II. Introduction to Systems

1) What are systems?

- Any process that results in the transformation of a signal
- Block diagram is used to represent a system

2) How to interconnect systems?

- Series (cascade) interconnection
- Parallel interconnection

3) System Properties

- Memory

→ a system is memoryless if the system output $y(\text{n})$ depends only on $x(\text{n})$ at time n.

Example:

• Causality

→ a system is causal if the output y(n) at anytime depends upon <u>present and past values</u> of the input

Example: $y(\text{n}) = A\,x(n)$

$A\,x(n+1)$

$A\,x(n-1)$

• Invertibility

→ a system is invertible if distinct inputs lead to distinct outputs

Example: $y(\text{n}) = 2\,x(n+1)$

$3\,x^2(n)$

- Stability

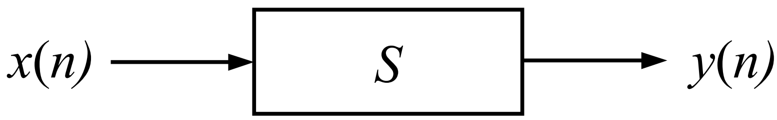
→ a system is stable if applying a bounded input to the system leads to a bounded output

Example:

$$y(n) = 3x(n)$$

- **Time-Invariance**

→ a system is time-invariant if a shift in the input produces the same shift in the output

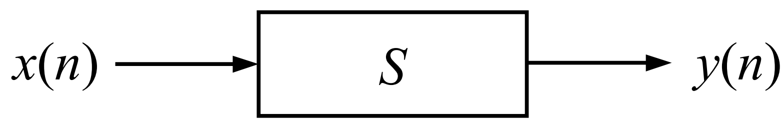


Example:

$$y(n) = 2x(n)$$
$$= x(2n)$$

• Linearity

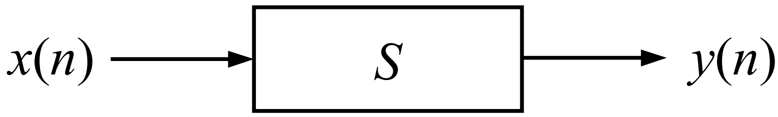
→ a system is linear iff the response to a weighted sum of signals is the weighted sum of the responses to each signal



Example: $$y(n) = 2x(n)$$

$$= x^2(n)$$

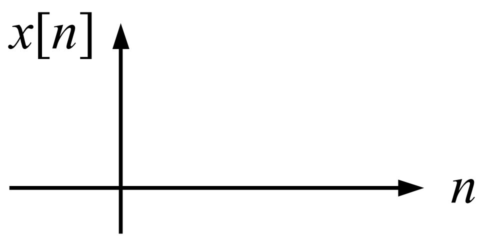
4) How to Relate Input/Output of a System



- For linear time-invariant system the unit impulse response can be used to relate input and output

4.1) Convolution Sum (for discrete time LTI system)

use property of $\delta[n]$



4.2) Graphical Convolution

5) Properties of Convolution

(1) Commutative

(2) Associative

(3) Distributive

6) Convolution Properties Applied to LTI Systems

8) Unit Step Response of a LTI

- Useful when the impulse response of a system is difficult to find

9) Stability Check of LTI Systems Using the Impulse Response