Signal Operations
Basic Operation of the Signals.

1.3.1. Time Shifting
1.3.2 Reflection and Folding
1.3.3. Time Scaling
1.3.4 Precedence Rule for Time Shifting and Time Scaling.
Time Shifting

- Time shifting is, as the name suggests, the shifting of a signal in time. This is done by adding or subtracting the amount of the shift to the time variable in the function.
- Subtracting a fixed amount from the time variable will shift the signal to the right (delay) that amount,
- while adding to the time variable will shift the signal to the left (advance).
1.3.3 Time Shifting.

- A time shift delay or advances the signal in time by a time interval $+t_0$ or $-t_0$, without changing its shape.

$$y(t) = x(t - t_0)$$

- If $t_0$ is positive the waveform of $y(t)$ is obtained by shifting $x(t)$ toward the right, relative to the tie axis. (Delay)

- If $t_0$ is negative, $x(t)$ is shifted to the left. (Advances)
Example 1: Continuous Signal.
A CT signal is shown in Figure below, sketch and label each of this signal;

a) $x(t - 1)$
Solution:

(a) \( x(t - 1) \)
Quiz 1: Time Shifting.

Given the rectangular pulse $x(t)$ of unit amplitude and unit duration.

Find $y(t) = x(t - 2)$
Ans Quiz 1: Time Shifting.
Given the rectangular pulse $x(t)$ of unit amplitude and unit duration. Find $y(t) = x(t - 2)$

**Solution:**
$t_0$ is equal to 2 time units. Shift $x(t)$ to the right by 2 time units.

(a) continuous-time signal in the form of a rectangular pulse of amplitude 1.0 and duration 1.0, symmetric about the origin; and
(b) time-shifted version of $x(t)$ by 2 time shifts.
Discrete Time Signal.

A discrete-time signal $x[n]$ is shown below. Sketch and label each of the following signal.

(a) $x[n - 2]$
Cont’d…

(a) A discrete-time signal, \( x[n-2] \).

A delay by 2

\[ x[n-2] \]

\[ \begin{array}{ccccccc}
0 & 1 & 2 & 3 & 4 & 5 \\
\hline
3 & & & & & \\
5 & & & & & \\
\end{array} \]
A discrete-time signal $x[n]$ is shown below. Sketch and label each of the following signal.

(a) $x[n - 3]$
• **Quiz 2**
• **Ans**

![Diagram](attachment://image.png)
1.3.2 Reflection and Folding.

- Let $x(t)$ denote a continuous-time signal and $y(t)$ is the signal obtained by replacing time $t$ with $-t$;

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

- $y(t)$ is the signal represents a refracted version of $x(t)$ about $t = 0$.

- Two special cases for continuous and discrete-time signal;
  
  (i) Even signal; $x(-t) = x(t)$ an even signal is same as reflected version.

  (ii) Odd signal; $x(-t) = -x(t)$ an odd signal is the negative of its reflected version.
Example:
A CT signal is shown in Figure 1.17 below, sketch and label each of this signal;
a) $x(-t)$
Solution:

(c) $x(-t)$
The continuous-time version of the unit-step function is defined by,

\[ u(t) = \begin{cases} 
1, & t > 0 \\
0, & t < 0 
\end{cases} \]

The discontinuity exhibit at \( t = 0 \) and the value of \( u(t) \) changes instantaneously from 0 to 1 when \( t = 0 \). That is the reason why \( u(0) \) is undefined.
STEPS To Remember

- If you have Time shifting and Reversal (Reflection) together
- Do 1st Shifting
- Then Reflection
• **Question 1**

(a) \( g(t) = 2u(4 - t) \)

(b) \( g(t) = u(2t) \)
• Solution
Question 2: Discrete Time Signal.

A discrete-time signal \( x[n] \) is shown below, Sketch and label each of the following signal.

(a) \( x[-n+2] \)  (b) \( x[-n] \)
Cont’d…

(a) A discrete-time signal, $x[-n+2]$.

Time shifting and reversal

![Diagram showing time shifting and reversal of a signal](image-url)
Cont’d…

(b) A discrete-time signal, $x[-n]$.

- Time reversal
A continuous signal $x(t)$ is shown in Figure. Sketch and label each of the following signals.

a) $x(t) = u(t - 1)$

b) $x(t) = [u(t) - u(t - 1)]$

c) $x(t) = \delta(t - 3/2)$
Solution:

(a) $x(t) = u(t - 1)$

(b) $x(t) = [u(t) - u(t-1)]$

(c) $x(t) = d(t - 3/2)$
Time Scaling.

- Time scaling refers to the multiplication of the variable by a real positive constant.
- If $a > 1$ the signal $y(t)$ is a compressed version of $x(t)$.
- If $0 < a < 1$ the signal $y(t)$ is an expanded version of $x(t)$.

$$y(t) = x(at)$$
Example
Cont’d…

✓ In the discrete time,

\[ y[n] = x[kn], \]

✓ It is defined for integer value of \( k, k > 1 \). Figure below for \( k = 2 \), sample for \( n = \pm 1 \),
1.4.5 Step Function.

The discrete-time version of the unit-step function is defined by,

\[ u[n] = \begin{cases} 
1, & n \geq 0 \\
0, & n < 0 
\end{cases} \]
Tutorial 1

Q 1 A continuous-time signal $x(t)$ is shown below, Sketch and label each of the following signal

(a) $x(t - 2)$ (b) $x(2t)$ (c) $x(t/2)$ (d) $x(-t)$

![signal](image)
Tutorial 1

• Q3 Graph these combinations of discrete-time functions

(a) \( g[n] = u[n] + u[-n] \)  \hspace{2cm} (b) \( g[n] = u[n] - u[-n] \)
Tutorial 1

(a) $g[n]$

(b) $g[n]$
1.4.6 Impulse Function.

The discrete-time version of the unit impulse is defined by,

\[
\delta[n] = \begin{cases} 
1, & n = 0 \\
0, & n \neq 0 
\end{cases}
\]
Graph the following discrete-time functions.

(a) \[ g[n] = 5\delta[n-2] + 3\delta[n+1] \]
(b) \[ g[n] = 5\delta[2n] + 3\delta[4(n-2)] \]
\[ g[n] = 5 \cos\left(\frac{2\pi n}{8}\right) u\left[\frac{n}{2}\right] \]