Signals and Systems for BME

BME 322

Lecture 1

- Introduction -

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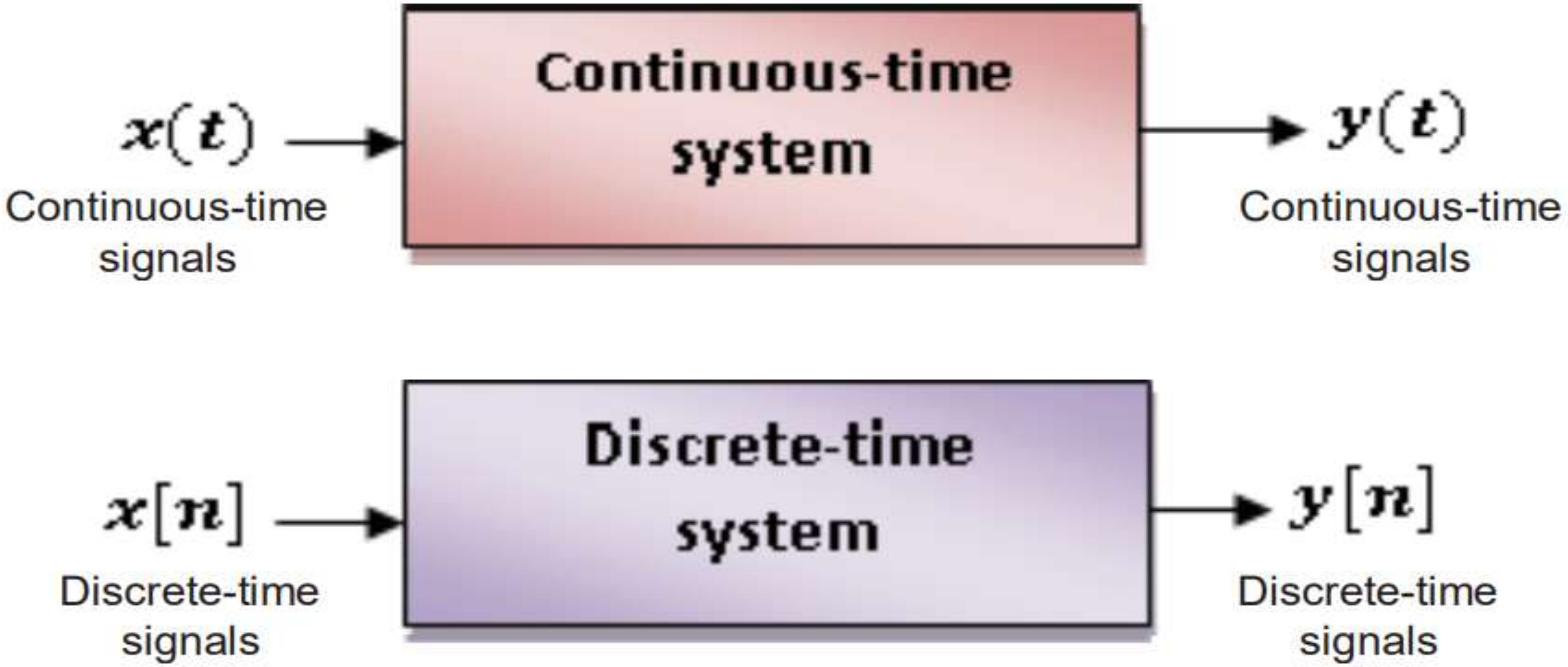
What is a system ?

