COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

Digital Signal Processing (DSP)

CTE 306

Lecture 12

- Introduction to systems -

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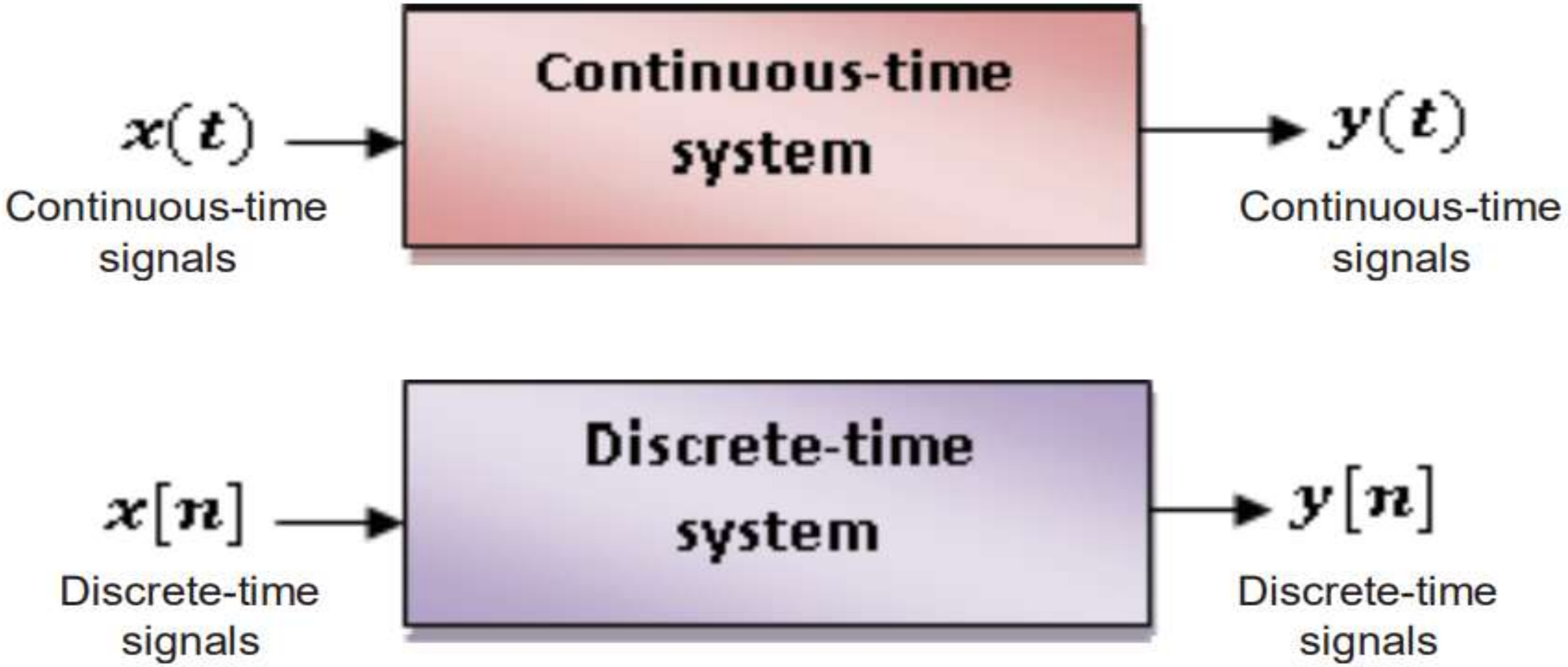
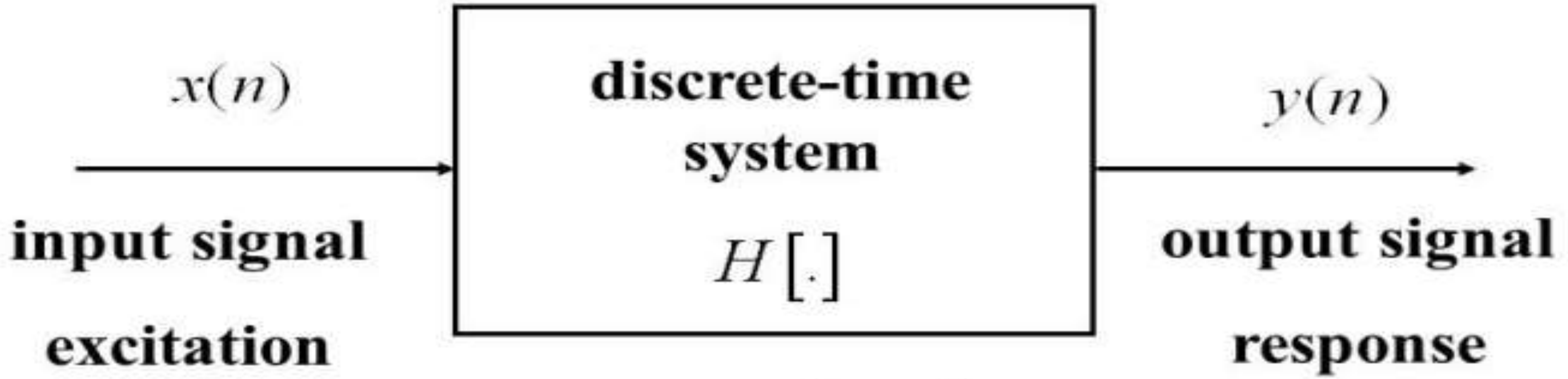
What is a system ?

