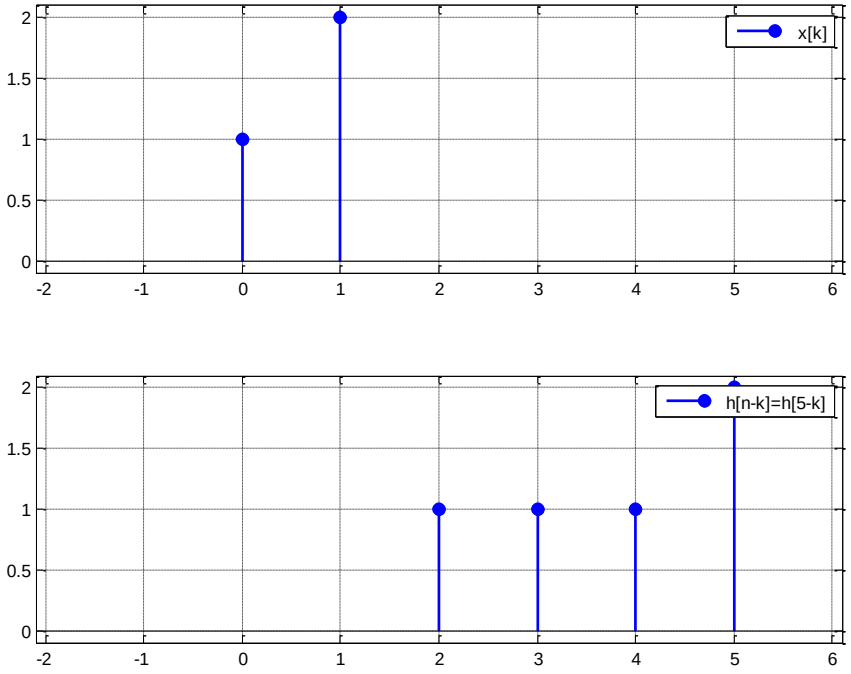

```
78
79 -    kx=[0 1];
80 -    x=[1 2];
81 -    kh=0:3;
82 -    h=[2 1 1 1];
83 -    subplot(2,1,1)
84 -    stem(kx,x,'fill','linewidth',2),grid or
85 -    axis([-2.1 6.1 -0.1 2.1])
86 -    legend('x[k]')
87 -    n=4;
88 -    suplot(2,1,2)
89 -    stem(-kh+n,h,'fill','linewidth',2),grid
90 -    axis([-2.1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



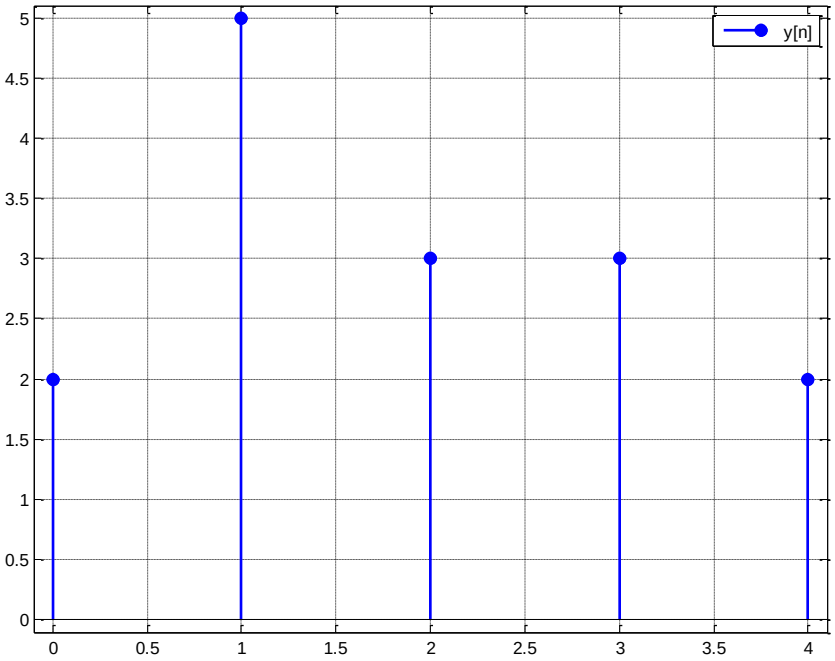

```
78
79 -    kx=[0 1];
80 -    x=[1 2];
81 -    kh=0:3;
82 -    h=[2 1 1 1];
83 -    subplot(2,1,1)
84 -    stem(kx,x,'fill','linewidth',2),grid or
85 -    axis([-2.1 6.1 -0.1 2.1])
86 -    legend('x[k]')
87 -    n=5;
88 -    subplot(2,1,2)
89 -    stem(-kh+n,h,'fill','linewidth',2),grid
90 -    axis([-2.1 6.1 -0.1 2.1])
91 -    legend('h[n-k]=h[5-k]')
92
```

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

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