



SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECB212 – DIGITAL SIGNAL PROCESSING

II YEAR/ IV SEMESTER

UNIT 1 - DISCRETE FOURIER TRANSFORM

TOPIC – LINEAR CONVOLUTION



LINEAR CONVOLUTION



- The convolution sum relates the input, output and unit sample response of the discrete time systems
- Linear convolution is a very powerful technique used for the analysis of Linear Time Invariant systems
- $x(n)$ can be expressed as sum of weighted impulses

$$y(n) = x(n) * h(n)$$



LINEAR CONVOLUTION



- The behavior of the LTI system is completely characterized by the unit sample response $h(n)$

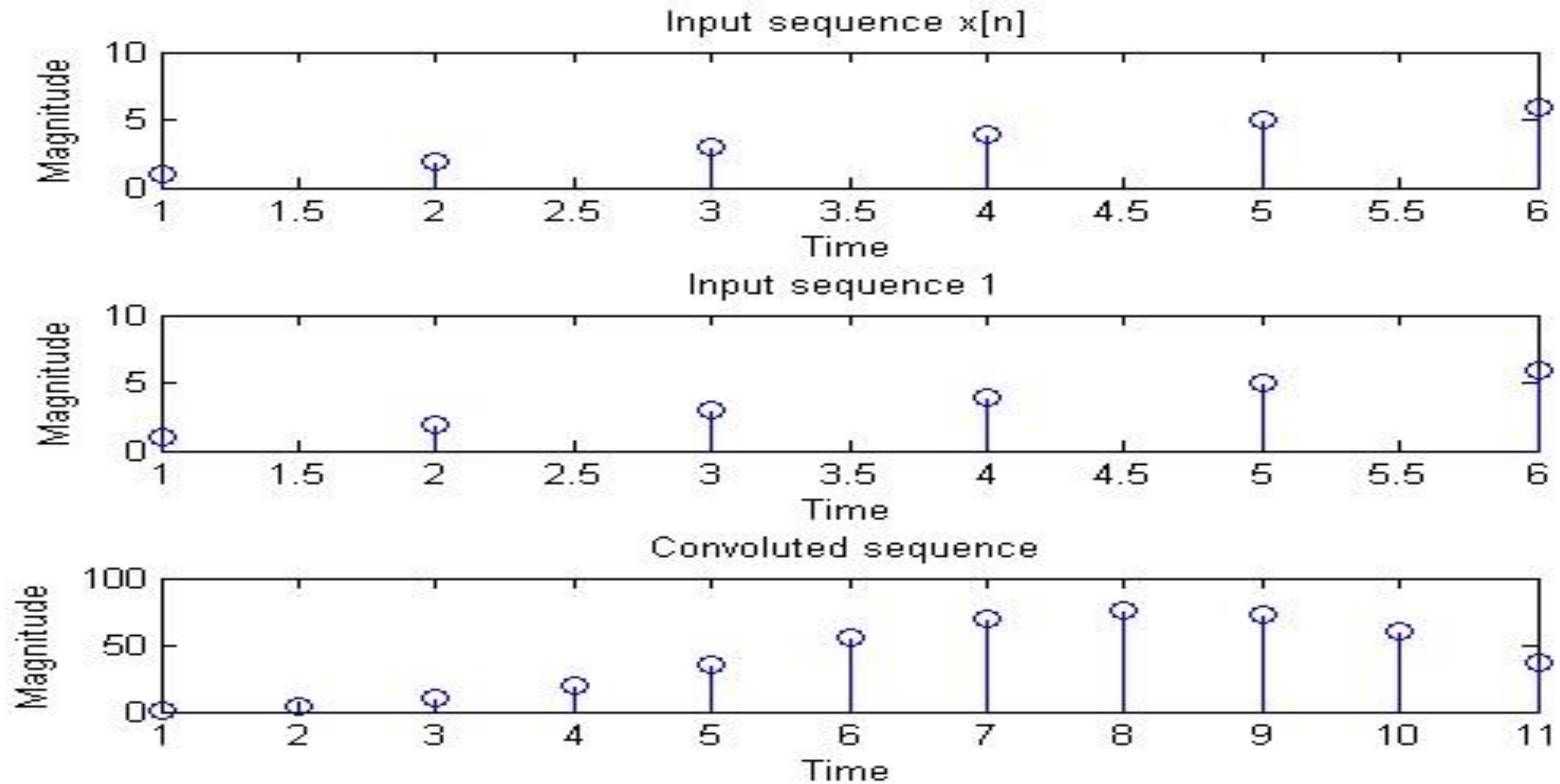
$$y(n) = \sum_{k=-\infty}^{\infty} x(k) h(n - k)$$

- It is the linear convolution of $x(n)$ and $h(n)$ gives $y(n)$ Inverse Z Transform:



