Al-Mustaqbal University

College of Engineering and Technology

Department of Biomedical Engineering

Stage: three

Signal Processing

2023-2024

Lecture (1): Introduction to Digital Signal Processing (DSP)

Introduction to Digital Signal Processing (DSP)

1) **Digital Signal Processing**: is concerned with the representation of signals by sequence of number or symbols and the processing of these signals.
2) **Signal**: Anything that conveys information can be termed as a signal.

   A signal can also be defined as a single valued function of one or more independent variables which has some information.

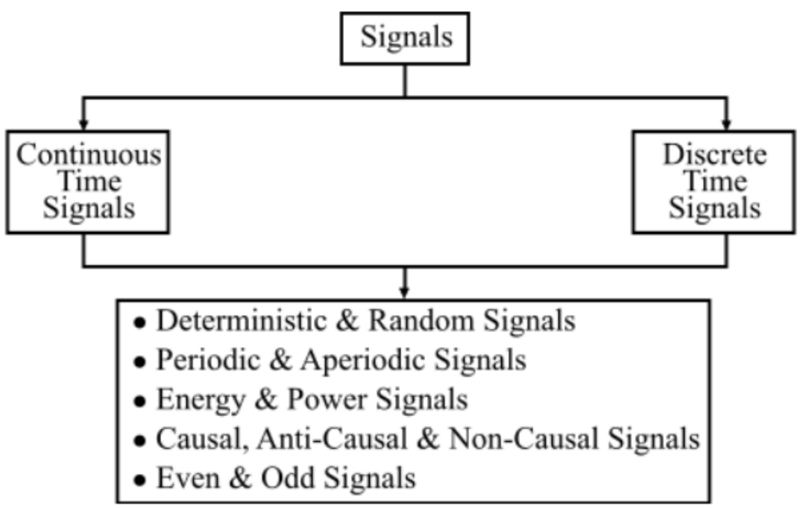
   A signal may also be defined as any physical quantity that varies with time or any other independent variable. For example:

$$f(t) = 3t^2 \quad (one\ variable) or (one\ dimentional\ signal)$$

$$f(t) = 3x + 4xy + 6x^2 \quad (two\ variables\ x\ \&y) or (two\ dimentional\ signal)$$

Some common examples of a signal are human speech, electric current, electric voltage, etc.

1) **Classification of Signals**
   Signals are classified into the following categories:



A) **Continuous Time Signals**: The signals which are defined for every instant of time are called as continuous time signals. The continuous-time signals are also called as analog signals. The graphical representation of continuous-time signals is shown in (Figure-1)

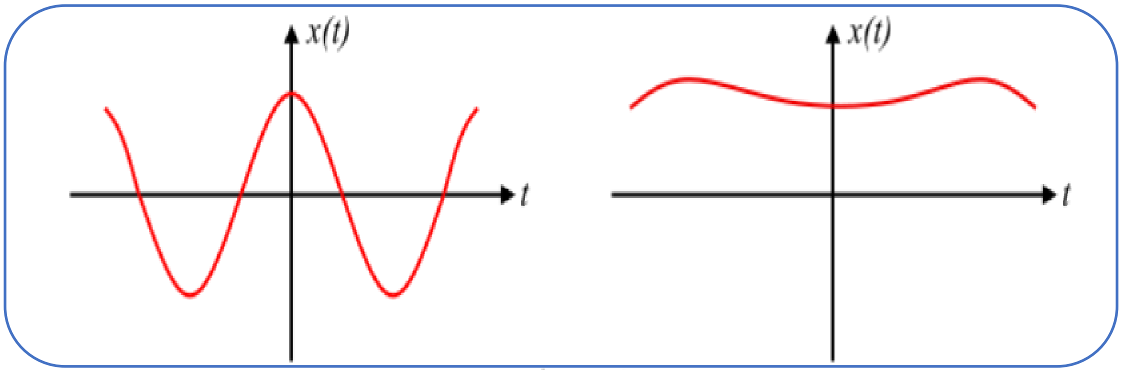
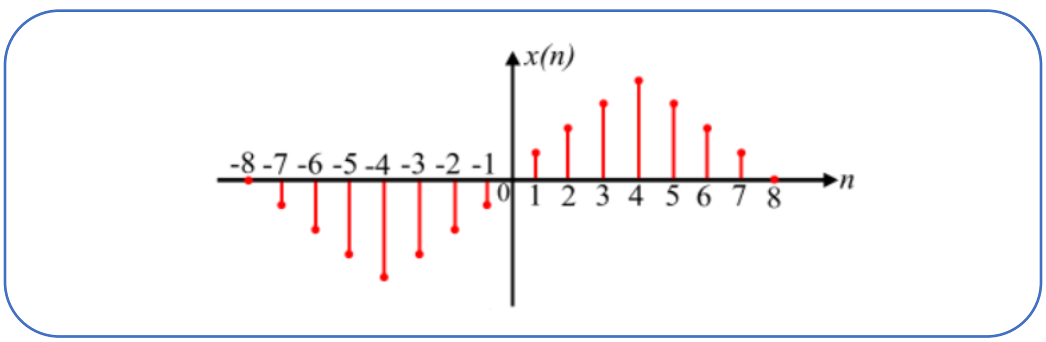


