Basic Types of Digital Signals

The unit-step and unit-impulse functions

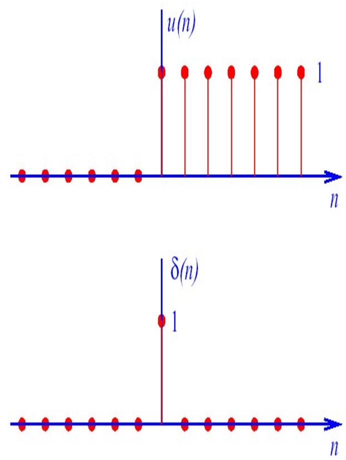
Unit-step function:

$$u(n) = \begin{cases} 0, & n < 0 \\ 1, & n \geq 0 \end{cases}$$

Unit-impulse function:

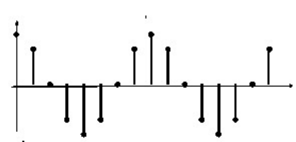
$$\delta(n) = \begin{cases} 1, & n = 0 \\ 0, & n \neq 0 \end{cases}$$

$$\delta(n) = u(n) - u(n-1)$$

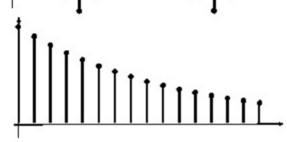


Basic Types of Digital Signals

sinusoidal sequence $\cos[\omega_0 n]$



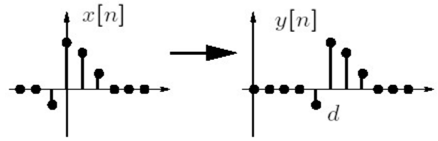
exponential sequence a^n



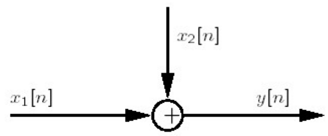
sindemo

Basic Operations

- ideal delay: $y[n] = x[n-d]$



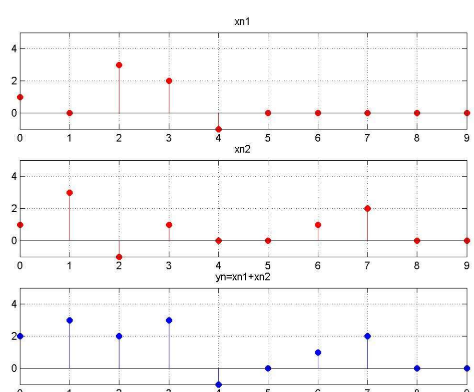
- sum, difference:
  $y[n] = x_1[n] \pm x_2[n]$



- multiplication: $y[n] = x_1[n]x_2[n]$

operations

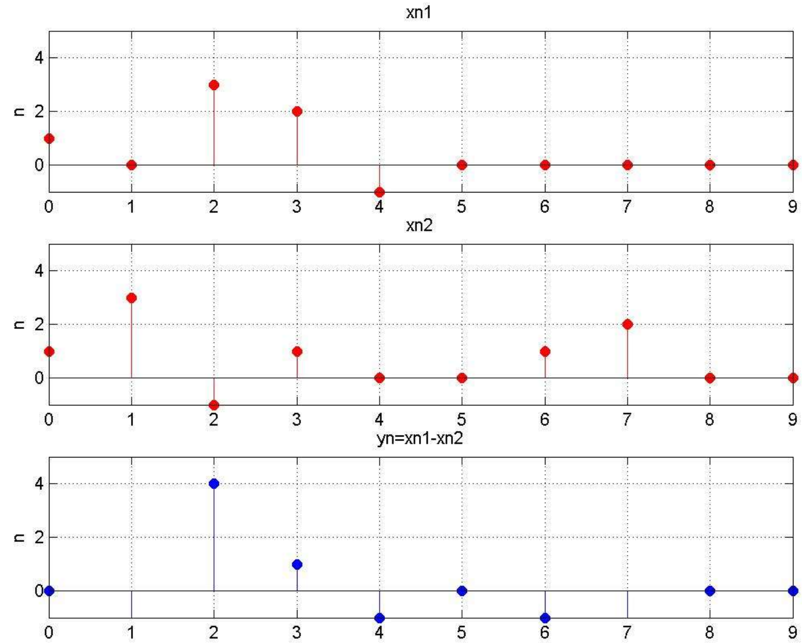
Operations in Matlab



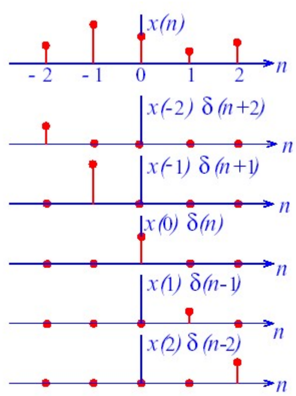
xn1 = [1 0 3 2 -1 0 0 0 0 0];

xn2 = [1 3 -1 1 0 0 1 2 0 0];

