➢ Signals Transformation

Signal Transformation plays a central concept in signals and systems analysis. Where you need to know the shape of signal after deformation(s)/processing or how to construct a signal from another group of signals

Examples:

Pilot Actions —Through electrical and mechanical system→ **Changes in aircraft thrust قوة الدفع, OR Positions in the control surfaces**

Changes in velocity or heading توجيه ←Through Dynamics and Kinematics—

Elements of a communication system. The transmitter changes the message signal into a form suitable for transmission over the channel. The receiver processes the channel output (i.e., the received signal) to produce an estimate of the message signal.

➢ Signals Transformation (1- Of Independent Variable (time))

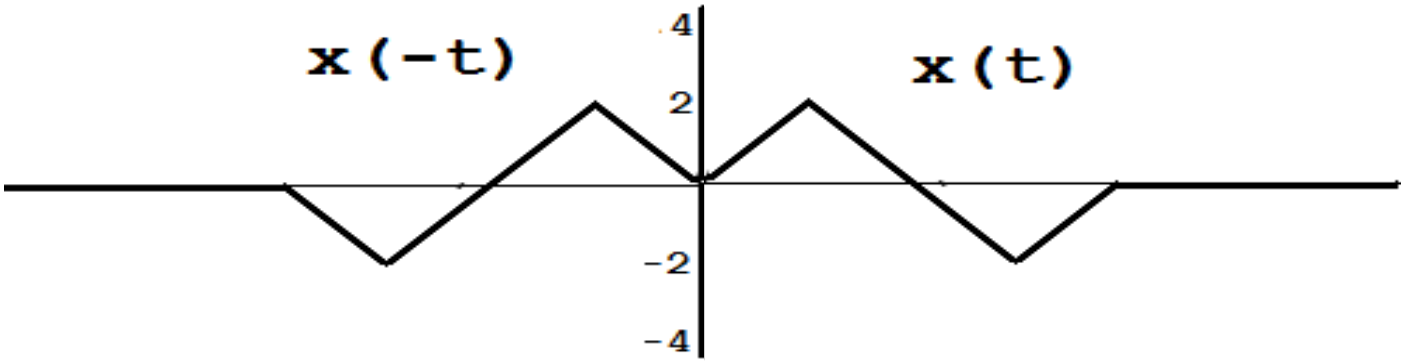
A- Basic Operations on the independent Variable:

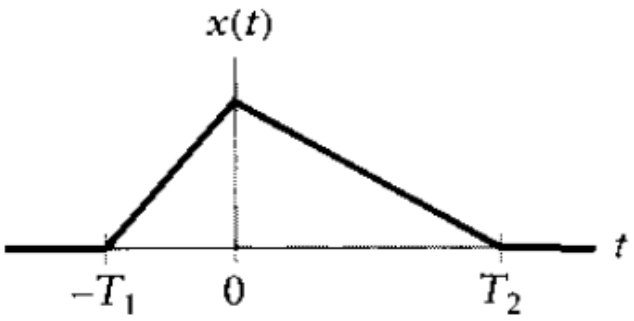
1- <u>Time Reversal</u>:

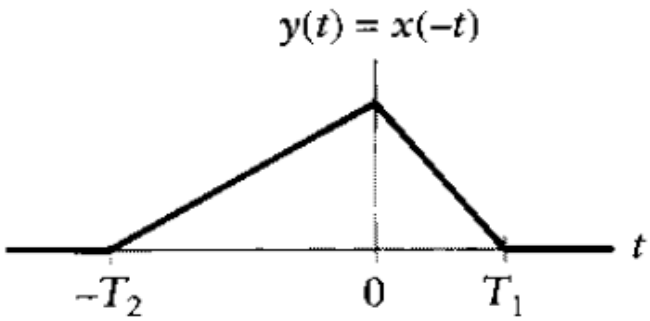
It is a reflection of the signal around the vertical axis (i.e. reversing it) at t=0 for the continuous-time signals, OR at n=0 for discrete-time signals.

e.g. if x(t) is an audio file, x(-t) is the same file but played backward.