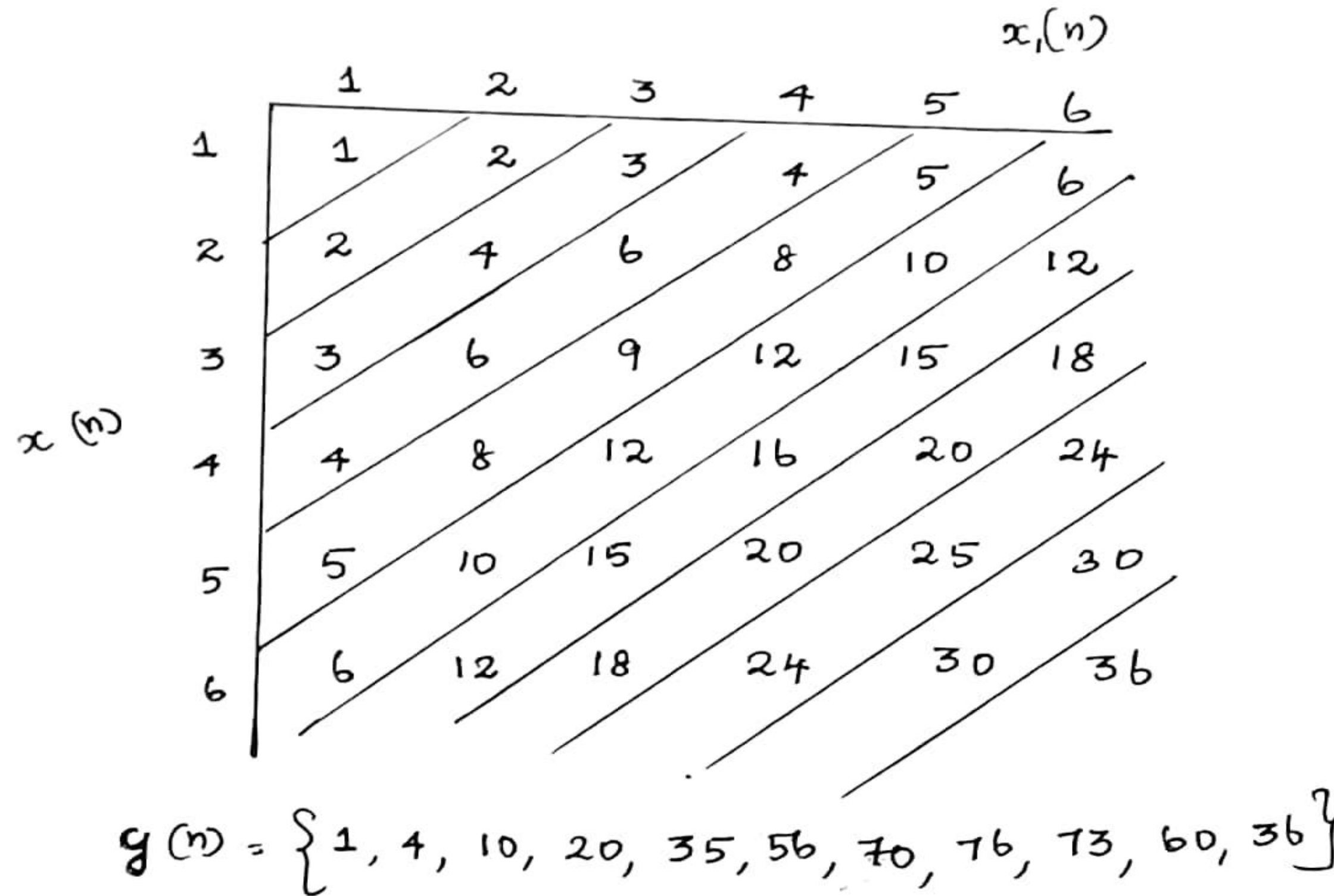


REPRESENTATION OF CONVOLUTION





REPRESENTATION OF CONVOLUTION





LINEAR CONVOLUTION



Four methods available to compute convolution sum:

1. Definition Method
2. Graphical Method
3. Tabulation Method
4. Multiplication Method



CONVOLUTION SUM



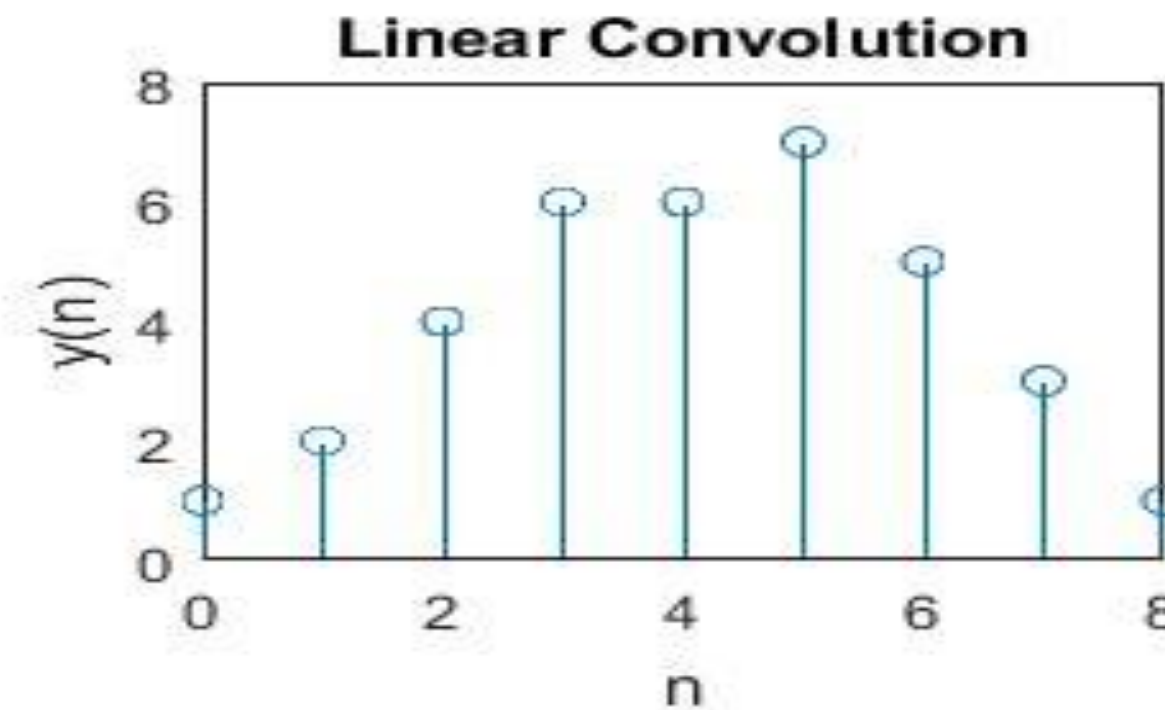
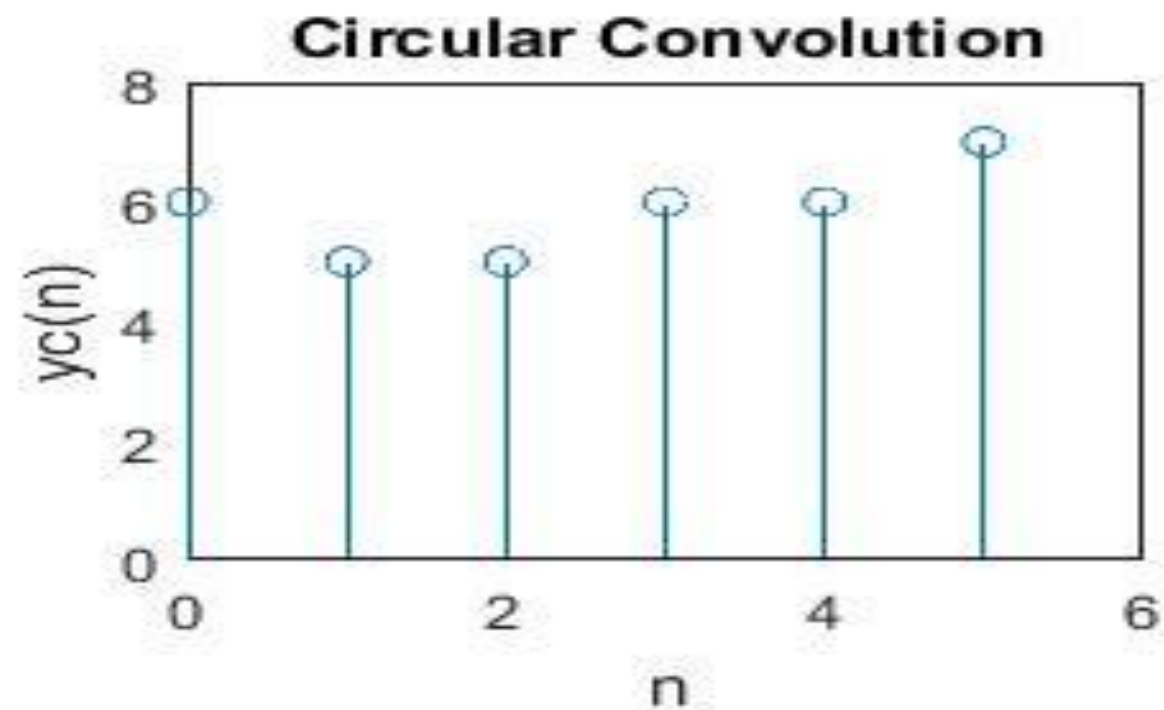
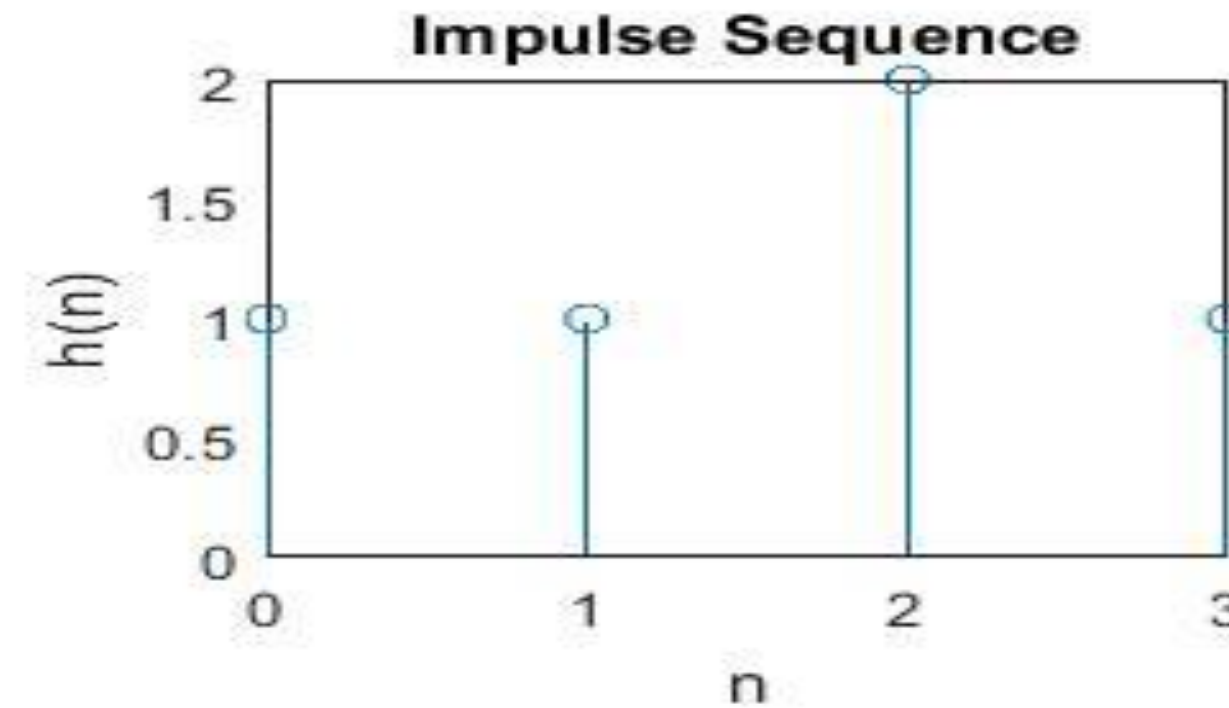
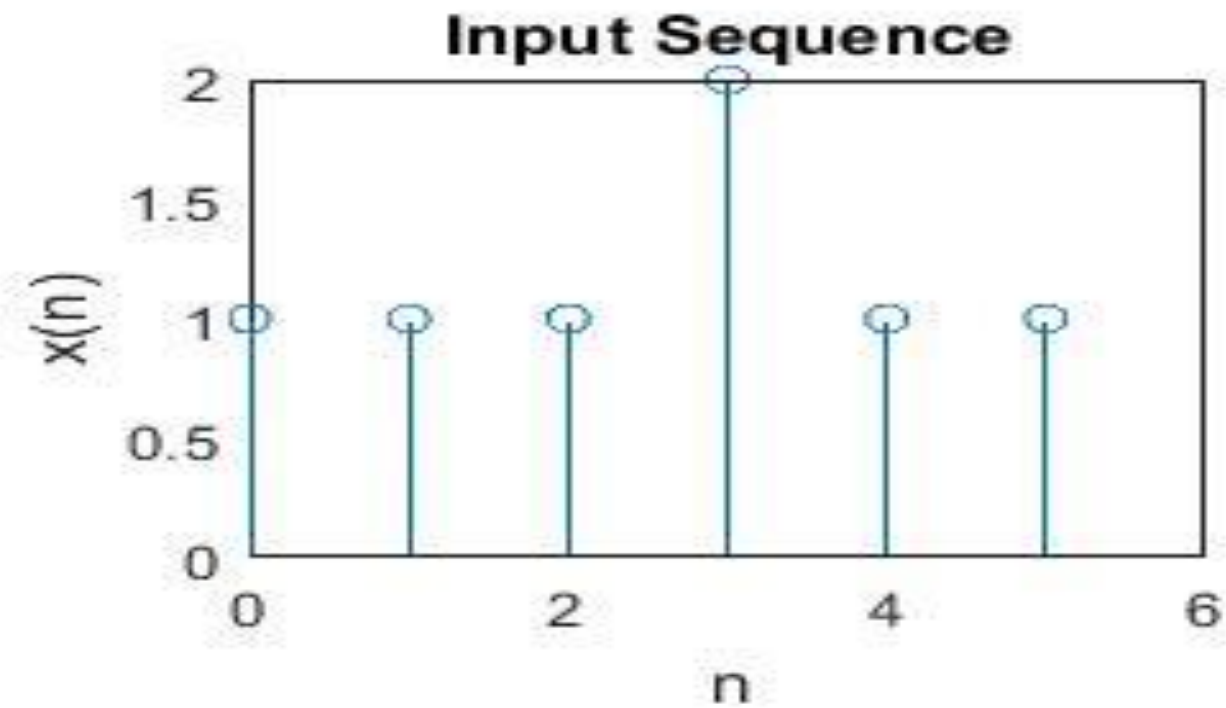
Four steps involved in computing convolution sum:

1. Folding
2. Shifting
3. Multiplication
4. Summation

- Let M be the total no. of samples of $x(n)$ and N be the total no. of samples of $h(n)$ then the total no. of samples in $y(n)$ be **$M+N-1$**



CONVOLUTION SUM





CONVOLUTION SUM



$$x(n) = \{1, 1, 1, 2, 1, 1\} \quad h(n) = \{1, 1, 2, 1\}$$

	1	1	1	2	1	1		
			1	1	2	1		
<hr/>								
		1	1	1	2	1	1	
	2	2	2	4	2	2		
		1	1	1	2	1	1	
	1	1	1	2	1	1		
<hr/>								
1	2	4	6	6	7	5	3	1
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$$y(n) = \{1, 2, 4, 6, 6, 7, 5, 3, 1\}$$



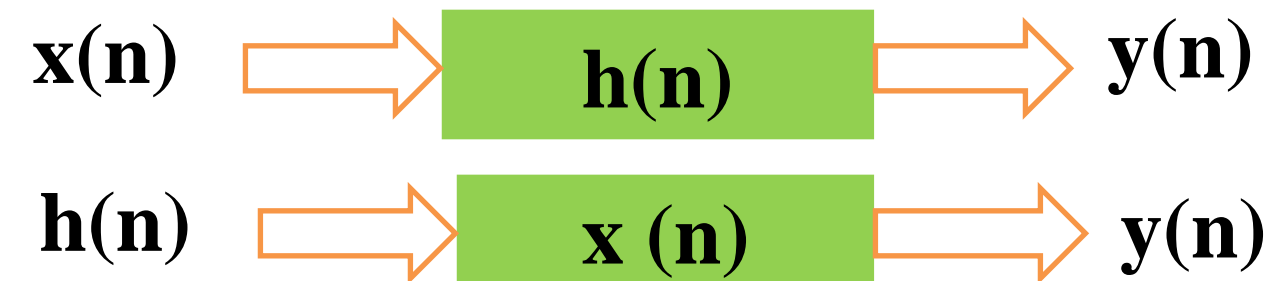
PROPERTIES OF CONVOLUTION SUM



- It can be classified into
 1. Commutative Property
 2. Associative Property
 3. Distributive Property