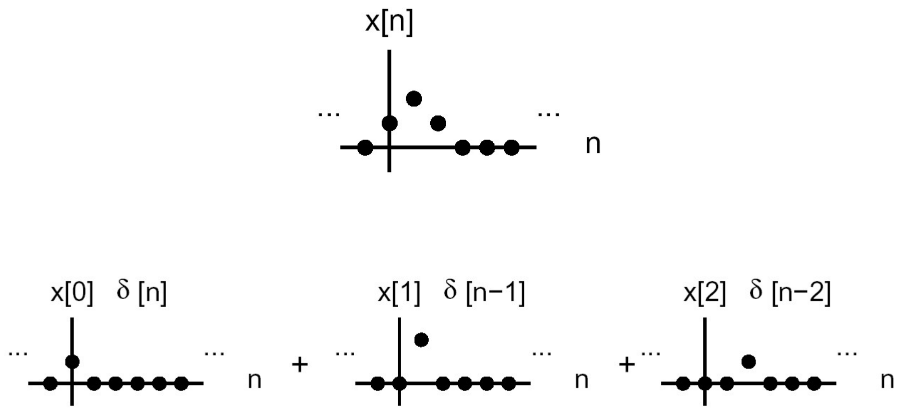
yn = xn1 + xn2;



x[n] via impulse functions



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



Time Domain Analysis

Linear Time-Invariant Systems

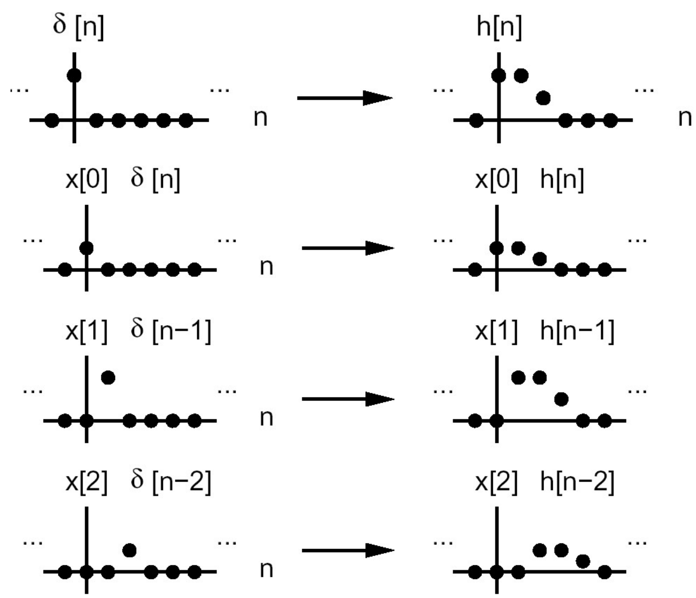
Definition of a system:

$$y(n) = T\{x(n)\}$$

where $T\{\cdot\}$ is an operator that maps an input sequence $x(n)$ into an output sequence $y(n)$.

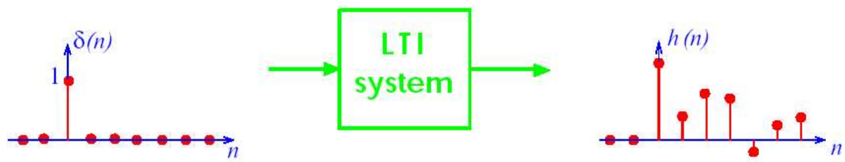
Linear system: A system (or processor) is linear if it obeys the principle of superposition.

Principle of superposition: If the input of a system contains the sum of multiple signals then the output of this system is the sum of the system responses to each separate signal.