Mirror



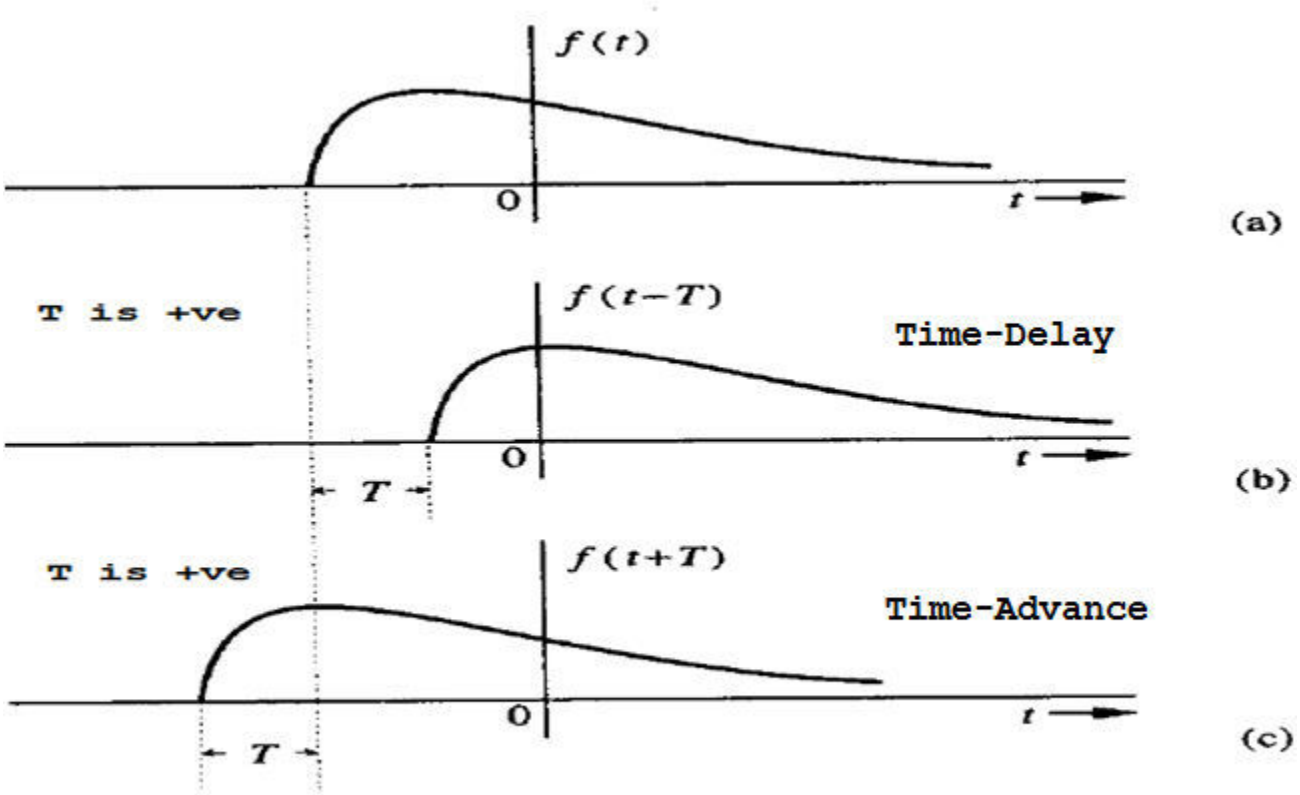




2- Time Shift: $y(t) = x(t - t_o)$

It is the same signal in shape but moved either to right ($t_o > 0$, and called Time-Delay) or to the left ($t_o < 0$, and called Advance) of the original signal.
e.g. Any application has a transmitter and multiple receivers.

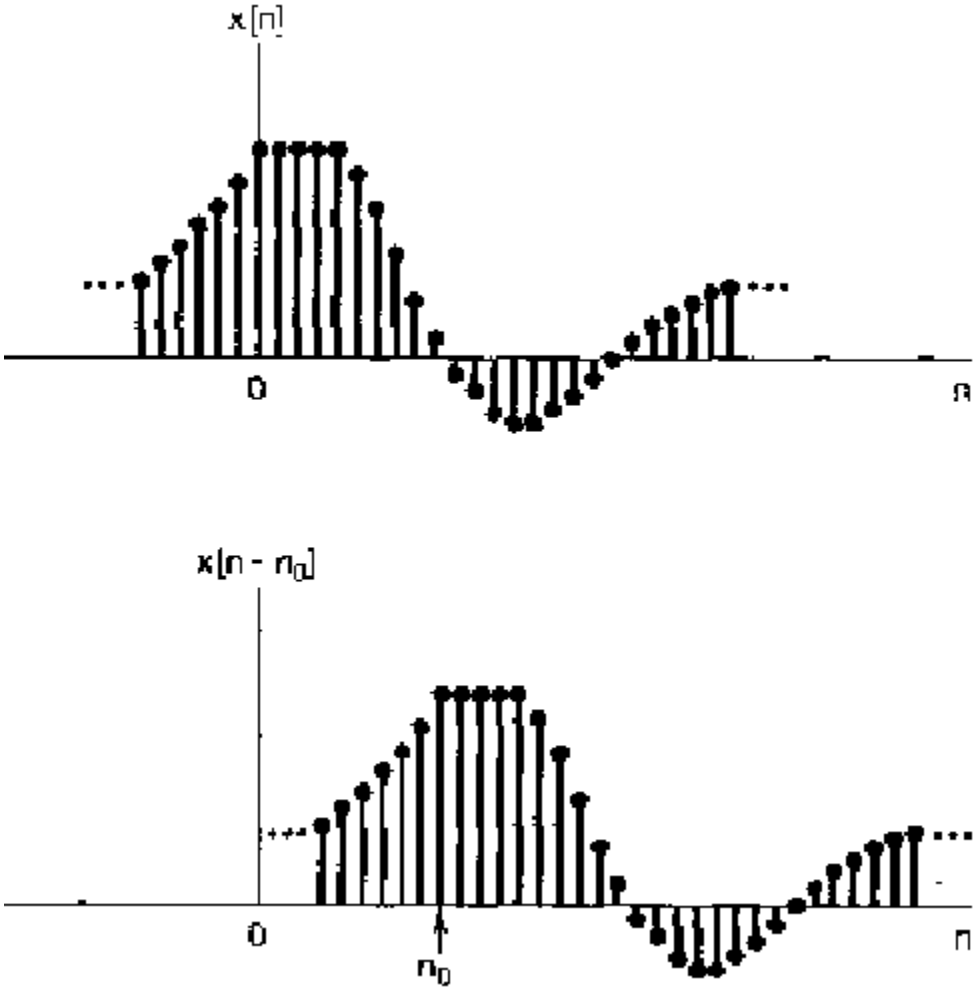
Example:
The original signal f(t) at (t = -5) will occur at a new location of the signal f(t-2) at:
t-2 = -5 → t= -3
i.e. the new location at (t=-3)
Similarly, its new location of the signal f(t+2) at:
t+2=-5 → t= -7
i.e. the new location will be at (t= -7)