Commutative :

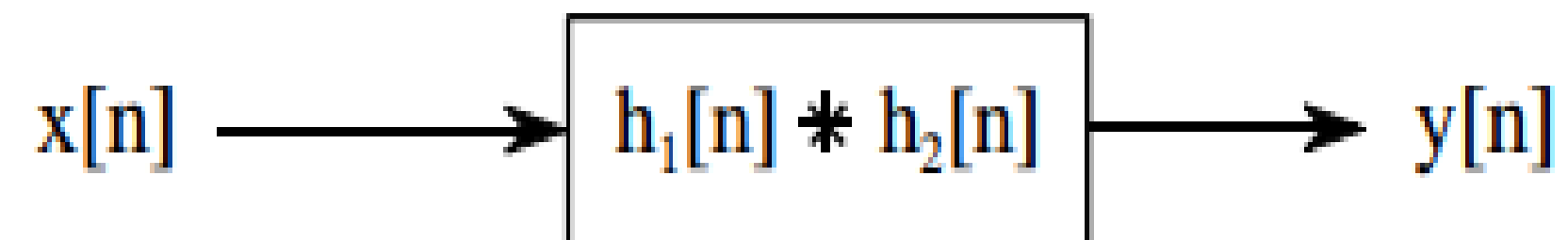
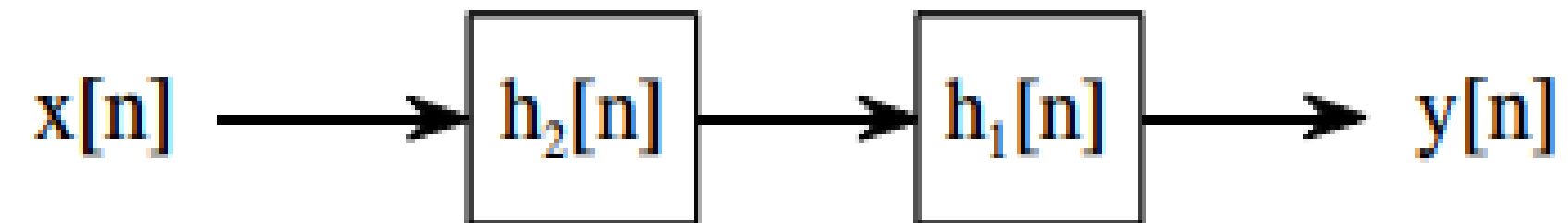
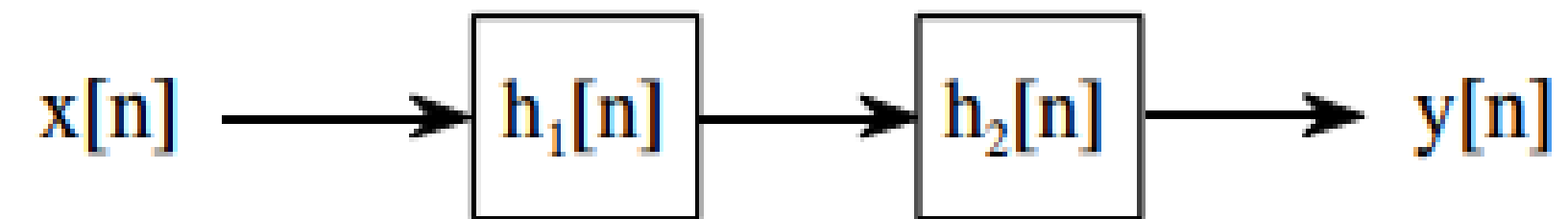
$$y(n) = x(n) * h(n) = h(n) * x(n)$$





