AL- MUSTAQBAL UNIVERSITY COLLEGE
DEPARTMENT OF BIOMEDICAL ENGINEERING

Digital Signal Processing (DSP)

BME 312

Lecture 4

- Periodic & Aperiodic Signals -

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Classification of Signals

One of the most important classify of a signals are:

- Periodic signals.
- Non periodic signals.

Revision on Numbers

- Real numbers are the numbers that we normally use and apply in real-world applications.

- Real Numbers include:

  - ❖ Whole Numbers (like 0, 1, 2, 3, 4, etc)

  - ❖ Rational Numbers (like 3/4, 0.125, 0.333, 1.1, etc)

  - ❖ Irrational Numbers (like π, $\sqrt{2}$, etc)

- Real Numbers can also be positive, negative or Zero.

Periodic Signals

- A continuous-time signal, x(t) is a periodic signal if $x(t + nT) = x(t)$, where T is the period of the signal and n is an integer.

- Sinusoidal, square and triangular waves are periodic signals.

- For $x(t) = x_1(t) + x_2(t)$, where $x_1(t)$ and $x_2(t)$ are two periodic signals with fundamental T_1 and T_2 respectively, x(t) is a periodic signal if T_1/T_2 = a rational number.

- The fundamental period, T for x(t) is the least common multiples (LCM) of T_1 and T_2.

Least Common Multiples (LCM)

- The smallest positive number that is a multiple of two or more numbers.

- The multiples of 4 are: 4, 8, 12, 16, 20, 24, 28, 32,36, 40, 44,...

- The multiples of 5 are: 5, 10, 15, 20, 25, 30, 35, 40,45, 50, ...

- So, the common multiples of 4 and 5 are: 20, 40, (and 60, 80, etc ..., too).

- The smallest of the common multiples is 20, so the least common multiple (LCM) of 4 and 5 is 20.

Example

Determine whether each of the following signal is periodic. If a signal is periodic, determine its fundamental period.

$$x(t) = \cos(t + \pi/4)$$

Sol:

$x(t) = \cos(t + \pi/4)$ is in the form

$A \cos(2\pi f_0 t)$

Where f_0 is the fundamental frequency.

In this case, $f_0 = 1/(2\pi)$.

Therefore, the fundamental frequency, $T_0 = 1/f_0 = 2\pi$

Example

Determine whether or not the following signals are periodic. In case a signal is periodic, specify the fundamental frequency.

$$x(t) = 8 \sin (0.8 \pi t + \pi/4) + 5 \cos (0.6 \pi t + \pi/6)$$

$W_1 = 0.8 \pi \Rightarrow T_1 = 2 \pi / W_1 \Rightarrow 2 \pi / 0.8 p \Rightarrow 5/2$

$W_2 = 0.8 \pi \Rightarrow T_2 = 2 \pi / W_2 \Rightarrow 2 \pi / 0.6 \pi \Rightarrow 10/3$

$T_1 / T_2 = 5/2 * 3/10 = 3/4 \Rightarrow$ Rational Number $\Rightarrow$ Periodic.

$3 T_2 = 4 T_1 = T$

$T = 3 T_2 \Rightarrow 3 * 10/3 \Rightarrow 10$ Sec.

$T = 4 T_1 \Rightarrow 4 * 5/2 \Rightarrow 10$ Sec.

The fundamental frequency, T_0 is the least common multiples (LCM) which is 10 seconds.

Example

Determine whether or not the following signals are periodic. In case a signal is periodic, specify the fundamental frequency.

$$x(t) = \cos(\pi/3)t + \sin(\pi/4)t$$

Sol:

This is the sum of two functions that are both periodic.

Their fundamental periods are $T_1 = 6$ seconds and $T_2 = 8$ seconds respectively.

$T1/T2 = 6/8$ is a rational number.

Therefore x(t) is a periodic signal.

The fundamental frequency, T_0 is the least common multiples (LCM) which is 24 seconds.

Classification of Signals

One of the most important classify of a signals are:

- Continuous time signals.
- Discrete time signals.

Learning Outcomes

Students are able to:

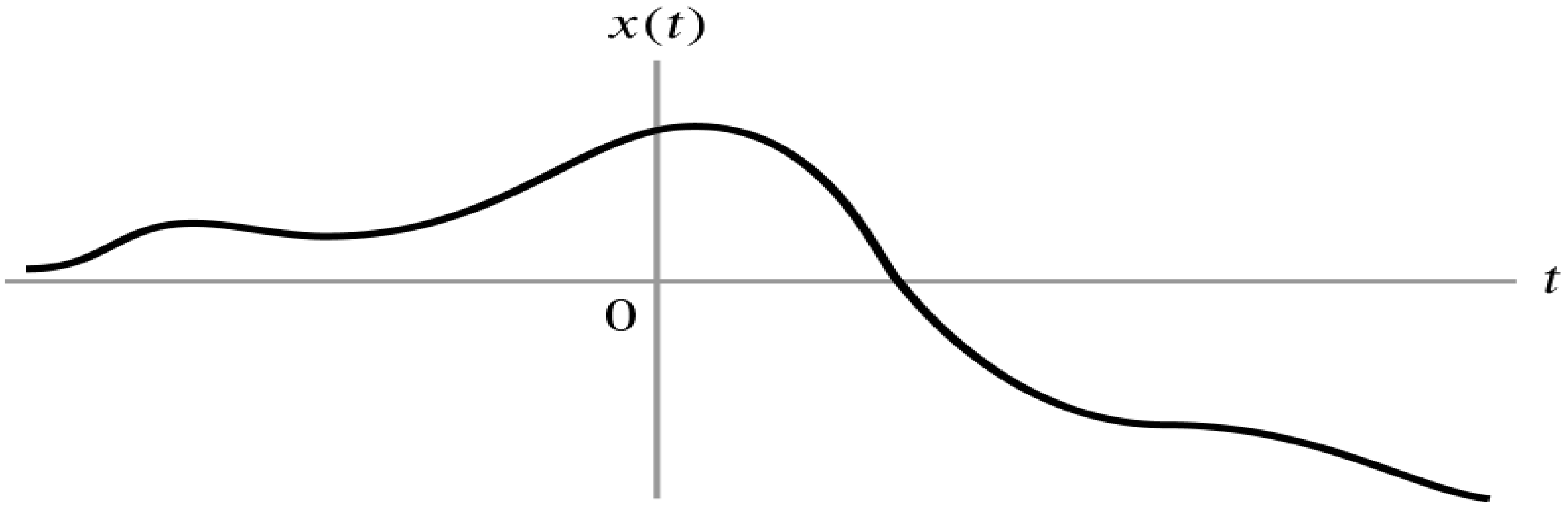
- Represent continuous-time signals in frequency domain..

- Perform basic operations on continuous-time signals..

Continuous Time (CT) Signals

- In continuous time signals the independent variable is continuous, and they are defined for a continuum of values

- Most of the signals in the physical world are CT signals—E.g. voltage & current, pressure, temperature, velocity, etc.



Learning Outcomes

Students are able to:

- Represent discrete-time signals in frequency domain..

- Perform basic operations on discrete-time signals..