- A system S is any physical device, process or computer algorithm that transforms input signals into output signals.



Input-output Description of Systems

- The input-output description of a discrete-time system consists of a mathematical expression or a rule, which explicitly defines the relation between the input and output signals



$$y(n) \equiv H[x(n)]$$

$$x(n) \xrightarrow{H} y(n)$$

Block diagram representation of a discrete – time system

Input-output Description of Systems

- In many applications of digital signal processing, we wish to design a device or an algorithm that performs some prescribed operation on discrete–time signals.

- Such a device or algorithm is called a discrete–time system.

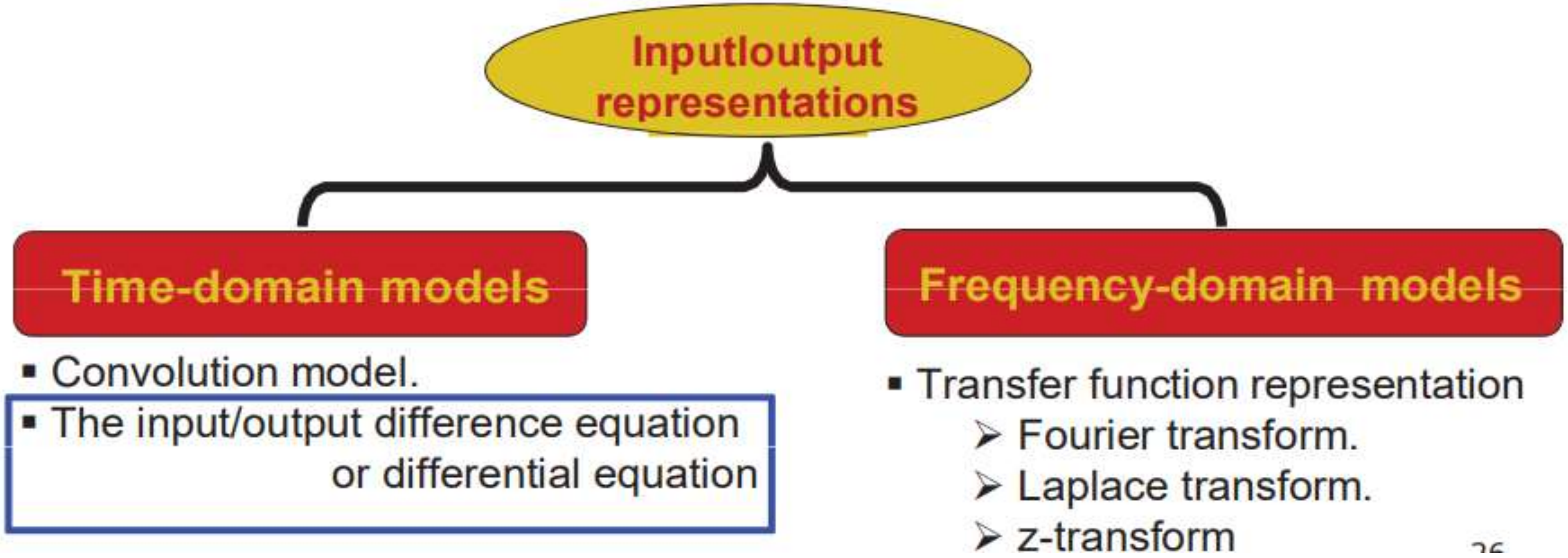
A mathematical model of a system

- A mathematical model of a system consists of the equations that describe the relationships between all signals appearing in that system. This model allow an in-depth study of that system.

