AL- MUSTAQBAL UNIVERSITY COLLEGE
DEPARTMENT OF BIOMEDICAL ENGINEERING

Digital Signal Processing (DSP)

BME 312

Lecture 2

- Introduction to DSP -

Dr. Zaidoon AL-Shammari
Lecturer / Researcher
zaidoon.waleed@mustaqbal-college.edu.iq

Signals

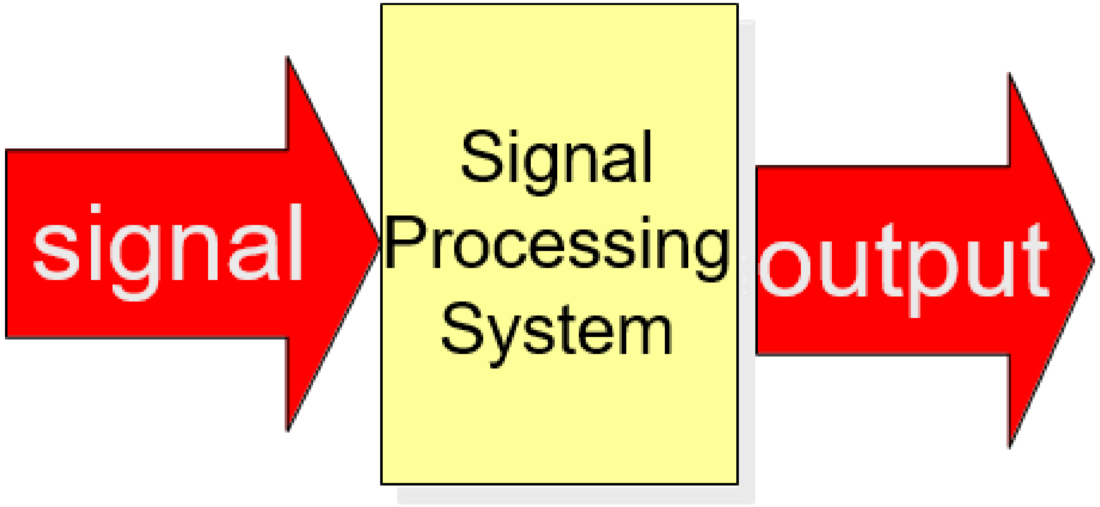
- A signal is a function of time representing a physical variable, eg: voltage, current etc.

- A signal is defined as a function of one or more independent variables.