Figure (1): Continuous time signals

B) Discrete Time Signals: Those signals which are defined only at discrete instants of time are called as discrete time signals. The amplitude of discrete time signals is continuous but these signals are discrete in time. The amplitude of a discrete time signal between two time instants is just not defined. For the discrete time signals, the independent variable is time, denoted by (n). As these signals are defined only at discrete time instants, therefore, they are given by a sequence x(n) or x(nT) where, n is an integer. The graphical representation of discrete time signals is shown in (Figure-2).



Figure(2):Discrete time signal

Both discrete-time and continuous-time signals may be further classified as follows :-

a. **Deterministic Signals** : A deterministic signal is the one that exhibits no uncertainty of amplitude and phase at any instant of time. These signals have a regular pattern. Sine wave, exponential signals, square wave, etc. are the examples of deterministic signals.

*Deterministic Signals can be easily define by function. For example

X(t)=sine(3t)

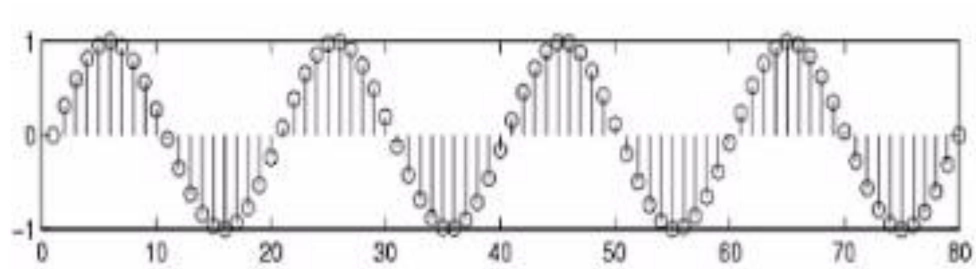


Figure (3): Deterministic signal

b. **Non-Deterministic or Random Signals**: A signal that has uncertainty about its occurrence is known as random signal. A random signal has irregular pattern and cannot be represented by the mathematical equations. Thermal noise generated in an electric circuit is a common example of random signal**.**

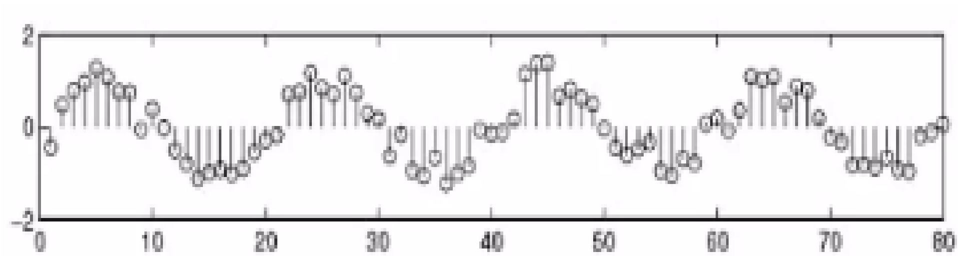


Figure (4): Random signal

c. **Periodic Signals**: A periodic signal is defined as a signal which has a definite pattern which repeats itself at regular intervals of time.

-A continuous time signal x(t) is said to be periodic if and only if

$x(t) = x(t \pm nT_o)$ for $-\infty < t < \infty$

Where, **n** is integer & T_0 is fundamental period (smallest positive fixed value of time for which signal is periodic.