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

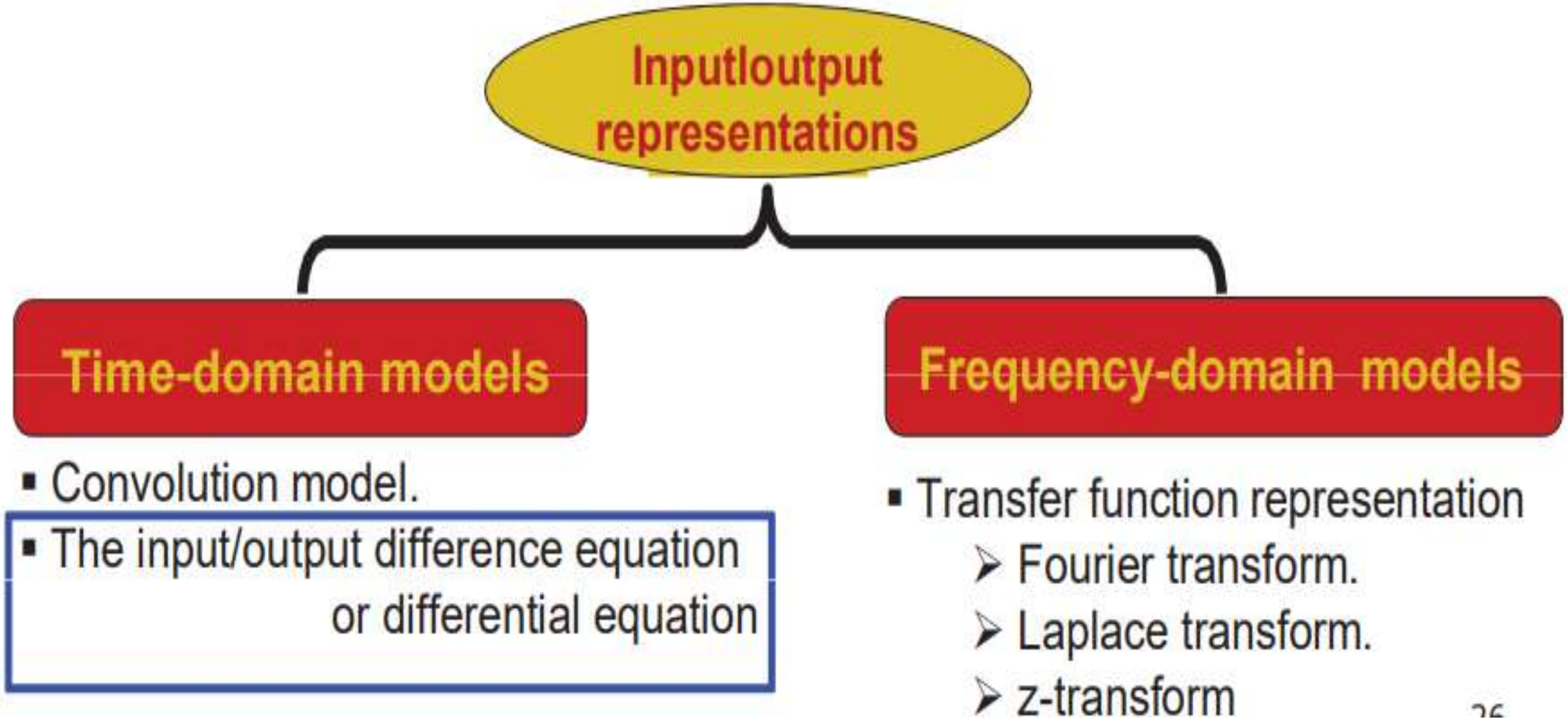


A mathematical model of a system

- 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



- 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

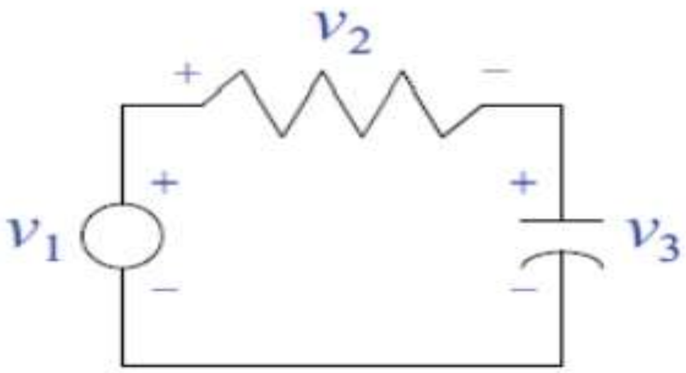
$$y[n] = \frac{1}{N}[x[n] + x[n-1] + x[n-2] + \cdots + x[n-N+1]]$$

- 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.

Review: Kirchhoff's laws

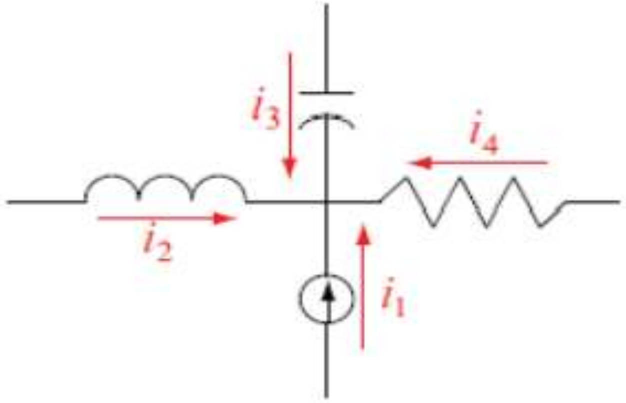
Kirchhoff's voltage law (KVL):



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

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

Kirchhoff's current law (KCL):

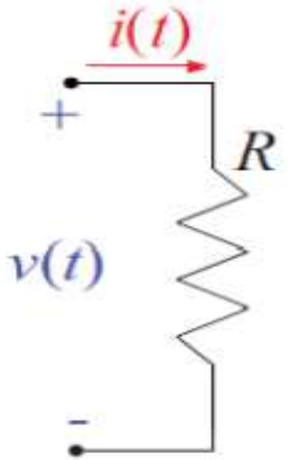


The sum of currents entering a node is equal to zero:

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

Review: linear circuit elements

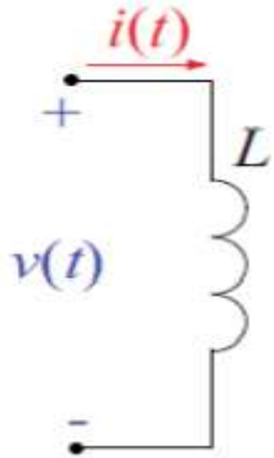
Resistor:



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

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

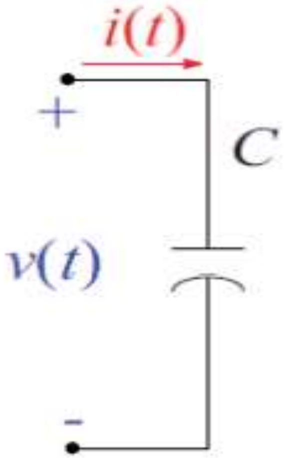
Inductor:



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

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

Capacitor:

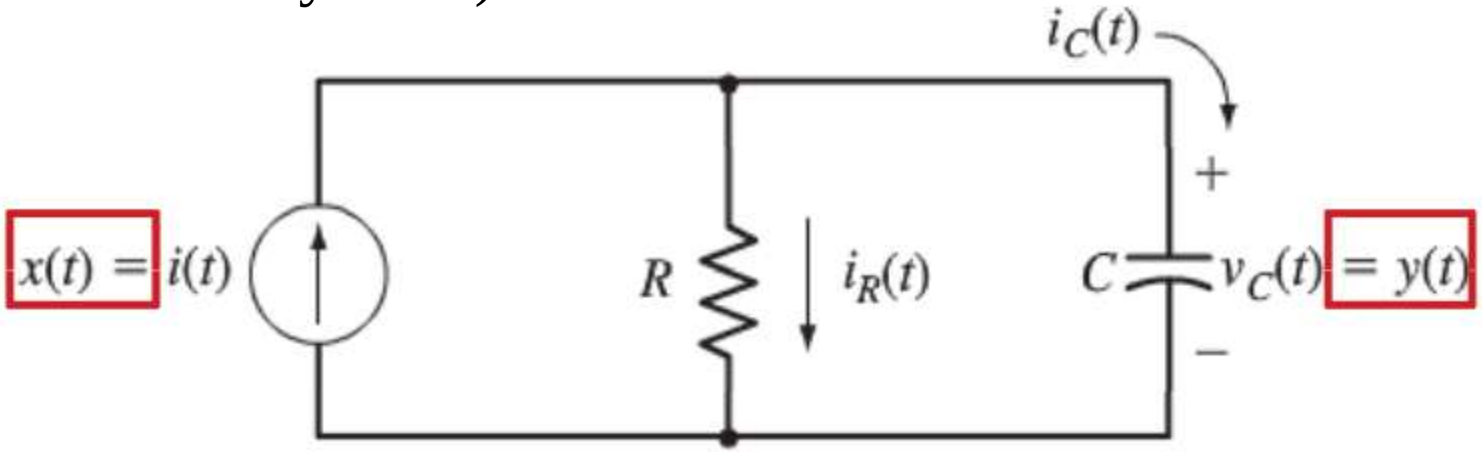


$$i(t) = C\frac{dv(t)}{dt}$$

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

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).

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