LTI System

The sequence $\{h(n)\}$ is commonly referred to as impulse response of the LTI system



An important property of convolution:

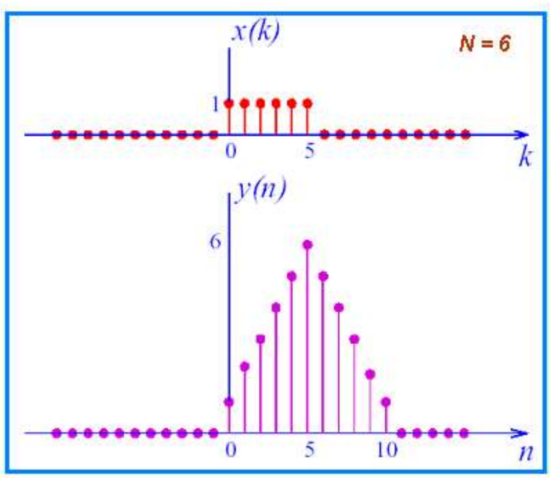
$$\{x(n)\} * \{h(n)\} = \sum_{k=-\infty}^{\infty} x(k)h(n-k) = \sum_{k=-\infty}^{\infty} h(k)x(n-k)$$
$$= \{h(n)\} * \{x(n)\} \quad \Longrightarrow$$

the order in which two sequences are convolved is unimportant!

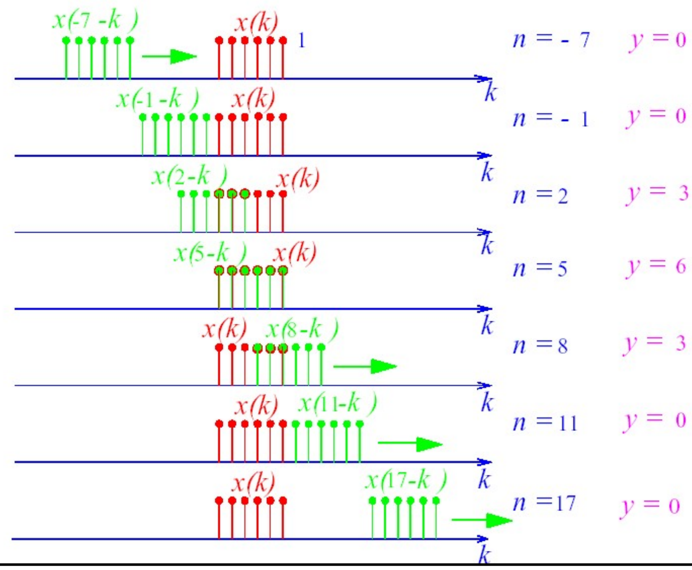
Example-Convolution of Two Rectangles

$$y(n) = \{x(n)\} * \{x(n)\}$$

convex1

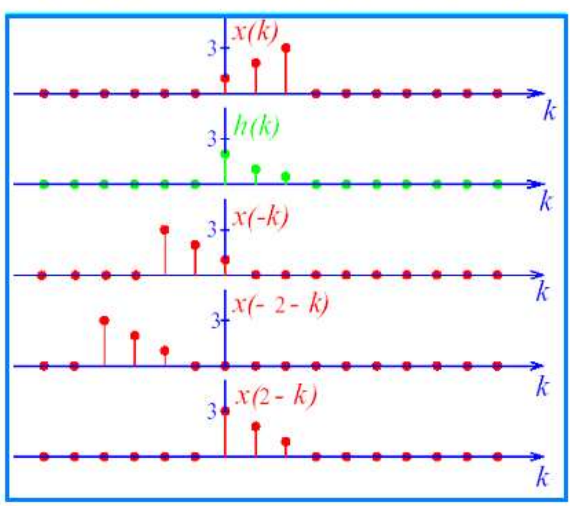


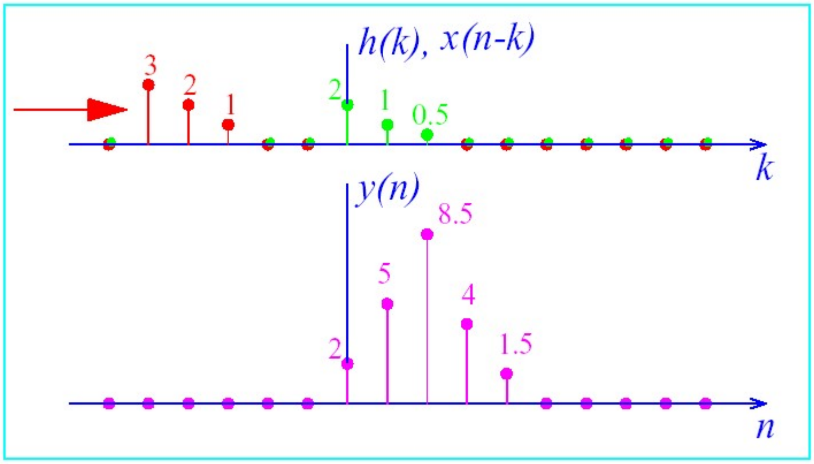
Example..(Continued)