- The basic type of mathematical models is: input/output representations describing the relationship between the input and output signals of a system.

Input/output representation

- More specifically, a discrete–time system is a device or algorithm that operates on a discrete–time signal called the input or excitation, according to some well–defined rule, to produce another discrete–time signal called the output or response of the system.



- Moving Average Filter (discrete-time system)

The N-point moving average (MA) filter is given by the input/output relationship:

$$y[n] = \sum_{k=0}^{N-1} \frac{1}{N} . x[n-k] \quad ; \text{where } \mathbf{N \text{ is a positive integer}}$$

Where

- x[n] is the input applied to the filter.
- y[n] is the resulting output response.

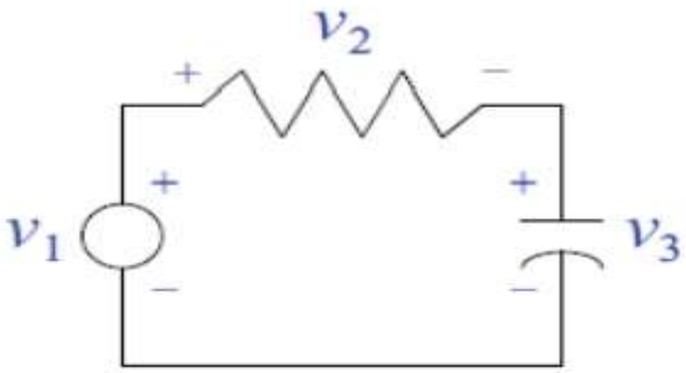
Examples of Systems

$$y[n] = \frac{1}{N}[x[n] + x[n-1] + x[n-2] + \cdots + x[n-N+1]]$$

- The output y[n] at time n of the N-point MA filter is the average of the N input values.

- MA filters are often used to reduce the magnitude of the noise that may be present in a signal.

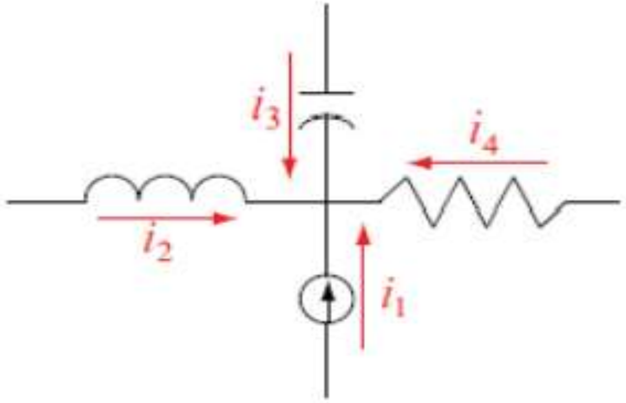
Kirchhoff's voltage law (KVL):



The sum of voltages in a loop is equal to zero:

$$-v_1 + v_2 + v_3 = 0$$

Kirchhoff's current law (KCL):

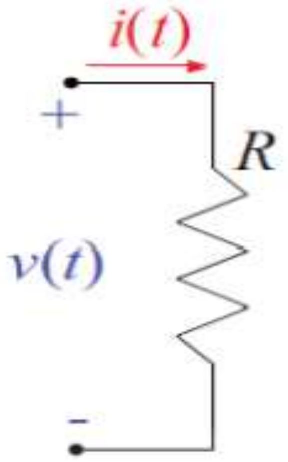


The sum of currents entering a node is equal to zero:

$$i_1 + i_2 + i_3 + i_4 = 0$$

Review: linear circuit elements

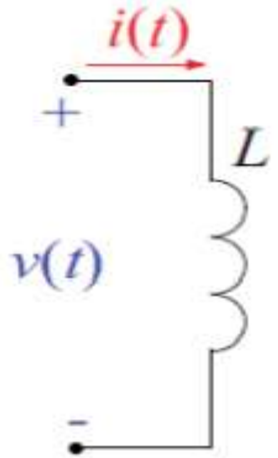
Resistor:



$$v(t) = Ri(t)$$

$$i(t) = \frac{v(t)}{R}$$

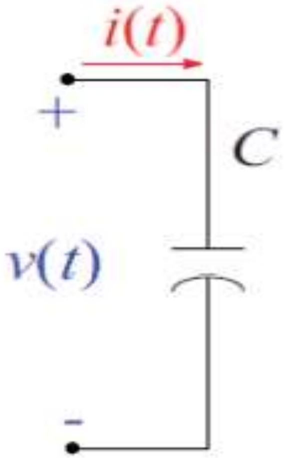
Inductor:



$$v(t) = L\frac{di(t)}{dt}$$

$$i(t) = \frac{1}{L}\int_{-\infty}^{t} v(\tau)d\tau$$

Capacitor:

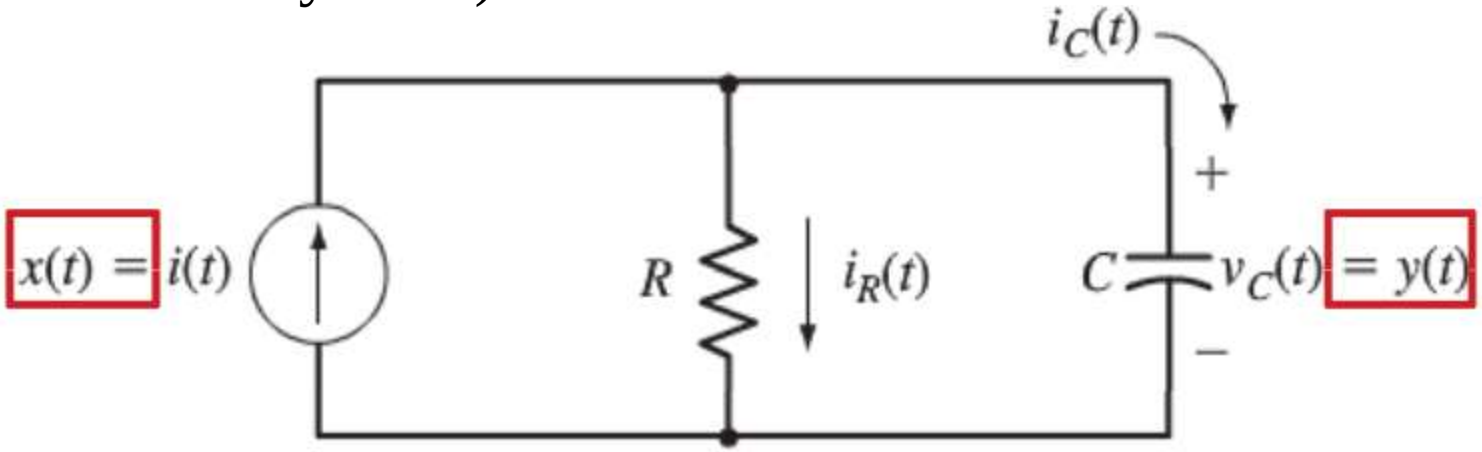


$$i(t) = C\frac{dv(t)}{dt}$$

$$v(t) = \frac{1}{C}\int_{-\infty}^{t} i(\tau)d\tau$$

Examples of Systems

- RC Circuit (continuous-time systems)



- Input/output differential equation of the circuit, that describe the relationship between the input x(t) and the output y(t).

$$C\frac{dy(t)}{dt} + \frac{1}{R}y(t) = x(t)$$

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- **Transient response analysis,** describe the behavior of the circuits before they reach steady-state conditions

- **At DC steady state (final state):**
  - ✓ Capacitor **C** behaves as **open circuit**.

    $i_C(t) \rightarrow 0$ as $t \rightarrow \infty$ Steady-state capacitor current

  - ✓ Inductor **L** behaves as **short circuit**.

    $v_L(t) \rightarrow 0$ as $t \rightarrow \infty$ Steady-state inductor voltage

Transient response

- The value of an **inductor current** or a **capacitor voltage** just **prior** to the closing (or opening) of a switch **is equal to** the value **just after** the switch has been closed (or opened).

- **At** t= **0^+ (initial state):**
  - Capacitor **C** behaves as **short circuit** (wire).
  - Inductor **L** behaves as **open circuit**.

Transient response

- The complete solution for the circuit is

$$y(t) = y(\infty) + [\, y(t0^{+}) - y(\infty)\,]\, e^{-(t-t0)/\tau}$$

Where

- t0 is the time when the source voltage switches.
- τ time constant of the circuit, It determines how fast the current or voltage transitions between initial and final value.
  - $\tau = R.C$ for capacitive circuits.
  - $\tau = L/R$ for inductive circuits.