ASSOCIATIVE PROPERTY

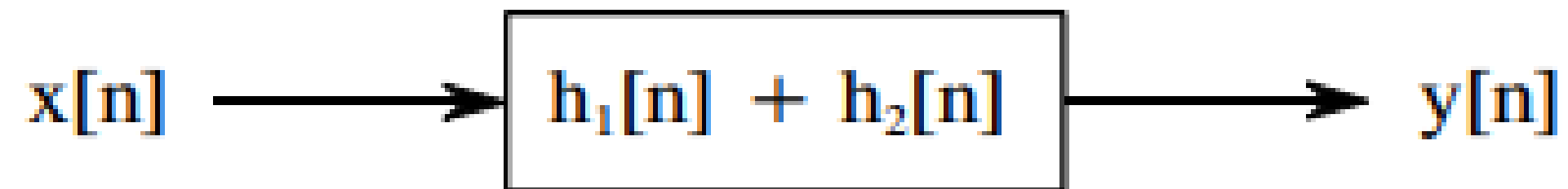
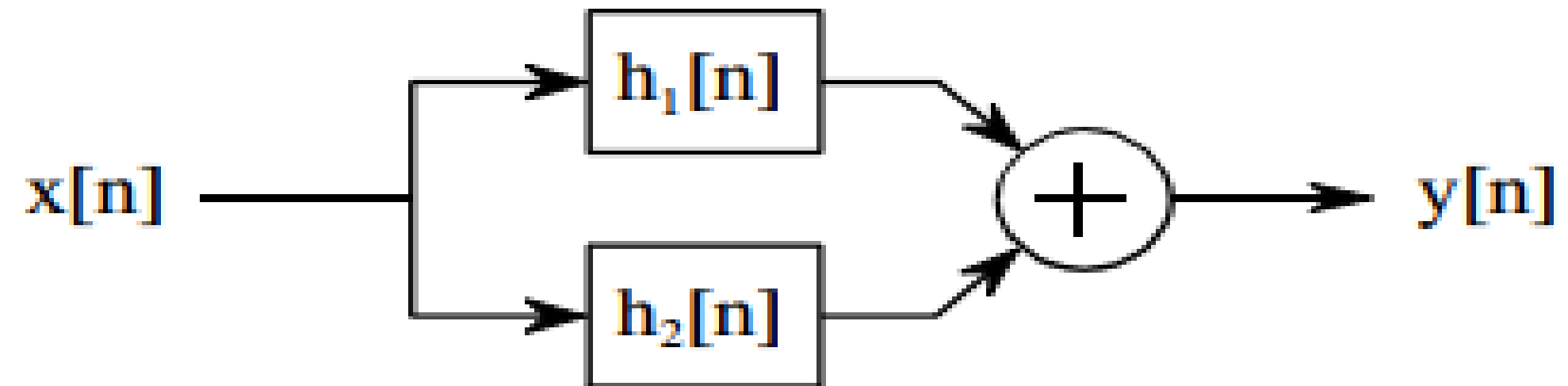
$$[x(n) * h_1(n)] * h_2(n) = x(n) * [h_1(n) * h_2(n)]$$





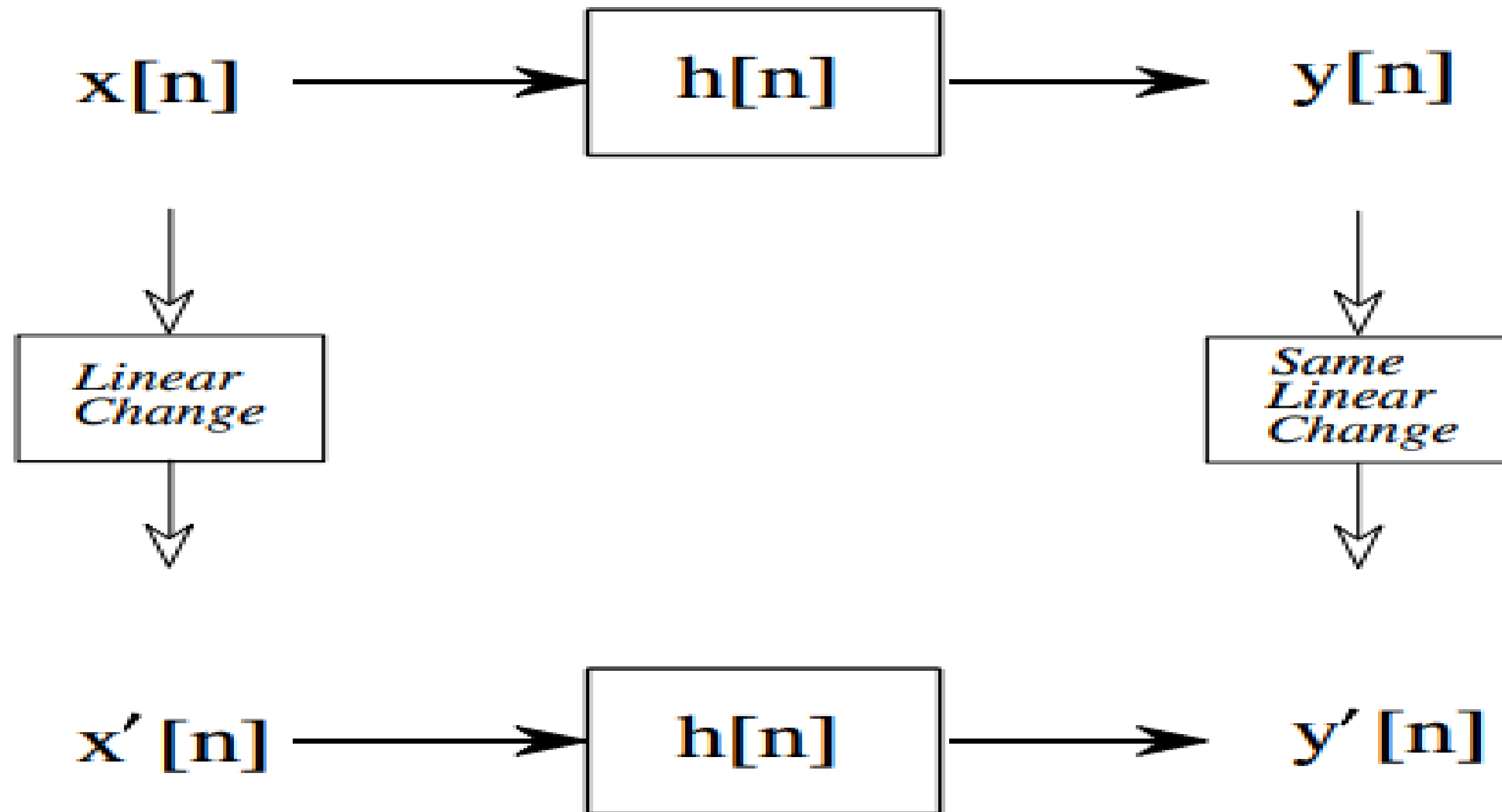
DISTRIBUTIVE PROPERTY

$$\mathbf{x(n) * h_1(n) + x(n) * h_2(n) = x(n) * [h_1(n) + h_2(n)]}$$



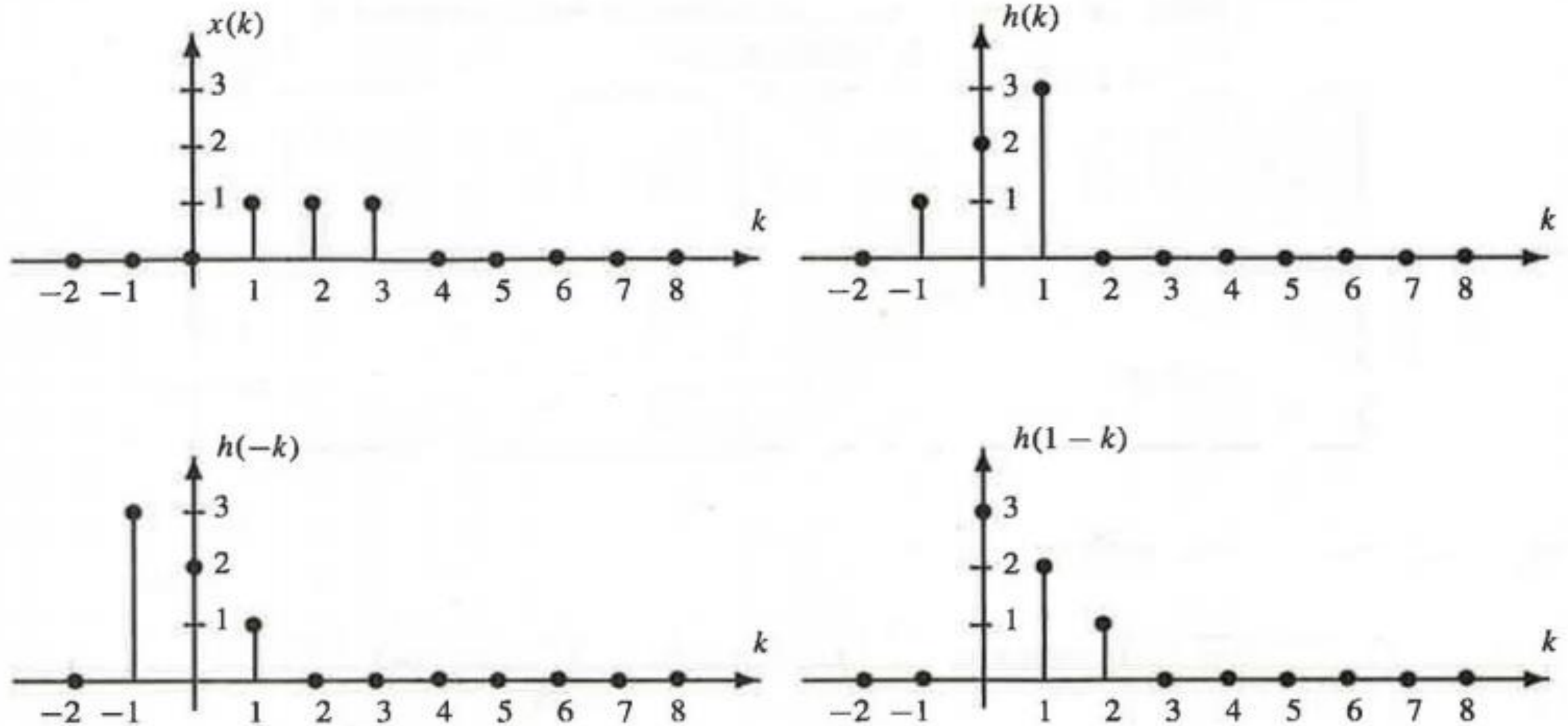


INPUT & OUTPUT TRANSFERENCE



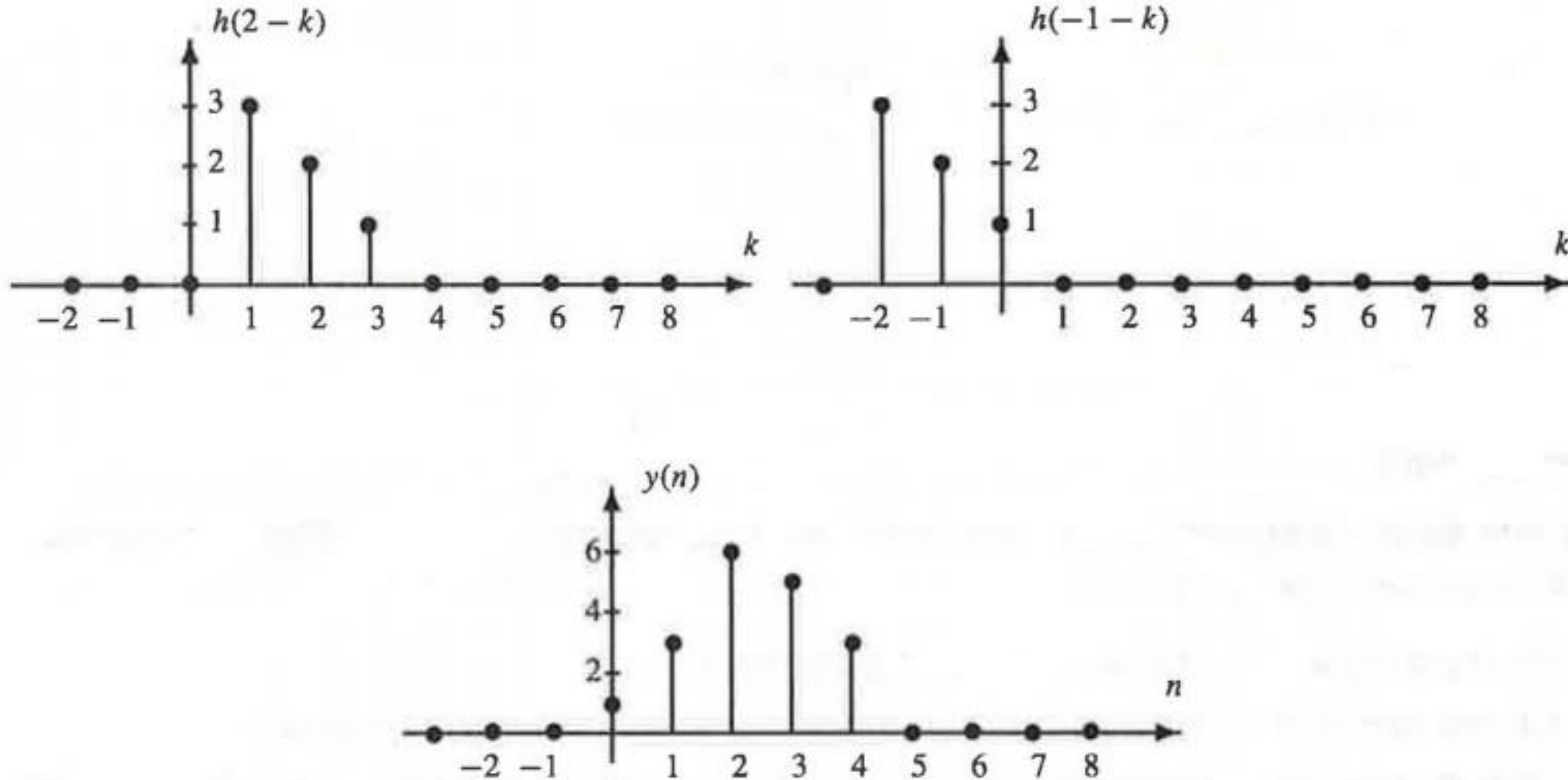


GRAPHICAL REPRESENTATION





GRAPHICAL REPRESENTATION





MULTIPLICATION METHOD



Find the convolution sum of the sequence :-

$$x(n) = \{1, 2, 3, 4, 5\}$$

$$h(n) = \{6, 7, 8\}$$

	1	2	3	4	5	
			6	7	8	
<hr/>						
	8	16	24	32	40	
7	14	21	28	35		
6	12	18	24	30		
<hr/>						
6	19	40	61	82	67	40
<hr/>						

$$y(n) = \{6, 19, 40, 61, 82, 67, 40\}$$



TABULATION METHOD



$$x(n) = \{1, 2, 3, 4, 5\} \quad h(n) = \{6, 7, 8\}$$

	6	7	8	$\rightarrow h(n)$
1	6	7	8	
2	12	14	16	
3	18	21	24	
4	24	28	32	
5	30	35	40	

$x(n)$
 \uparrow

$$y(n) = \{6, 19, 40, 61, 82, 67, 40\}$$



DEFINITION METHOD



$$x(n) = \{1, 2, 3, 4, 5\} \quad h(n) = \{6, 7, 8\}$$

$$x(0) = 1, \quad x(1) = 2, \quad x(2) = 3, \quad x(3) = 4, \quad x(4) = 5$$

$$h(0) = 6, \quad h(1) = 7, \quad h(2) = 8$$

$$M = 5$$

$$N = 3$$

$$y(n) = M + N - 1 \Rightarrow 5 + 3 - 1 \Rightarrow 7$$

$$y(n) = 7 \text{ samples } [n \text{ varies } 0 \text{ to } 6]$$

$$y(n) = \sum_{k=0}^{M-1} x(k) h(n-k)$$

$$n=0$$

$$y(0) = \sum_{k=0}^{M-1} x(k) h(0-k) \Rightarrow y(0) = 6$$

$$n=1$$

$$y(1) = \sum_{k=0}^{M-1} x(k) h(1-k) \Rightarrow y(1) = 19$$

$$n=2$$

$$y(2) = \sum_{k=0}^{M-1} x(k) h(2-k) \Rightarrow y(2) = 40$$

$$n=3$$

$$y(3) = \sum_{k=0}^{M-1} x(k) h(3-k) \Rightarrow y(3) = 61$$

$$n=4$$

$$y(4) = \sum_{k=0}^{M-1} x(k) h(4-k) \Rightarrow y(4) = 82$$

$$n=5$$

$$y(5) = \sum_{k=0}^{M-1} x(k) h(5-k) \Rightarrow y(5) = 67$$

$$n=6$$

$$y(6) = \sum_{k=0}^{M-1} x(k) h(6-k) \Rightarrow y(6) = 40$$

$$y(n) = \{6, 19, 40, 61, 82, 67, 40\}$$



ASSESSMENT



1. Define convolution sum.
2. Total no. of samples in $y(n)$ will be -----
3. List the methods involved to compute convolution sum.
4. $y(n) = x(n) * h(n) = h(n) * x(n)$ is defined as ----- property
5. Mention the steps involved to compute linear convolution.
6. List the properties of convolution sum.



THANK YOU