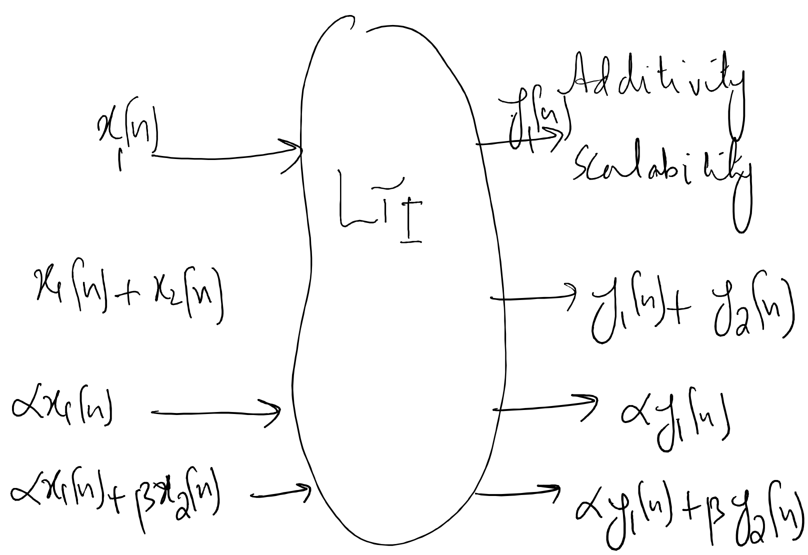


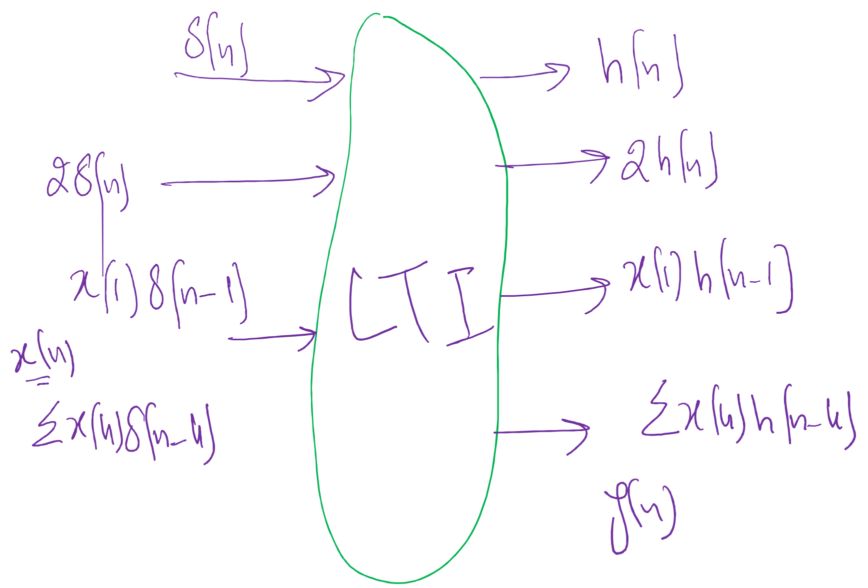
Example-Convolution Of Two Sequences

$$\{x(n)\} = \{\ldots, 0, 1, 2, 3, 0, \ldots\}$$
$$\{h(n)\} = \{\ldots, 0, 2, 1, 0.5, 0, \ldots\}$$




h(k), x(n-k)
3
2
1
2
1
0.5
k
y(n)
8.5
5
4
2
1.5
n


$x_1(n)$
LTI
$y_1(n)$
Additivity
Scalability
$x_1(n) + x_2(n)$
$y_1(n) + y_2(n)$
$\alpha x_1(n)$
$\alpha y_1(n)$
$\alpha x_1(n) + \beta x_2(n)$
$\alpha y_1(n) + \beta y_2(n)$



A pic is a 2D signal so giving it to convolving filter will extract its important features irrespective of its place and size and time