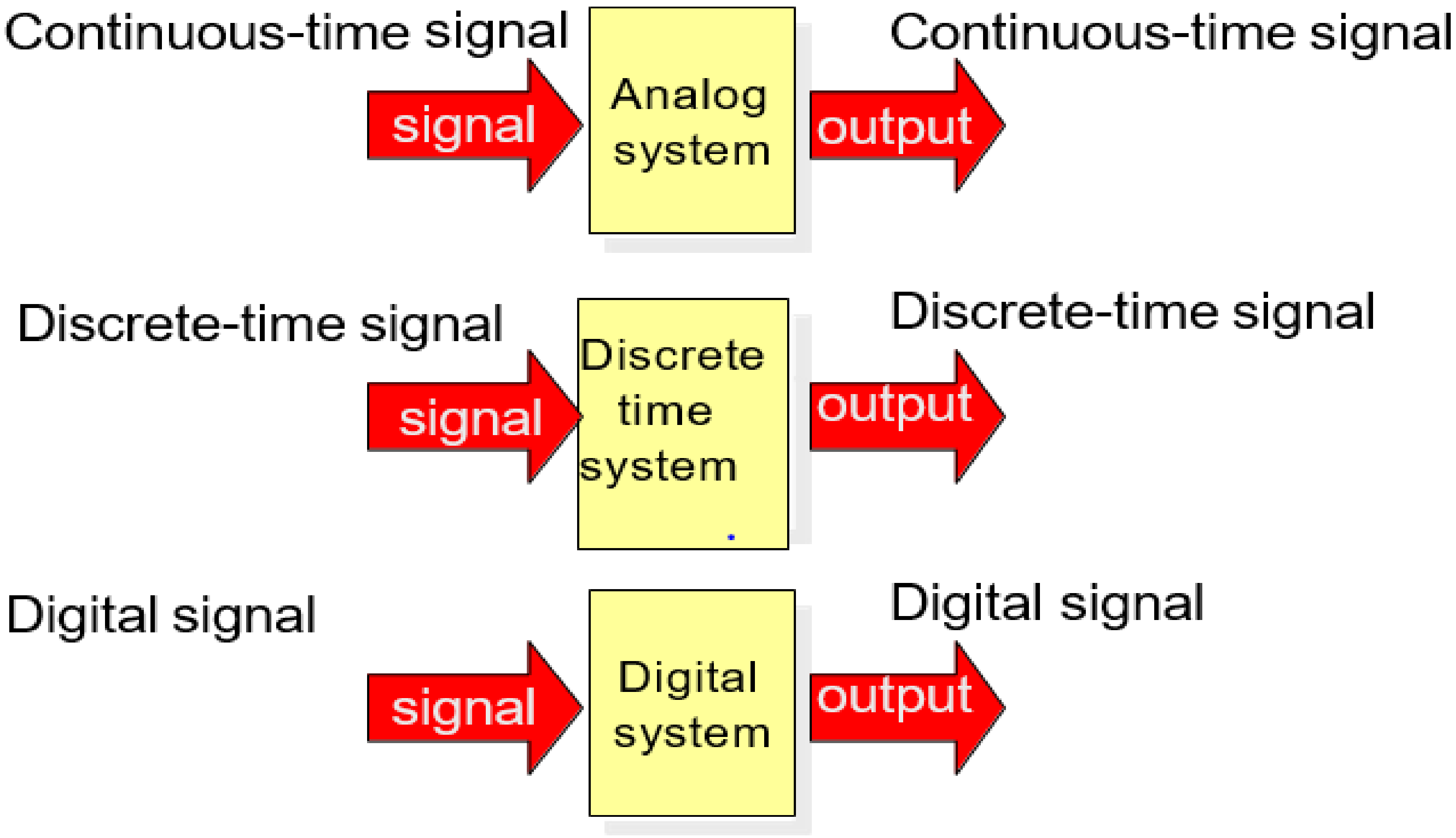
  - For example, the function $x(t) = 5t$

  - That signal is represented as a function of an independent variable t (time).

- Signals are functions of independent variables that carry information.



- Facilitate the extraction of desired information.


Continuous-time signal
signal
Analog system
output
Continuous-time signal
Discrete-time signal
signal
Discrete time system
output
Discrete-time signal
Digital signal
signal
Digital system
output
Digital signal