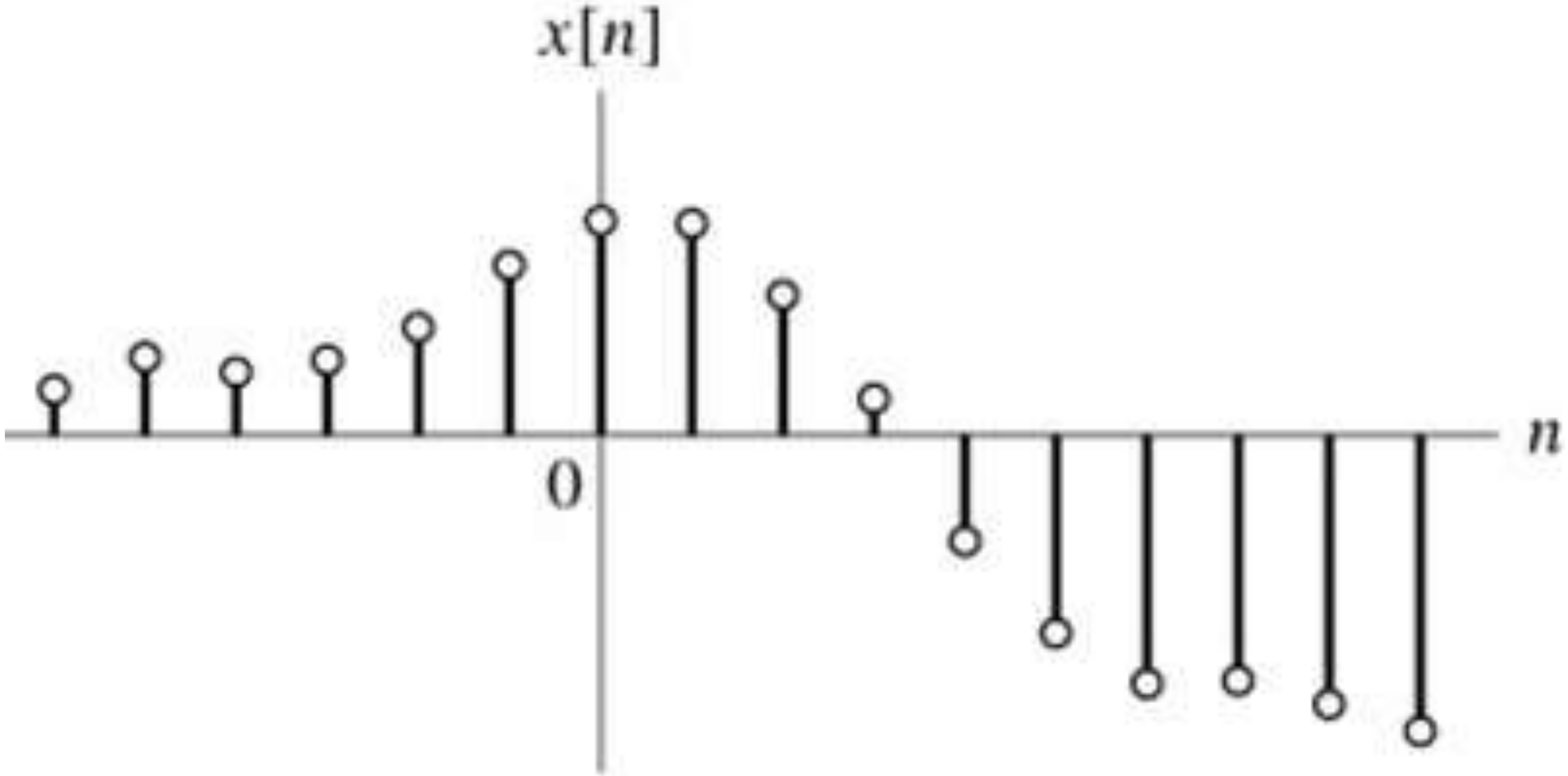
Discrete Time (DT) Signals

- A discrete-time signal is defined only for discrete values of the independent variable at uniform intervals $t = nT$ where T is the interval between time samples and n is an integer.

- This signal, which is a sequence of numbers, may be obtained by sampling a continuous time signal.

- Discrete time signals are defined only at discrete times and for these signals the independent variable takes on only a discrete set of values.

Example DT Signal



Representation

- To distinguish between continuous-time and discrete time signals, we will use the symbol ‘t’ to denote the continuous time independent variable and ‘n’ to denote the discrete time independent variable.

Functional Notation

- For functions whose independent variable is either real numbers or complex numbers, the independent variable will be enclosed in parentheses ( ).

- For functions whose independent variable is integers the independent variable will be enclosed in brackets [ ].