COLLEGE OF ENGINEERING AND TECHNOLOGIES

ALMUSTAQBAL UNIVERSITY

Digital Signal Processing (DSP)

CTE 306

Lecture 10

- Convolution II -

(2023 – 2024)

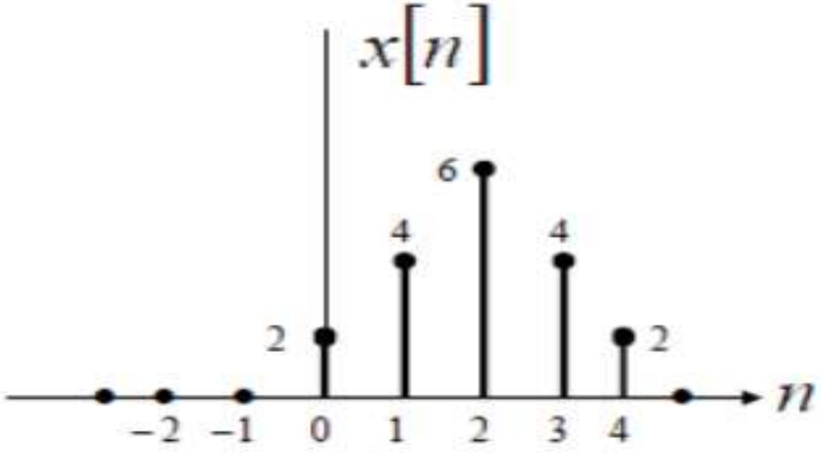
Dr. Zaidoon AL-Shammari

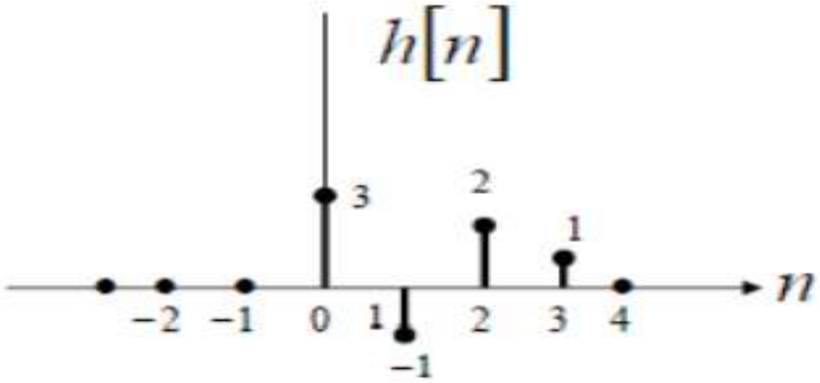
Lecturer / Researcher

zaidoon.waleed@mustaqbal-college.edu.iq

Example

Ex.1 Find $y[n]=x[n]*h[n]$

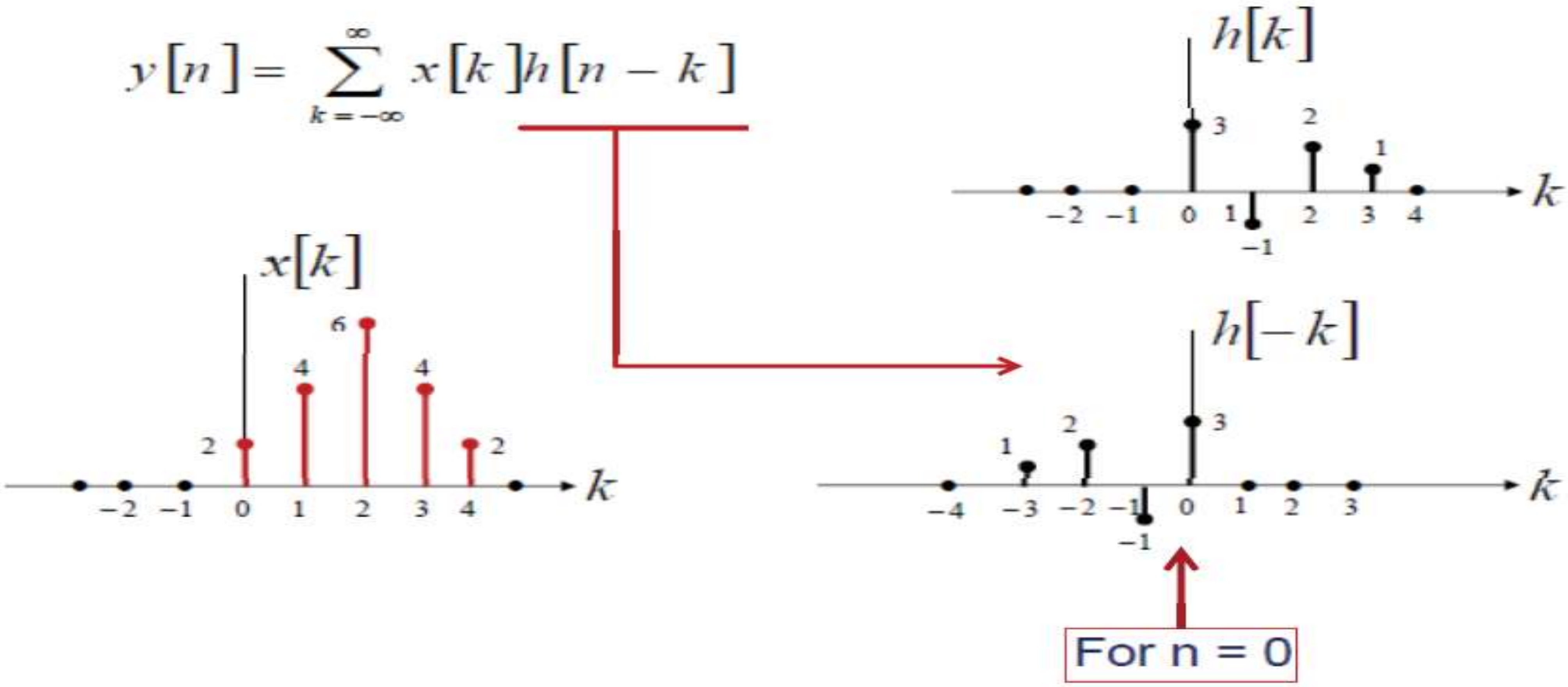