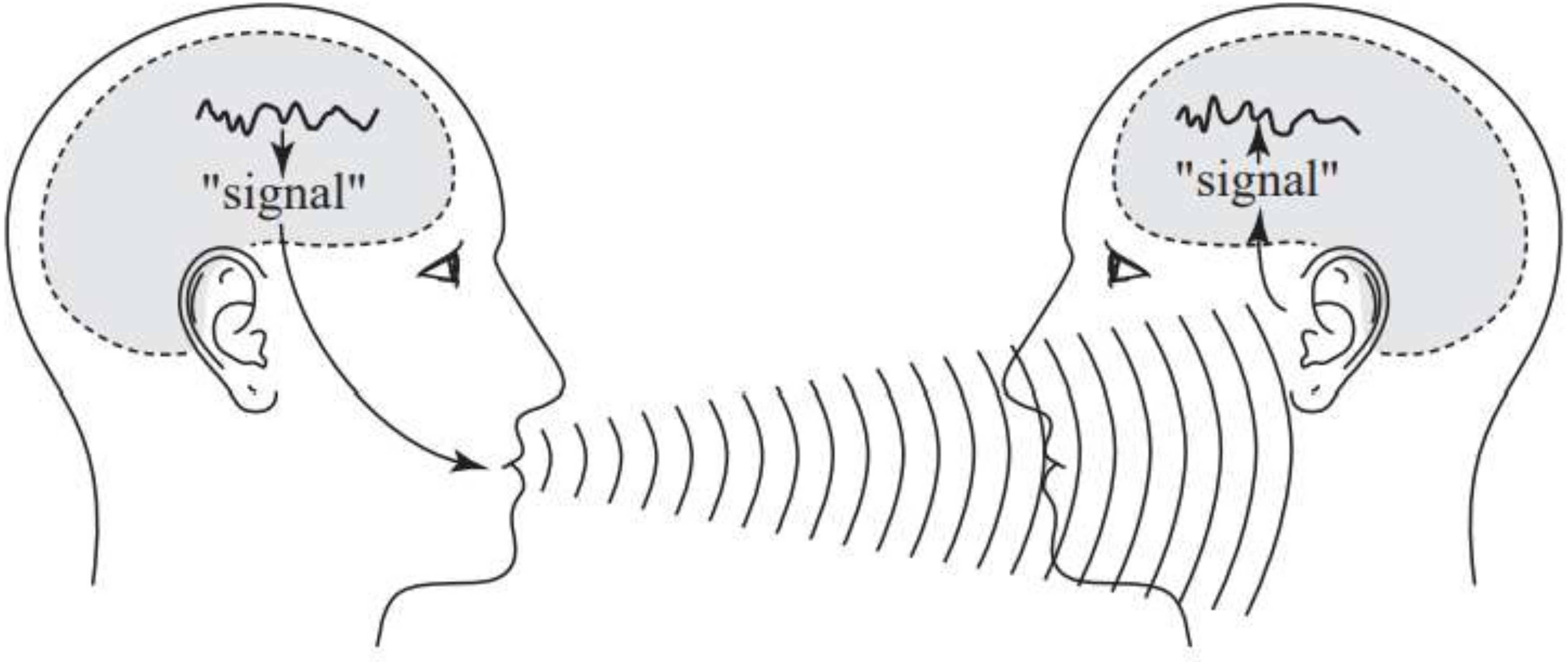


Fig:

Communication between two people involving signals and signal processing by systems

Classification of Signals

Based on different features for signals, we may identify five methods of classifying signals:

- Continuous-Time and Discrete-Time Signals.
- Analog and Digital Signals.
- Periodic and Non periodic Signals.
- Deterministic and Random Signals.
- Even and Odd Signals.

