➢ Systems Properties

3- Causality:

The system is said to be casual if the output at any time depends only on the present or past values of the input (not on future values).
Also called "*nonanticipative*" لا يتنبأ – لا يستشرف system.

Examples:
- The RC circuit, where the capacitor voltage responds only to present and past values of source voltage.
- Automobile motion, where it does not anticipate future actions of the driver.

Note: *All Memoryless systems are also causal systems*.

The noncausal systems are applicable when we are processing a stored data (like a recorded audio file) or when the independent variable is not the time (like in image processing), or when there is a time-delay in the system.

The counter example strategy stated previously for Memoryless is applicable to check causality of a given system.

➢ Systems Properties

3- Causality:

Self-Check Examples:

$$y[n] = x[n] + 3x[n+1]$$

$$y(t) = x(t)\cos(t+1)$$

$$y[n] = x[-n]$$

➢ Systems Properties

4- Stability:

The system is said to be stable if bounded inputs leads to bounded outputs BIBO.

$$x(t) \text{ Bounded} \Rightarrow |x(t)| < B \quad , \; B < \infty \quad , \text{ for all } t$$

***Stability of physical systems generally results from the presence of mechanics that dissipates energy.**

Examples:

- **The RC circuit is stable, as R dissipates energy.**
- **The Automobile represent stable system as the friction dissipates energy and the speed does not go to ∞ .**

-A bank account with initial deposit without further withdrawals represents unstable system as the balance increased without a bound.

4- Stability:

Self-Check Examples:

- $y(t) = t\,x(t)$

- $y(t) = e^{x(t)}$

Signals and Systems

Lecture # 7

System Properties (continued)

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Topics of the lecture:

- **Systems Properties.**(continued)
  5. **Time-Invariance**
  6. **Linearity**

➢ Systems Properties

5- Time-Invariance:

The system is said to be time-invariant if the behavior and characteristics of the system are (not change) fixed over time.

Example: in RC circuit if the values of resistance (R) and capacitance (C) are not changed over time then the RC circuit will be time-invariant. Then you expect to get the same results if you repeat the same experiment at two different times. But, if the values of (R) and (c) changed/fluctuate over time, then the results of repeated experiment will not be the same as the system becomes time-variant.

In signals and systems language, the system is said to be time-invariant if a time-shift in the input signal results in identical time-shift in the output signal.

So, any time-varying gain system is not time-invariant nor stable.

➢ Systems Properties

5- Time-Invariance:

1- let : $$x_1(t) \xrightarrow{S} y_1(t)$$

And let $$x_2(t) = x_1(t - t_o) \xrightarrow{S} y_2(t)$$

2- Get $y_2(t)$ in terms of $x_1(t)$ using the system equation. → I

3- Get the expression $y_1(t-t_o)$ by replacing each (t) by $(t-t_o)$ → II

4- check if the result of I and II are equal?

- If Yes → time-invariant system.
- If No → not time-invariant system

➢ Systems Properties

5- Time-Invariance:

Examples to be solved on the board :

$$y(t) = \sin(x(t))$$

$$y[n] = n\,x[n]$$

$$y(t) = x(2t)$$

➢ Systems Properties

5- Time-Invariance: $y(t) = \sin(x(t))$

➢ Systems Properties

5- Time-Invariance: $y[n] = n\,x[n]$

➢ Systems Properties

5- Time-Invariance: $y(t) = x(2t)$