$$y[n]=x[n]*h[n]=\sum_{k=-\infty}^{\infty}x[k]h[n-k]$$

Solution : Ex.1 (Method 1 - Graphical convolution)

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$



Graphical Method

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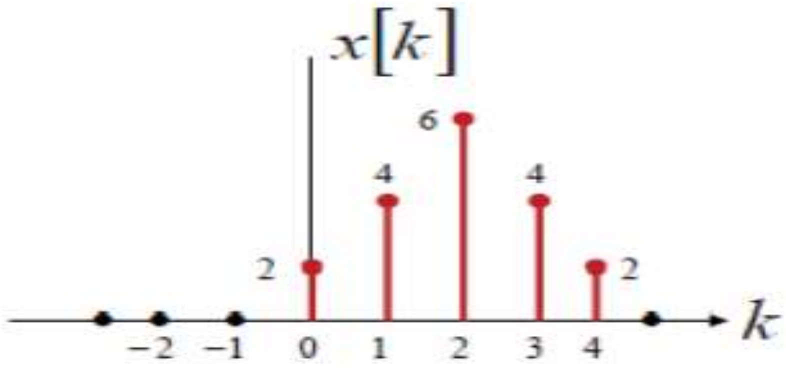
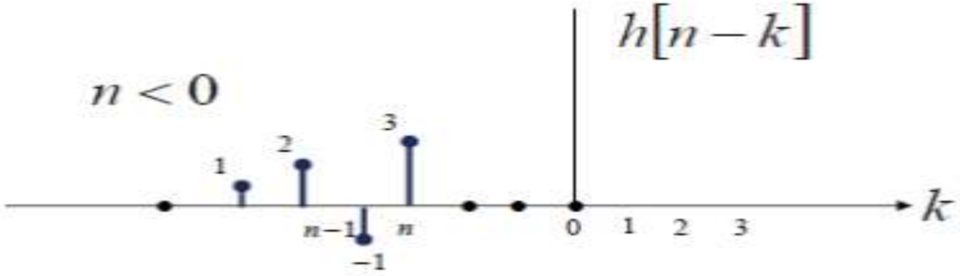
Solution : Ex.1 (Method 1 - Graphical convolution)

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$



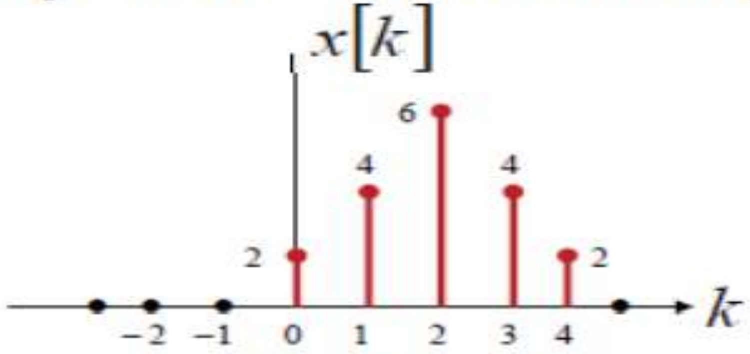
- For n < 0:



$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k] = 0$$

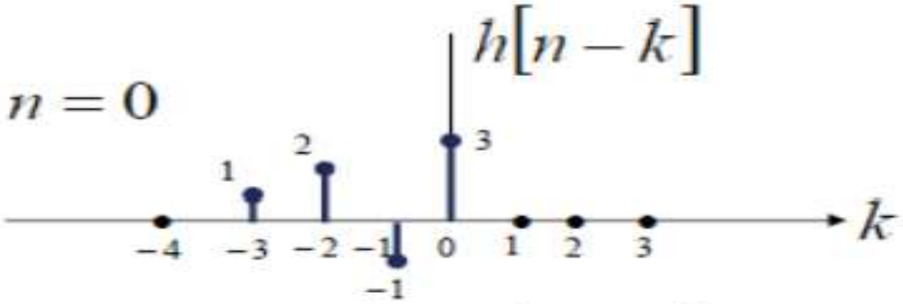
Solution : Ex.1 (Method 1 - Graphical convolution)

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$



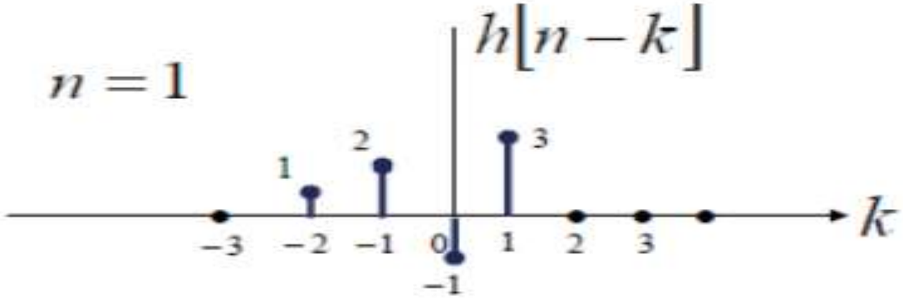
- For n = 0:

$$y[n] = (2)(3) = 6$$



- For n = 1:

$$y[n] = (2)(-1) + (4)(3)$$
$$= 10$$



Graphical Method

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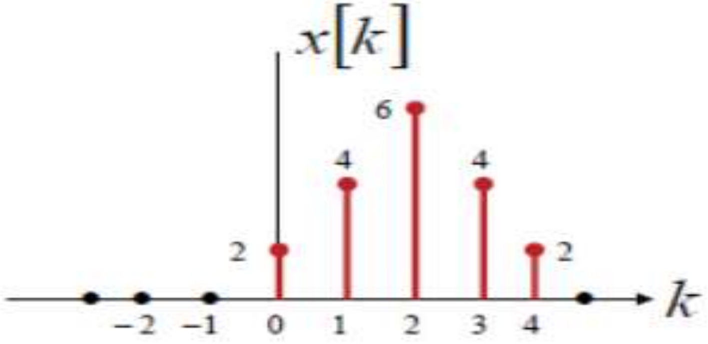
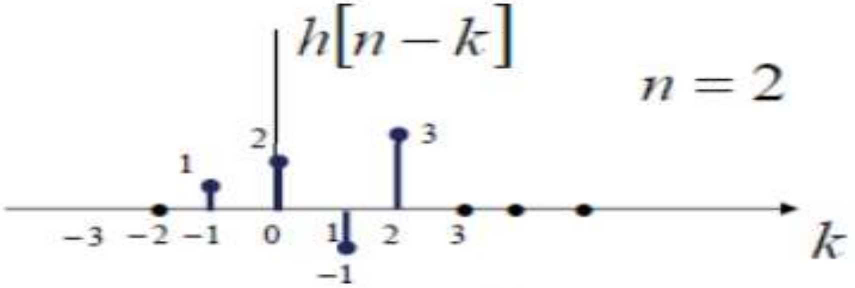
Solution : Ex.1 (Method 1 - Graphical convolution)

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$



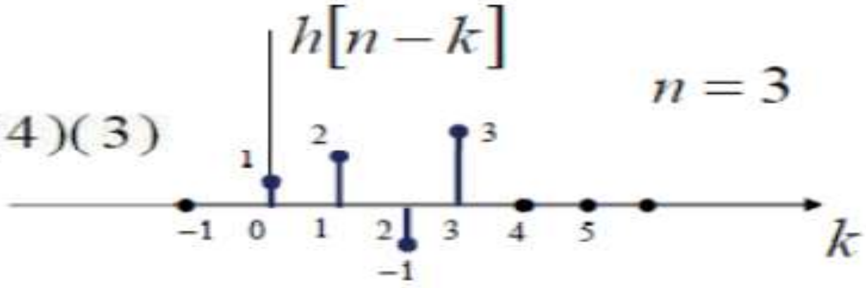
- For n = 2:

$$y[n] = (2)(2) + (4)(-1) + (6)(3)$$
$$= 18$$



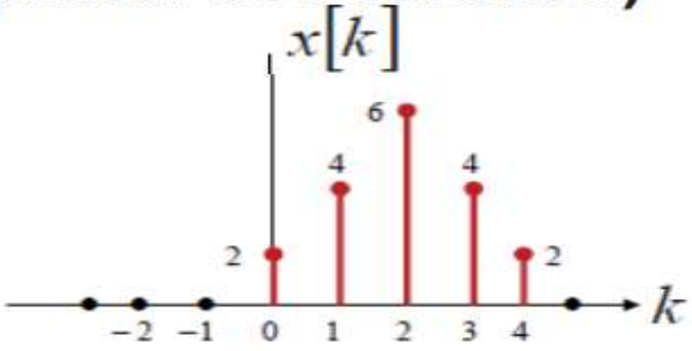
- For n = 3:

$$y[n] = (2)(1) + (4)(2) + (6)(-1) + (4)(3)$$
$$= 16$$



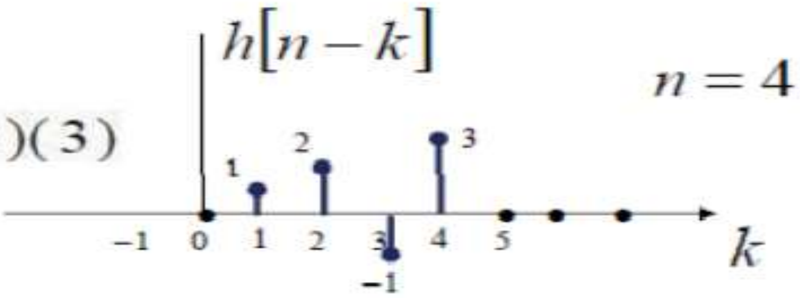
Solution : Ex.1 (Method 1 - Graphical convolution)

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$



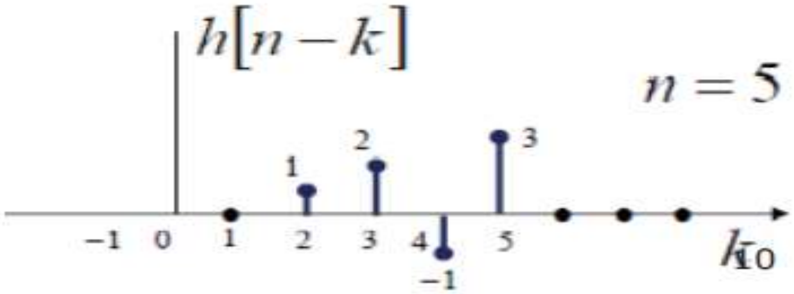
- For n = 4:

$$y[n] = (4)(1) + (6)(2) + (4)(-1) + (2)(3)$$
$$= 18$$



- For n = 5:

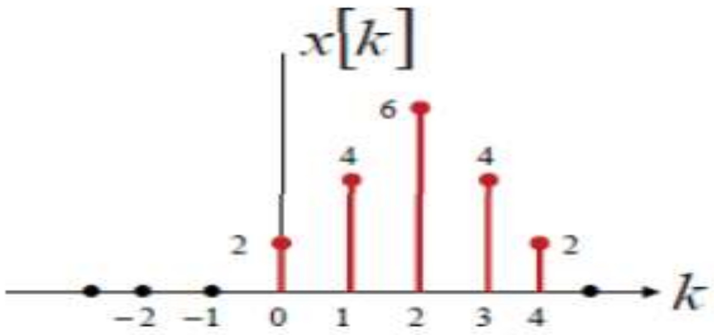
$$y[n] = (6)(1) + (4)(2) + (2)(-1)$$
$$= 12$$



Graphical Method

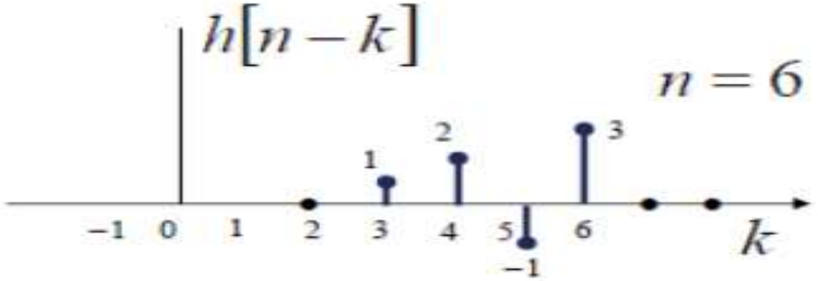
Solution : Ex.1 (Method 1 - Graphical convolution)

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$



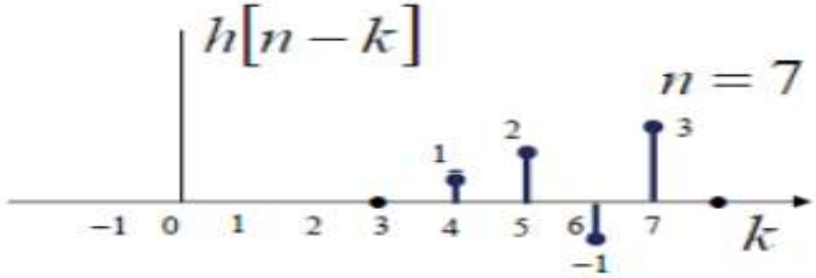
- For n = 6:

$$y[n] = (4)(1) + (2)(2) = 8$$



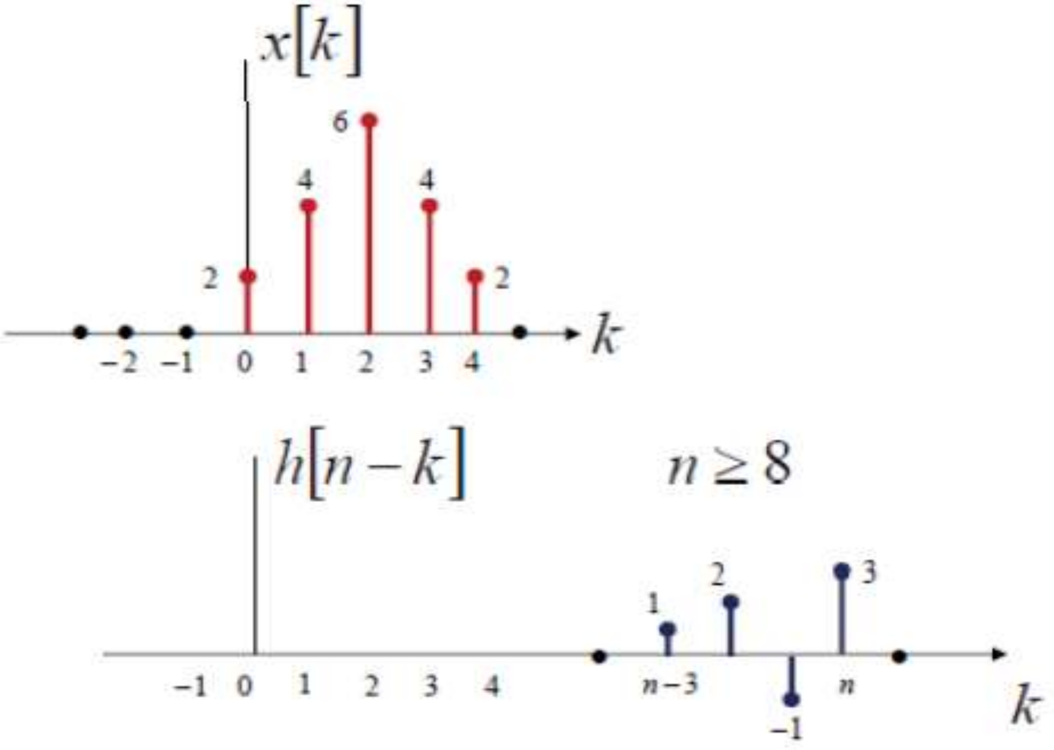
- For n = 7:

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



Solution : Ex.1 (Method 1 - Graphical convolution)

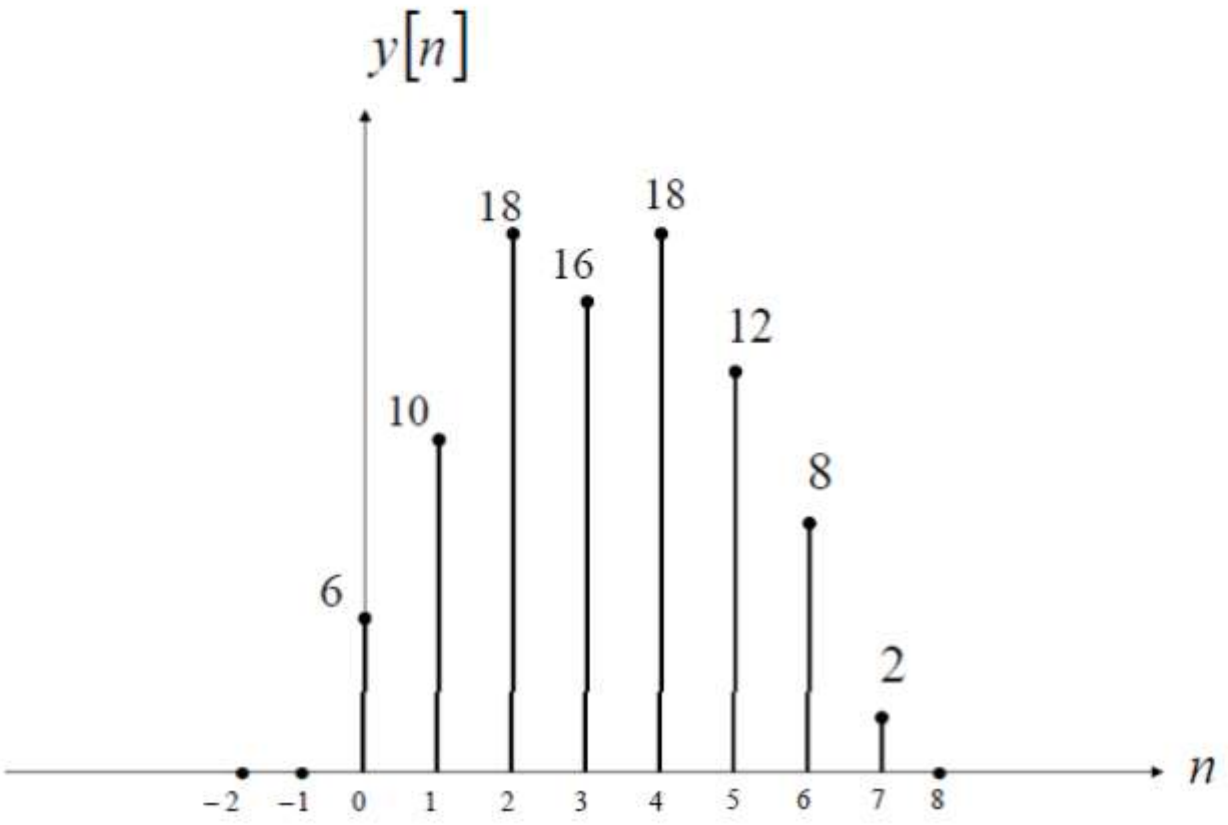
$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$



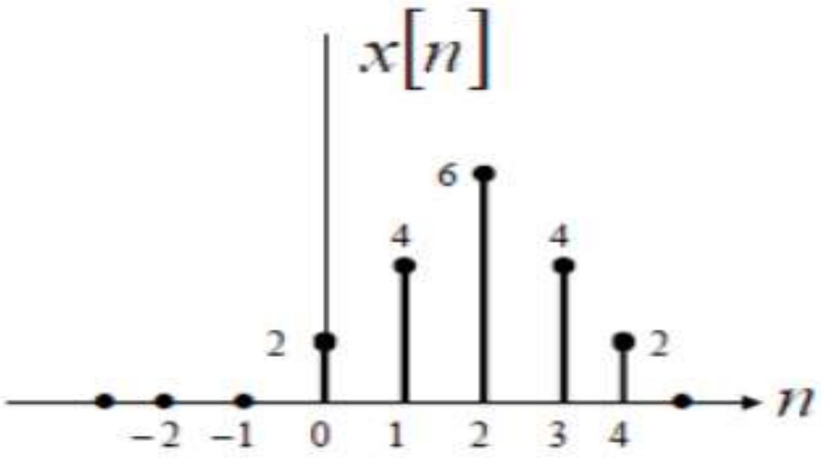
- For n ≥ 8:

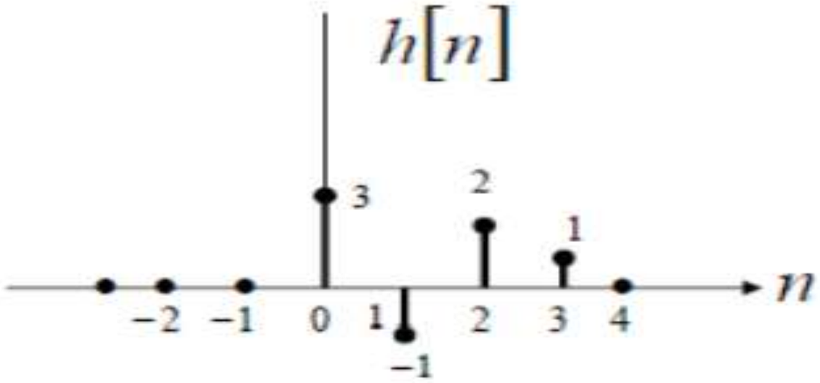
$$y[n] = 0$$

Solution : Ex.1 (Method 1 - Graphical convolution)



Ex.1 Find $y[n]=x[n]*h[n]$



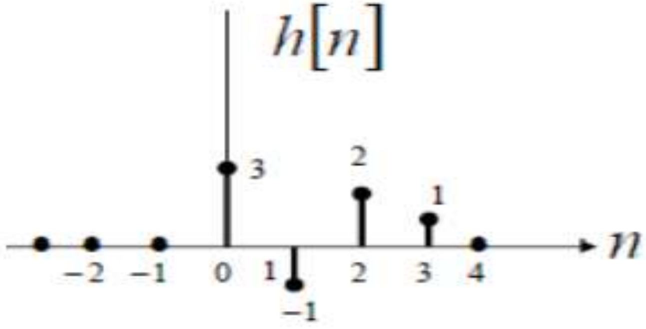


$$y[n]=x[n]*h[n]=\sum_{k=-\infty}^{\infty}x[k]h[n-k]$$

Solution : Ex.1 (Method 2 - Tabular method)

First: we denote **the nonzero terms** of the impulse response h[n] as the convolution mask

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



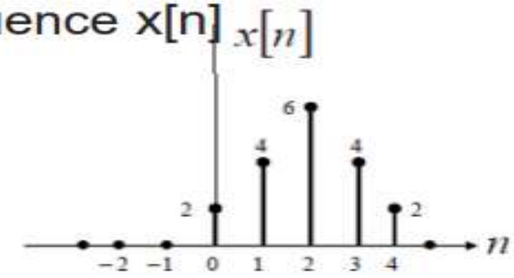
Second: we reverse the order of this convolution mask

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

Third: we slide the reversed convolution mask along the sequence x[n] and take the **dot product** between them for all n.

This process is illustrated in the following table for

$$n\chi\{0,1,\ldots,8\}$$



x=[0 0 2 4 6 4 2 0];

Solution : Ex.1 (Method 2 - Tabular method)

x=[00246420 0]

h=[3 -1 2 1]

$$y[n]=\sum_{k=-\infty}^{\infty} x[k]h[n-k]$$

n	k	−4	−3	−2	−1	0	1	2	3	4	5	6	7	8
n	x[k]	0	0	0	0	2	4	6	4	2	0	0	0	0
0	h[0−k]		1	2	-1	3								
1	h[1−k]			1	2	-1	3							
2	h[2−k]				1	2	-1	3						
3	h[3−k]					1	2	-1	3					
4	h[4−k]						1	2	-1	3				
5	h[5−k]							1	2	-1	3			
6	h[6−k]								1	2	-1	3		
7	h[7−k]									1	2	-1	3	
	h[8−k]										1	2	-1	3

- y[0]=[0 0 0 2].[1 2 -1 3] = 6
- y[1]=[0 0 2 4].[1 2 -1 3] = 10
- y[2]=[0 2 4 6].[1 2 -1 3] = 18
- y[3]=[2 4 6 4].[1 2 -1 3] = 16
- y[4]=[4 6 4 2].[1 2 -1 3] = 18
- y[5]=[6 4 2 0].[1 2 -1 3] = 12
- y[6]=[4 2 0 0].[1 2 -1 3] = 8
- y[7]=[2 0 0 0].[1 2 -1 3] = 2
- y[8]=[0 0 0 0].[1 2 -1 3] = 0

Tabular Method

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Solution : Ex.1 (Method 2 - Tabular method)