Al- Mustaqbal
University College

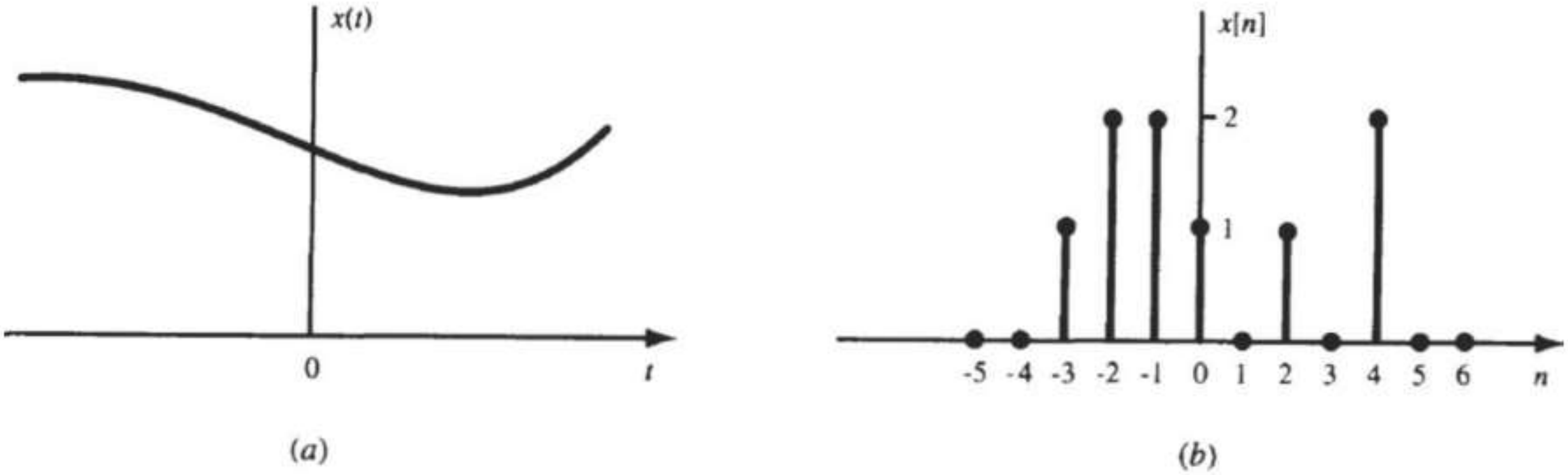


Fig: Graphical representation of :
(a) Continuous-time and **(b)** Discrete-time signals

Analog and Digital Signals

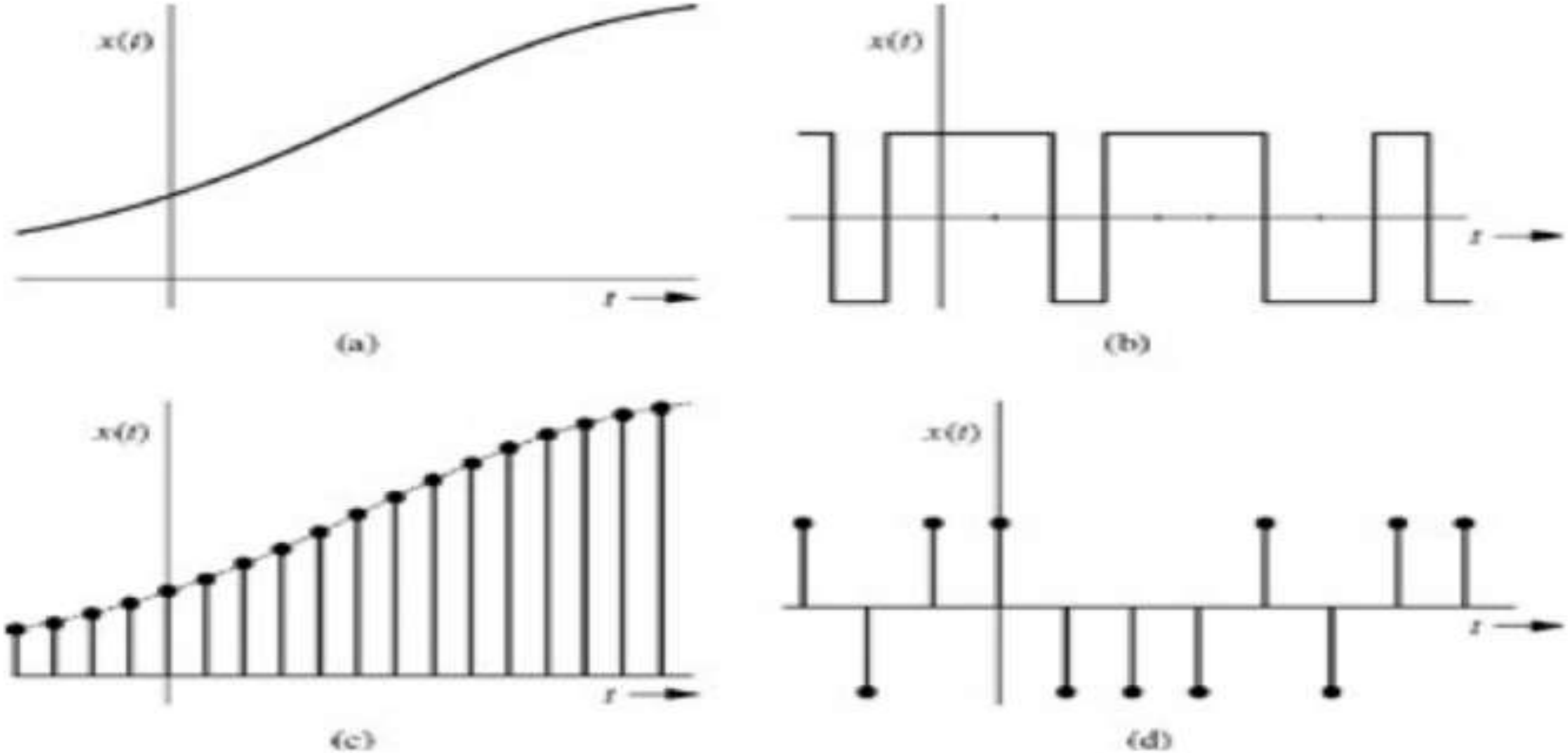


Fig: Graphical representation of:
(a) Analog, continuous time, **(b)** Digital, continuous time,
(c) Analog, discrete time, and **(d)** Digital, discrete time

Periodic and Non periodic Signals

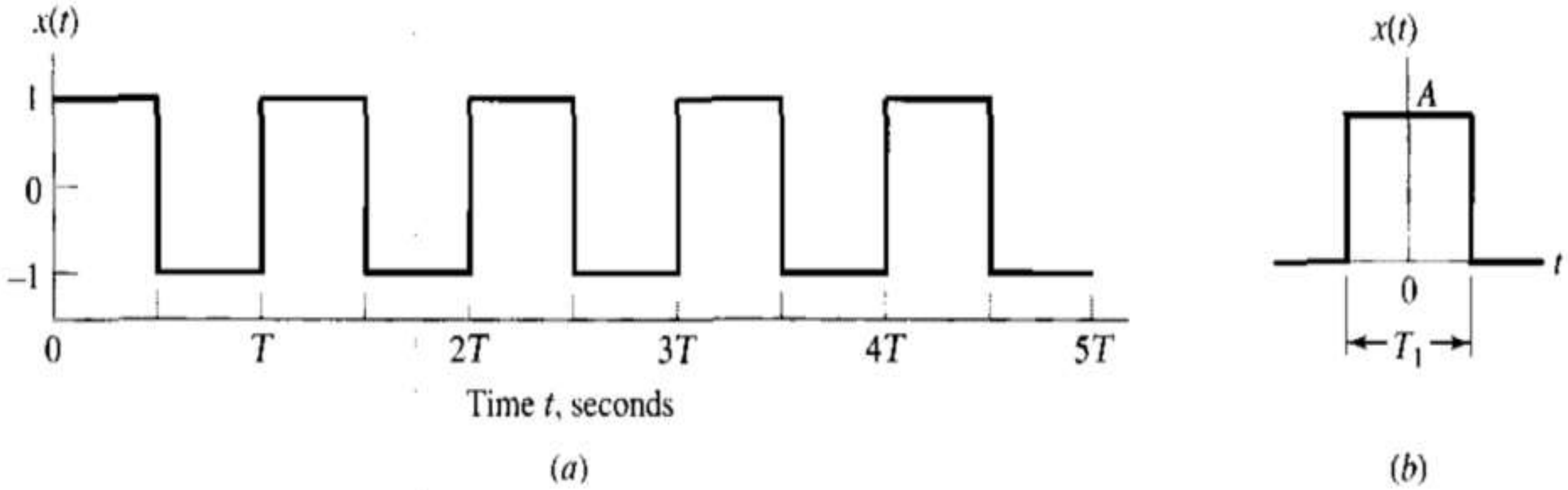
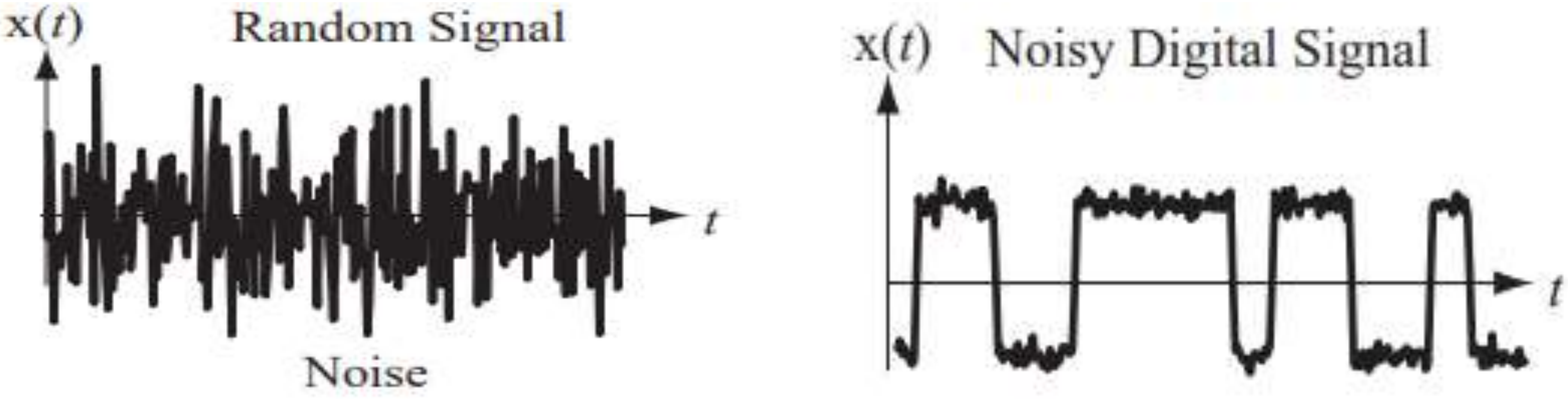


Fig: Graphical representation of:
(a) Periodic signal, square wave, **(b)** Non periodic, signal rectangular pulse



(a) **(b)**

Fig: Graphical representation of:
(a) Random Signal, **(b)** Noisy Digital Signal

Even and Odd Signals

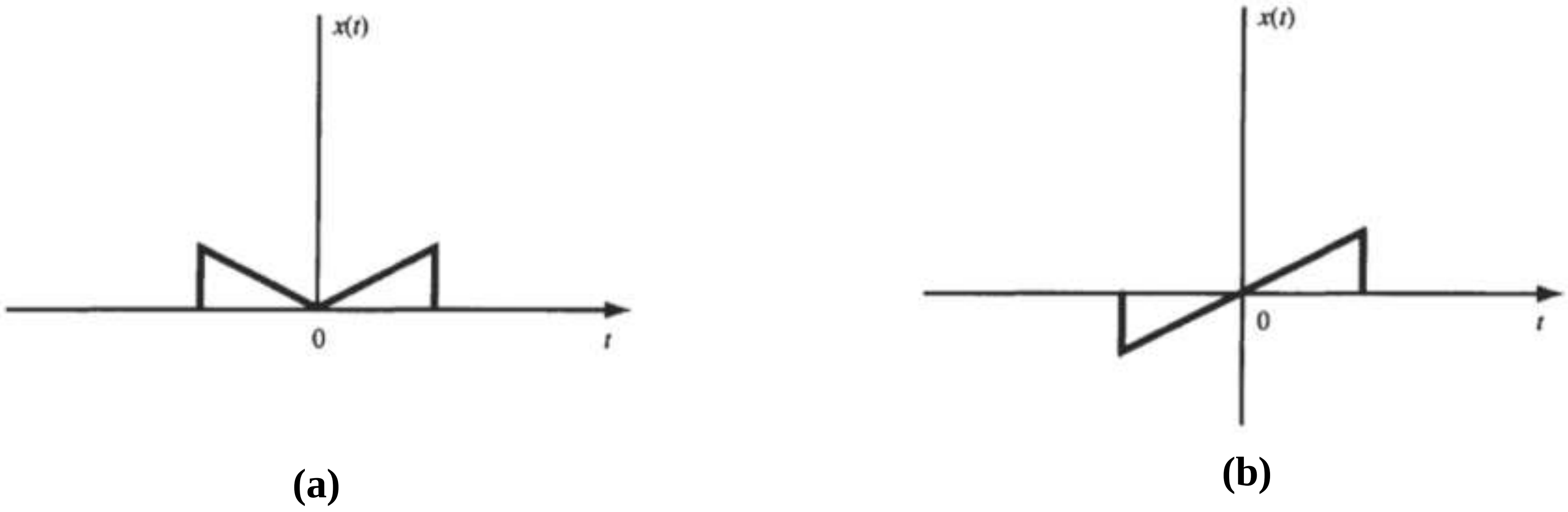


Fig: Graphical representation of:
(a) Even Signal **(b)** Odd Signal

These operations can be classified into two categories,

- Operations performed on the dependent variable and
- Operations performed on the independent variable.

- Amplitude scaling:

Let x(t) denote a continuous-time signal. The signal y(t) resulting from amplitude scaling applied to x(t) is defined by

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

Where c is the scaling factor. According to above equation the value of y(t) is obtained by multiplying the corresponding value of x(t) by the scalar c.

- **Addition:**

Let $x_1(t)$ and $x_2(t)$ denote a pair of continuous-time signals. The signal y(t) obtained by the addition of $x_1(t)$ and $x_2(t)$ is defined by

- $y(t) = x_1(t) + x_2(t)$

Multiplication:

Let $x_1(t)$ and $x_2(t)$ denote a pair of continuous-time signals. The signal y(t) resulting from the multiplication of $x_1(t)$ and $x_2(t)$ is defined by

- $y(t) = x_1(t)\, x_2(t)$

Operations performed on the independent variable

- Time scaling:
  Let x(t) denote a continuous-time signal. The signal y(t) obtained by scaling the independent variable, time t, by a factor a is defined by

  - y(t) = x(at)

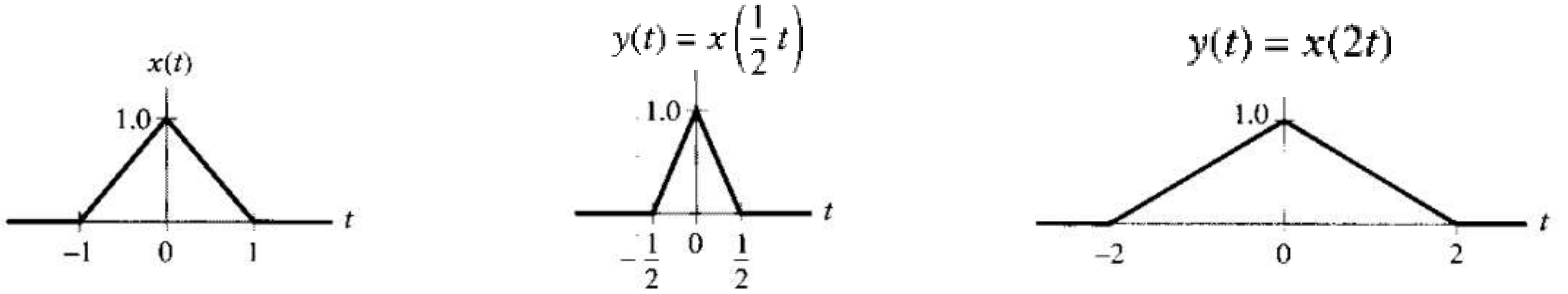


Fig:

(a) Continuous-time signal x(t), **(b)** Time expanded version of signal x(t) by factor 2 (= 1/2) **(c)** Compressed version of signal x(t) by factor 2 (= 2),

➢ Time Reversal (Reflection):

Let x(t) denote a continuous-time signal. Let y(t) denote the signal obtained by replacing time t with -t, as shown by

- y(t) = x(-t)

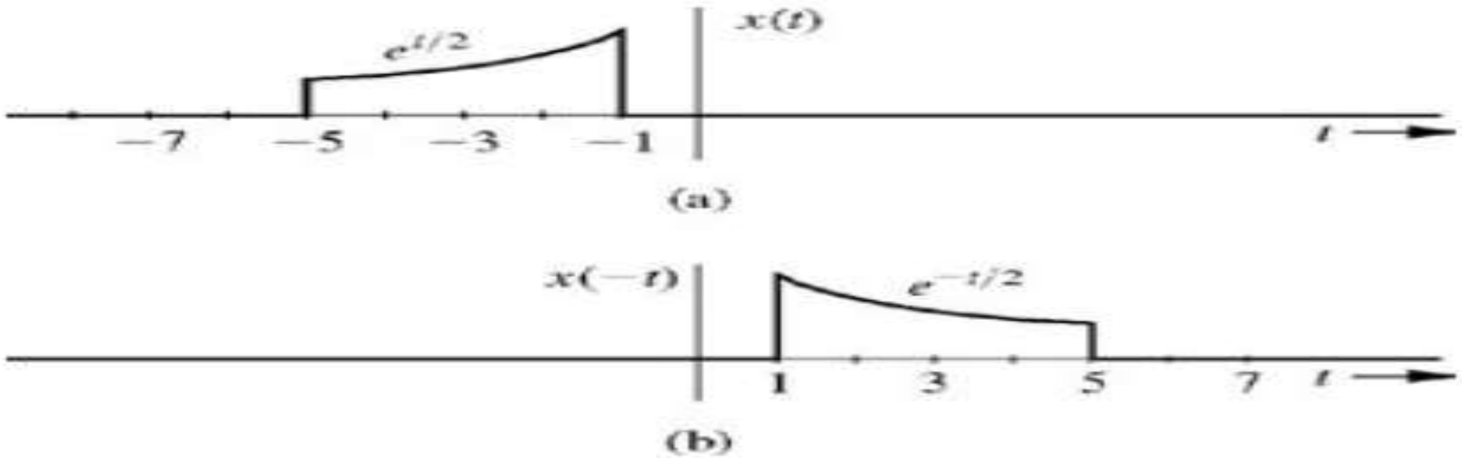


Fig: Operation of reflection:

(a) Continuous-time signal x(t) and **(b)** Reflected version of x(t) about the origin x(-t)

- Time shifting:

Let x(t) denote a continuous-time signal. The time-shifted version of x(t) is defined by

- $y(t) = x(t - t_o)$

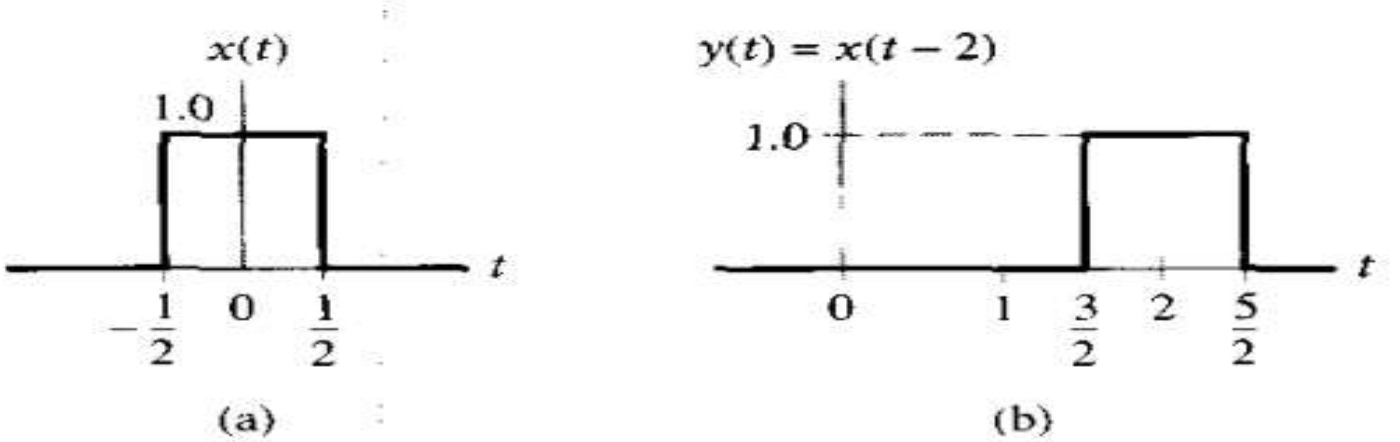


Fig: Time-shifting operation:
(a) Continuous-time signal x(t); and **(b)** Time-shifted version of x(t) by 2 time units

Basic Signals

- Sinusoidal Signal.
- Exponential Signal.
- Unit Step Function.
- Unit Ramp Function.
- Unit Impulse Function.