**fundamental frequency $f_0=1/T_0$ (Hz).

**fundamental Angular frequency $w_0=2\pi f_0=2\pi/T_0$ (rad).

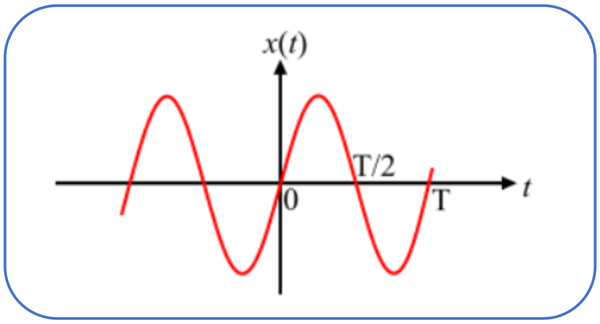


Figure (5): Continuous-time periodic signals

- A discrete-time signal x(n) is said to be periodic if it satisfies the following condition

$$x(n) = x(n \pm mN) \qquad \text{for all integers } n$$

Here, N is the time period of the periodic signal and a positive integer.

**fundamental frequency F=1/N

**Angular frequency $w_0=2\pi F=2\pi/N$

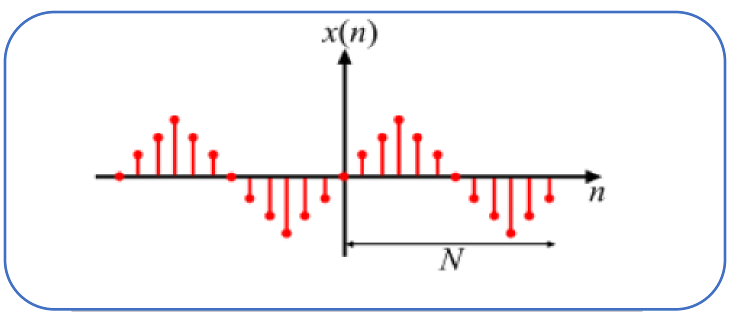


Figure (6): Discrete time periodic sequences

d. **Aperiodic Signals or Non-periodic signals**: A signal which does not repeat at regular intervals of time is known as aperiodic signal. This means that it does not have a fundamental frequency. non-periodic signals can be continuous or discrete, and they can be either deterministic or random.

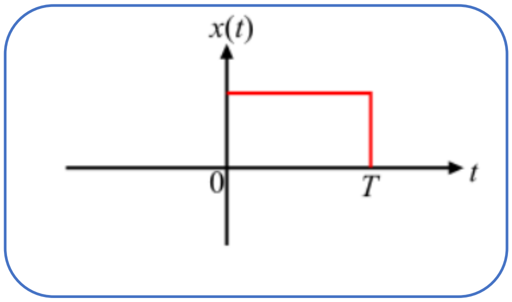


Figure (7): Non-periodic continuous signal

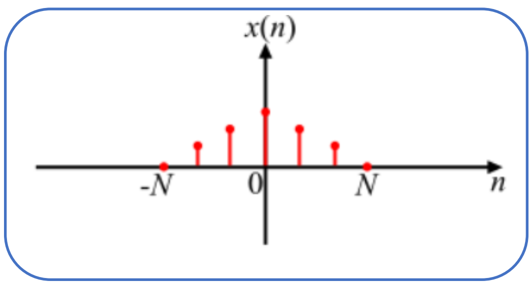


Figure (8): Non-periodic discrete signal

e. **Energy Signal:** A signal is said to be an energy signal if and only if its total energy E is finite, i.e., $0 < E < \infty$. The nonperiodic signals are the examples of energy signals.

f. **Power Signal:** A signal is said to be a power signal if its average power P is finite, i.e., $0 < P < \infty$. The periodic signals are the examples of power signals.

******Both energy and power signals are mutually exclusive, i.e., no signal can be both power signal and energy signal.

**All practical signals have finite energy; thus they are energy signals.

**the physical generation of power signal is impossible since its requires infinite duration and infinite energy.

g. Causal Signal: A continuous time signal $x(t)$ is called causal signal if the signal $x(t) = 0$ for $t < 0$. Therefore, a causal signal does not exist for negative time. The unit step signal u(t) is an example of causal signal.

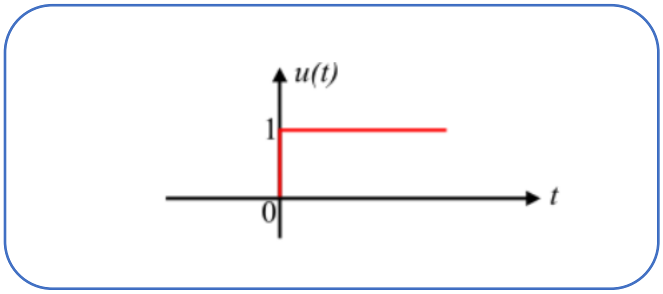


Figure (9): Causal signal

h. Anti-Causal Signal: A continuous-time signal x(t) is called the anti-causal signal if x(t) = 0 for t > 0. Hence, an anti-causal signal does not exist for positive time. The time reversed unit step signal u(-t) is an example of anti-causal signal.

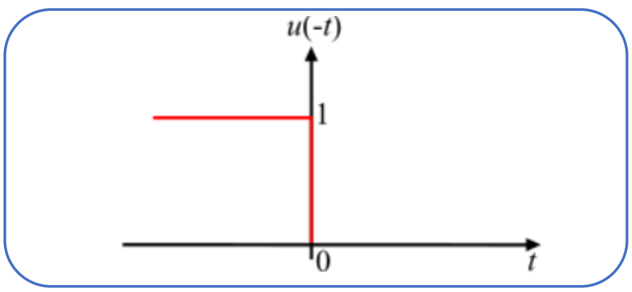


Figure (10): Anti-causal signal

i. Non-Causal Signal: a signal that exists for positive as well as negative time is neither causal nor anti-causal, it is non-causal signal. The sine and cosine signals are examples of non-causal signal

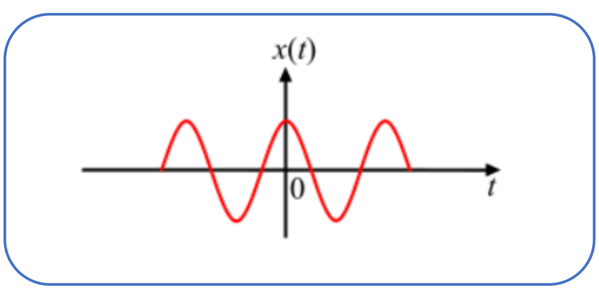


Figure (11): Non-causal signal

j. **Even Signal:** A signal is referred to as an even if it is identical to its time-reversed counterparts; x(t) = x(-t) or x(n)=x(-n)

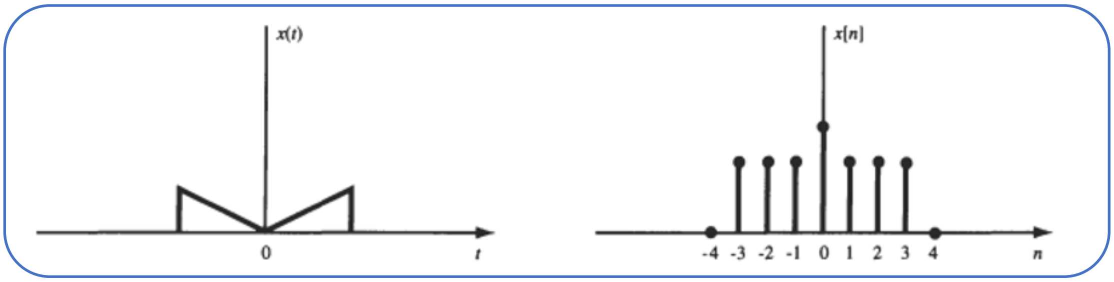


Figure (12): Even signal

k. **Odd Signal**: A signal is odd if x(t) = -x(-t). An odd signal must be 0 at t=0, in other words, odd signal passes the origin.

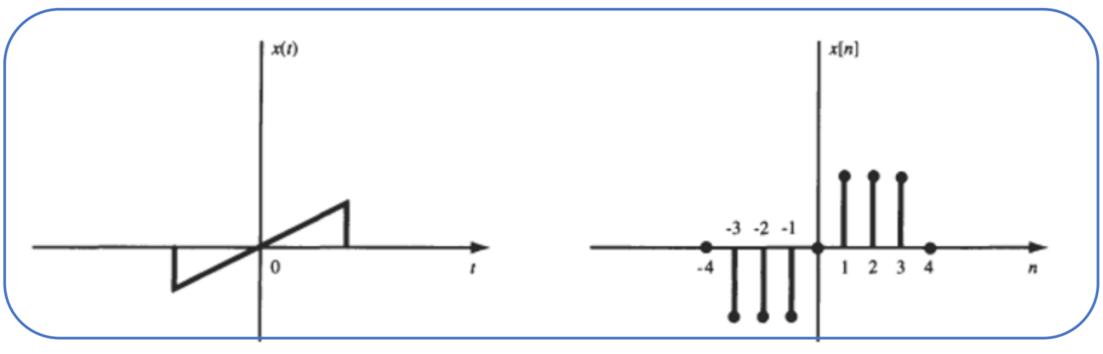


Figure (13): Odd signal