Time shifting a signal.

➢ Signals Transformation (1- Of Independent Variable (time))

2- Time Shift:



Discrete-time signals related by a time shift. In this figure $n_0 > 0$, so that $x[n - n_0]$ is a delayed verson of $x[n]$ (i.e., each point in $x[n]$ occurs later in $x[n - n_0]$).

➢ Signals Transformation (1- Of Independent Variable (time))

3- Time Scaling:

$$y(t) = x(at)$$

It is a signal similar to the original signal in shape but it is either compressed (a > 1, and called Time-Shrinking or Time-Compression) or stretched (a < 1, and called Time-Expansion or Time-Stretch) version of the original signal.

e.g. An audio file either played at double speed or half speed.

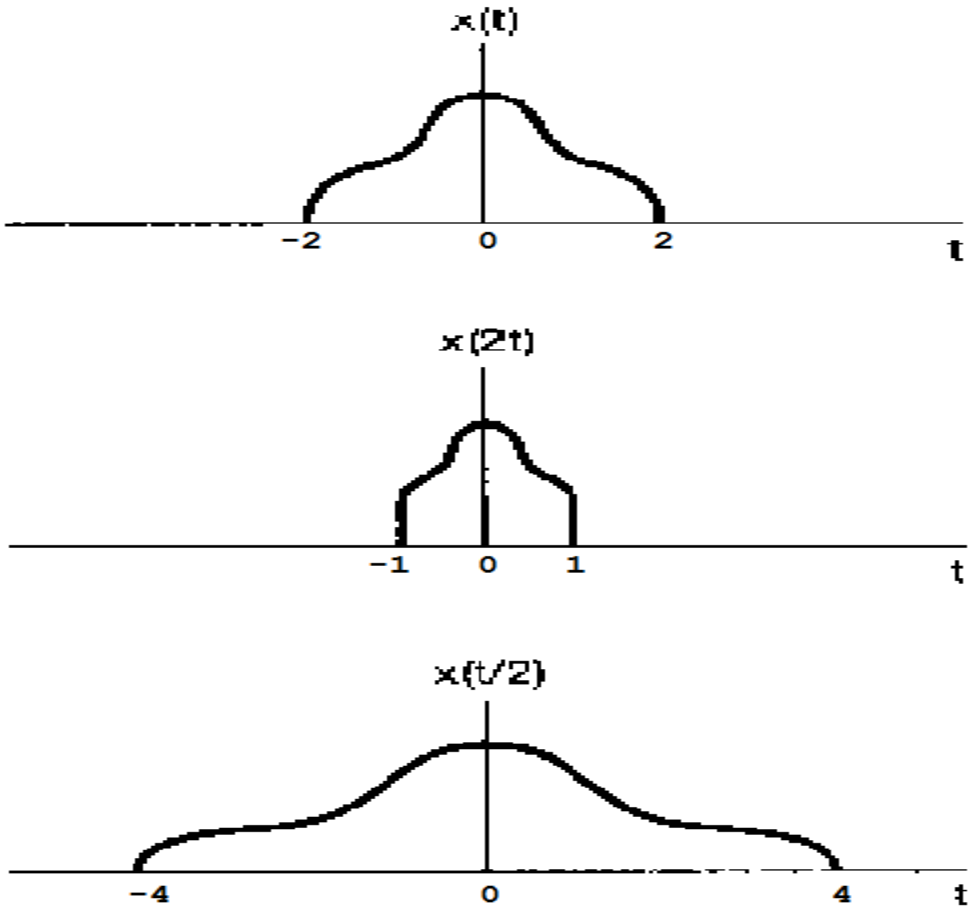
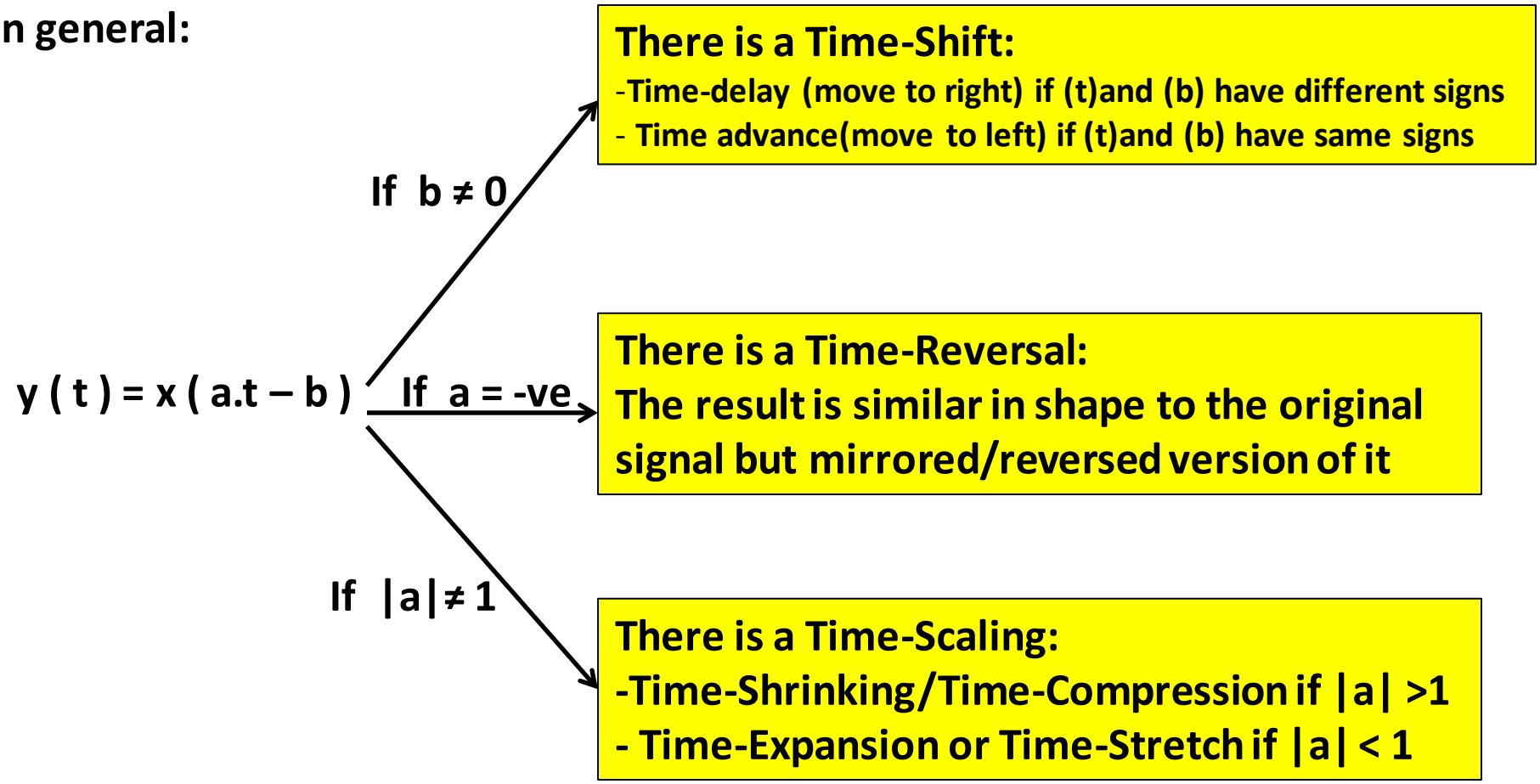


Figure 1.12 Continuous-time signals related by time scaling.

➢ Signals Transformation (1- Of Independent Variable (time))

In general:



A systematic approach to get y(t) = x (a.t – b) from x(t):

1- Do the time-shift i.e. get → y1(t) = x (t – b)

2- Do the time-reverse/scaling on the resulting signal, i.e get → y(t) = y1(a.t)

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Example: