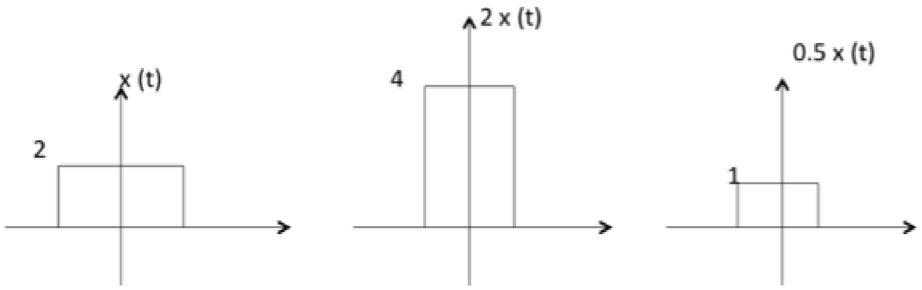
## Basic Operation on Signals

An issue of major importance is the use of systems to process or manipulate signals. This issue involves a combination of some basic operations.

However, two classes of these operations can be identified that are:

① **Operation of dependent variables**

**A.** Amplitude scaling (Amplitude shifting, Amplification): The scaled signal $ax_{(t)}$ is $x_{(t)}$ multiplied by the factor a where a is a constant real number, such as, the physical device that performs amplitude scaling is an electronic amplifier.



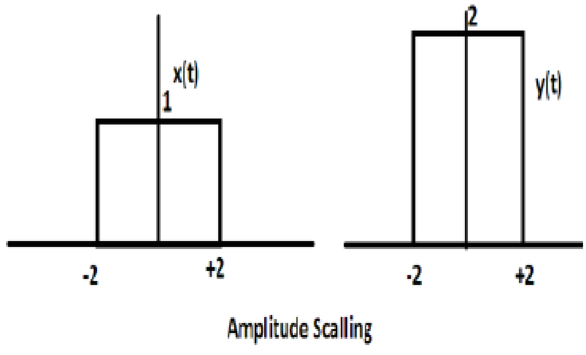




Figure 8: The amplitude scaling operation

In this case, only the values of y axis is changed since the amplitude is associated with this axis while, the values of x axis is constant.

**B.** Addition: If $x_1(t)$ and $x_2(t)$ denote a pair of CTSs. The signal z(t) obtained by the addition of $x_1(t)$ and $x_2(t)$ is defined by:

$z(t) = x_1(t) + x_2(t)$

In the case of DTS, it written as:

$z[n] = x_1[n] + x_2[n]$

It can be noted that the addition of two signals is nothing but addition of their corresponding amplitudes. This can be best explained by using the following example:

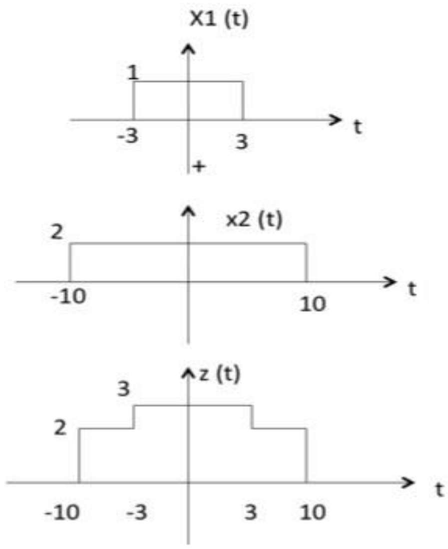



Figure 9: The addition operation

**C.** Subtraction: If $x_1(t)$ and $x_2(t)$ refer to a pair of CTSs. Then, the signal z(t) obtained by the subtracting of $x_1(t)$ from $x_2(t)$ is defined by:

$z(t) = x_1(t) - x_2(t)$

In the case of DTS, it written as:

$z[n] = x_1[n] - x_2[n]$

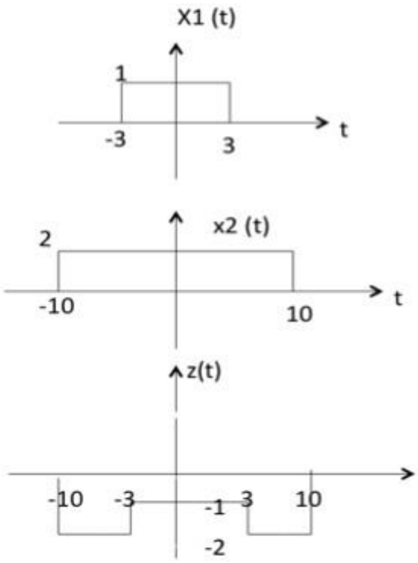



Figure 10: The subtraction operation

**D.** Multiplication: let $x_1(t)$ and $x_2(t)$ denote a pair of CTSs. The signal z(t) resulting from the multiplication of $x_1(t)$ and $x_2(t)$ is defined by the following equation:

$z(t) = x_1(t) * x_2(t)$

That is, for each prescribed time (t) the value of z(t) is given by the product of the corresponding values of $x_1(t)$ and $x_2(t)$.

For discrete-time signals we write:

$z[n] = x_1[n]\, x_2[n]$

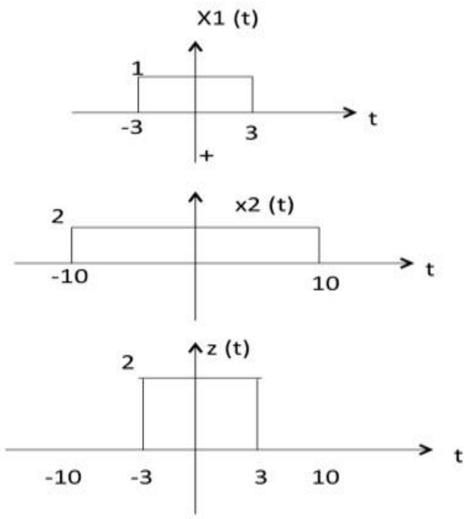



Figure 11: The Multiplication operation

## ② Operation of independent variables

**A.** Time shifting: Suppose that we have a signal x(t) and we define a new signal by adding/subtracting a finite time value to/from it. We now have a new signal, z(t). Graphically, this kind of signal operation results in a positive or negative "shift" of the signal along its time axis. However, note that while doing so, none of its characteristics are altered. This means that the time-shifting operation results in the change of just the positioning of the signal without affecting its amplitude.

If CTS is x(t), then z(t)=x(t−T) is the signal x(t) shifted to the right by T units.

If CTS is x(t), then z(t)=x (t+T) is the signal x(t) shifted to the left by T units.

When DTS is x[n], then z[n]=x[n−N] is the signal x[n] shifted to the right by N samples.

When DTS is x[n], then z[n]=x[n+N] is the signal x[n] shifted to the left by N samples.

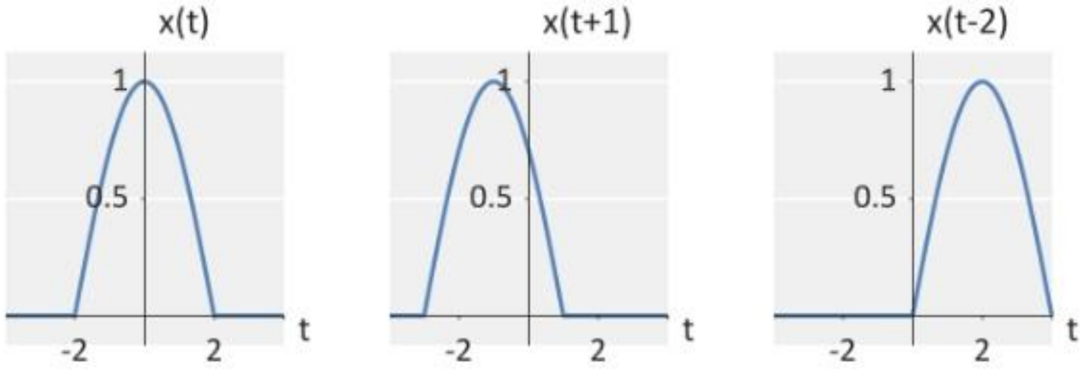



Figure 12: The time shifting operation

**B.** Time scaling: is a compression or expansion of a signal in time let x(t) denote a CTS, the signal z(t) obtained by scaling the independent variable, time (t), by a factor "a" is defined by two cases which are:

- If a > 1, the signal z(t) is a compressed version of x(t). In this case:

  z(t) = x(at)

- If a < 1, the signal z(t) is an expanded (stretched) version of x(t). Thus, the resulted signal z(t) is computed as:

  z(t) = x(t/a)

  Note: the factor "a" must not be equal to 0.

This mean that the signal x(t) is scaled in time by multiplying the time variable by a positive constant (a), to produce z(t).

All these cases are described in the below figure.

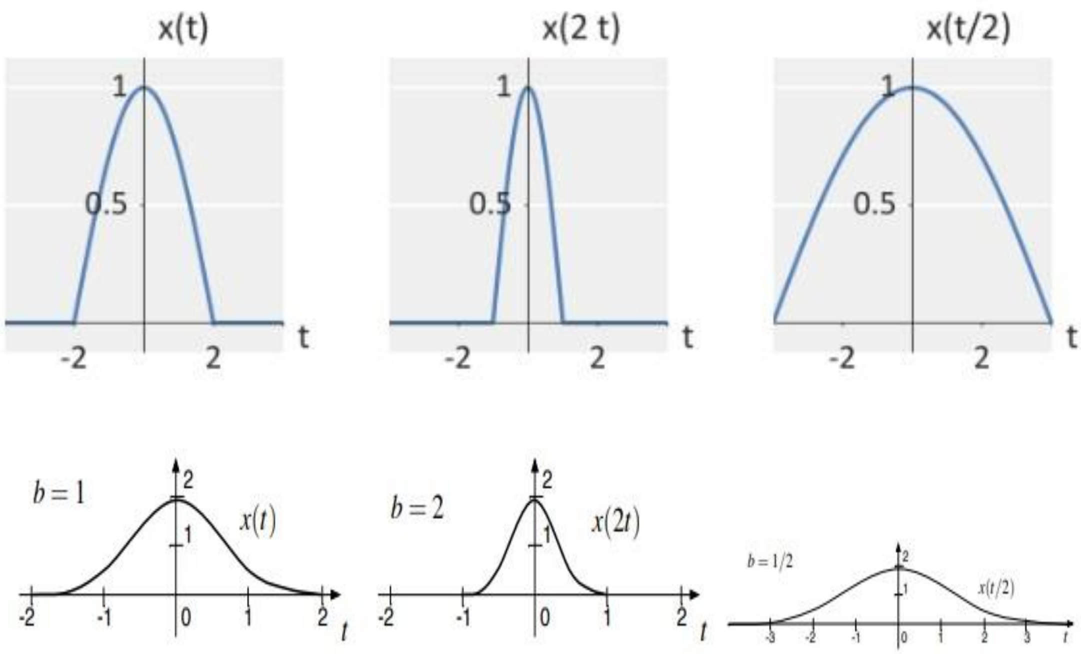



Figure 13: The time scaling operation

**C.** Time reversal (time inversion, reflection): The signal z(t) represents a reflected version of x(t) about the amplitude axis. Let x(t) denotes a CTS signal and z(t) denotes the signal obtained by replacing time (t) with (–t), as shown in the next two cases:

- The CTS is represented as:

y(t)=x(−t)

- While the DTS is as follows:

y[n]=x[−n]

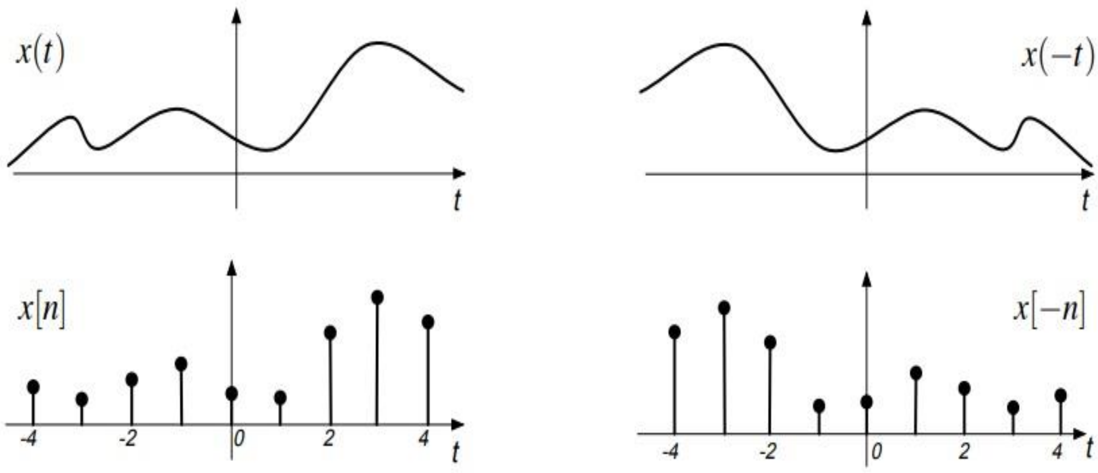



Figure 14: The time reversal operation