

# SIGNALS and SYSTEMS

2022-2023

LECTURE 05

# TOPICS

1-Linear time-Variant (LTV) – Linear time invariant (LTI) systems

2- Introduction to

- Unit Impulse, Impulse response,
- Transfer Function
- Convolution

## 5.1. Linear Time Invariant (LTI) and Time Variant Systems (LTV) Systems

- ❑ A system is said to be Linear Time Variant (LTV) when it satisfies both linearity and time **variance**.
- ❑ A system is said to be Linear Time Invariant (LTI) when it satisfies both linearity and time **invariance**.
- ❑ **Superposition Theorem For Linearity:**
  - ❑  $T[a_1x_1(t) + a_2x_2(t)] = a_1T[x_1(t)] + a_2T[x_2(t)]$
- ❑ **The condition for time invariance is**
  - ❑  $y(n,k) = y(n-k)$  where  $y(n,k) = T[x(n-k)]$

## 5.1. Let's Remember Linearity and Time variability

## 5.1.1 Check Linearity and Time (In)Variancy

□ Eg 1:  $y(n) = nx^2(n)$

## 5.1.1 Check Linearity and Time (In)Variancy

□ Eg 2:  $y(t) = x(t) + 5$

## 5.1.1 Check Linearity and Time (In)Variancy

□ Eg 3:  $y(t) = x(t^2)$

## 5.1.1 Check Linearity and Time (In)Variancy

□ Eg 4:  $y(t) = \cos t \cdot X(t)$



## 5.1.1 Check Linearity and Time (In)Variancy

□ Eg 5:  $y(t) = 2x(t)$

## Prerequisites for LTI Systems (Revision of Linearity & Time Variance)

- » System linearity is independent of time scaling
- » System linearity is independent of coefficient used in system relationship
- » If any added/subtracted term other than i/p and o/p is available in the system relationship then the system will be nonlinear
- » If output is summation of time shifted terms of input, then the system will be linear
- » Integral and Differential operators are linear operators
- » Even and Odd operators are linear operators
- » Real, Imaginary and Conjugate operators are nonlinear operators
- » Trigonometric, Inverse Trigonometric, Logarithmic, Exponential, Roots, Powers, Modulus, sgn, sa, sinc,.....
- » For zero i/p, o/p is also equal to zero
- » Split systems are linear systems

### For TIV System:

- » No time scaling
- » Coefficient in system relationship should be constant
- » Any added/subtracted term in the system relationship (except i/p and o/p) must be constant or zero



## 5.2. Impulse Response / Transfer Function / Convolution

□ **Transfer Function** is defined as the ratio of Laplace transform of output to the Laplace transform of input when all the initial conditions are assumed to be zero.

□ **Impulse response** means; the response of the system to impulse signal. Impulse response is calculated for generally only for LTI systems.

□ **Convolution** is a mathematical tool to combining two signals to form a third signal. Therefore, in signals and systems, the convolution is very important because it relates the input signal and the impulse response of the system to produce the output signal from the system.

- ❖ Next week, we will discuss
  - ❖ Examples for convolution
  - ❖ Frequency Domain

Thank You