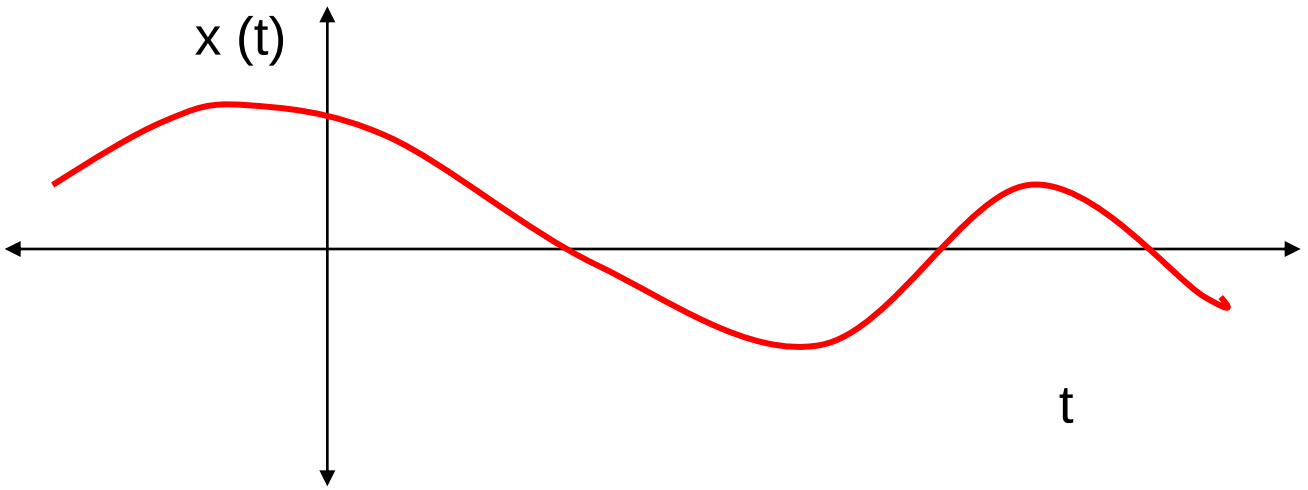
Basic Operations on Signals

Dr.K.S.Vishvaksenan
SSN College of Engineering

Signal is a function. It involves two variables.

1. Dependent (Amplitude)
2. Independent (Time)



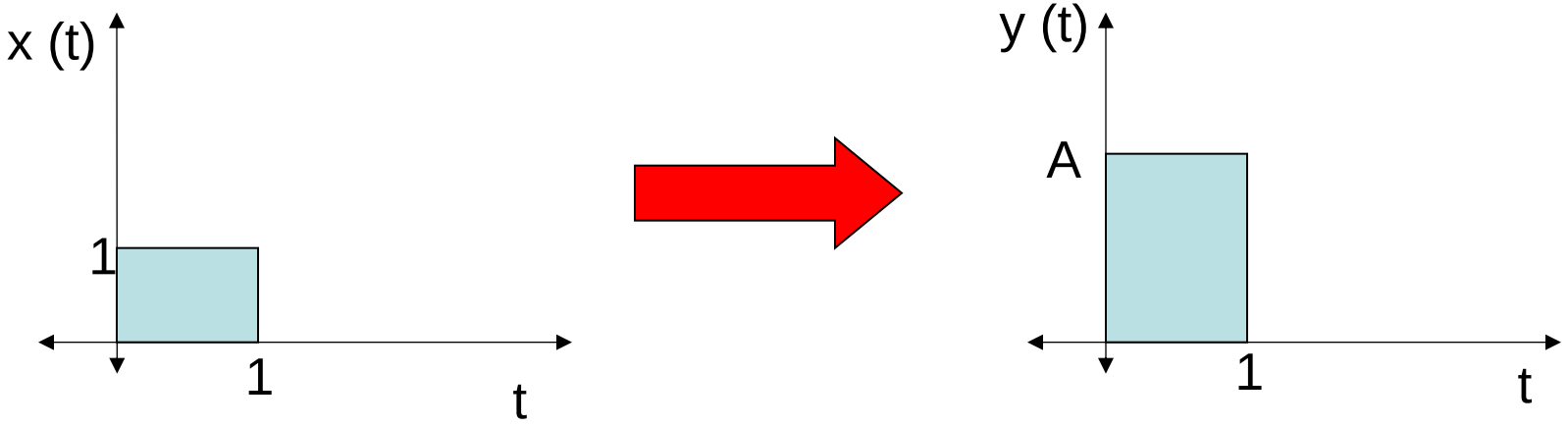
Operations performed on the dependent variable

- Amplitude Scaling
- Addition
- Multiplication
- Differentiation and Integration

Amplitude Scaling:

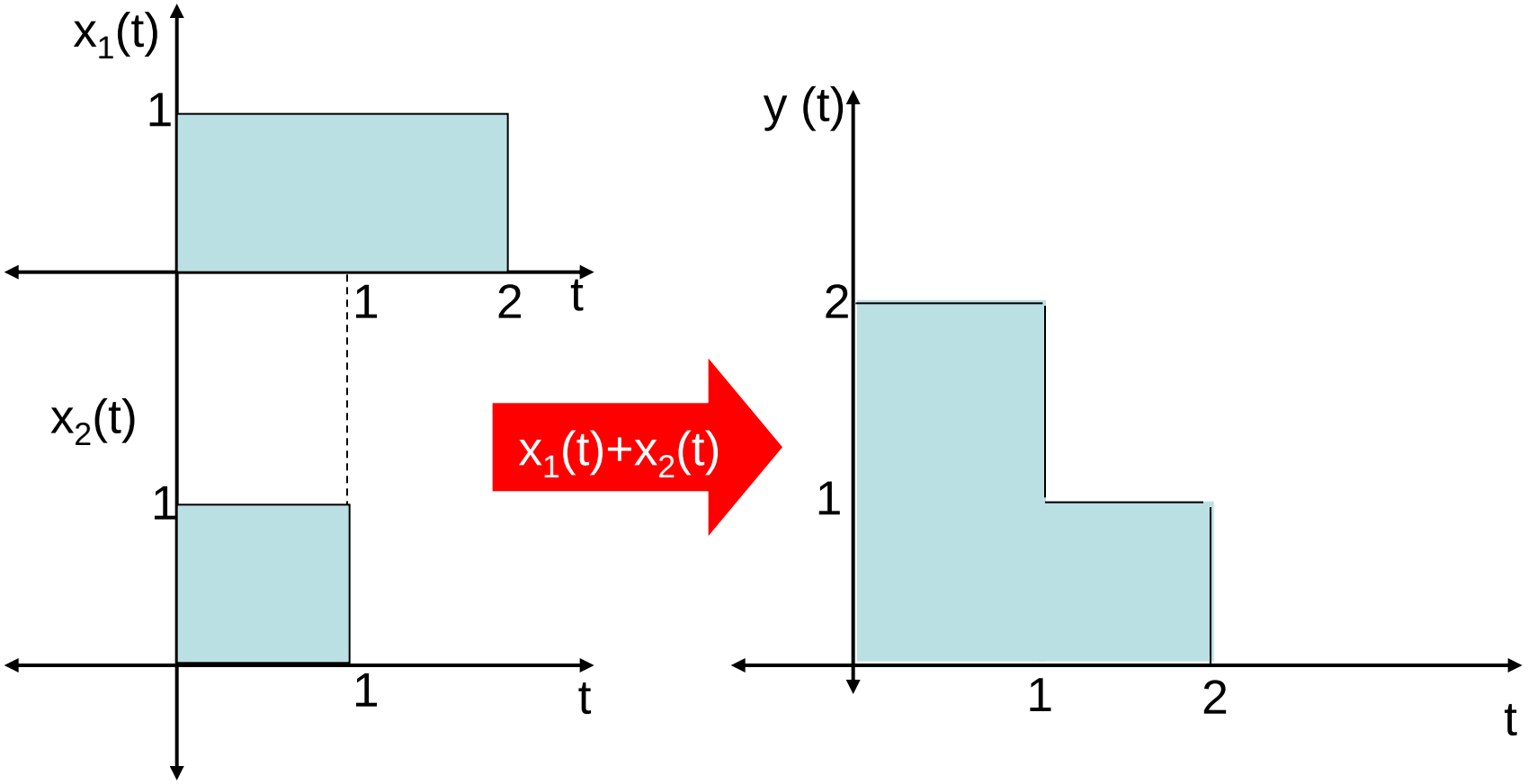
This operation is mathematically expressed as

$$y(t) = Ax(t)$$



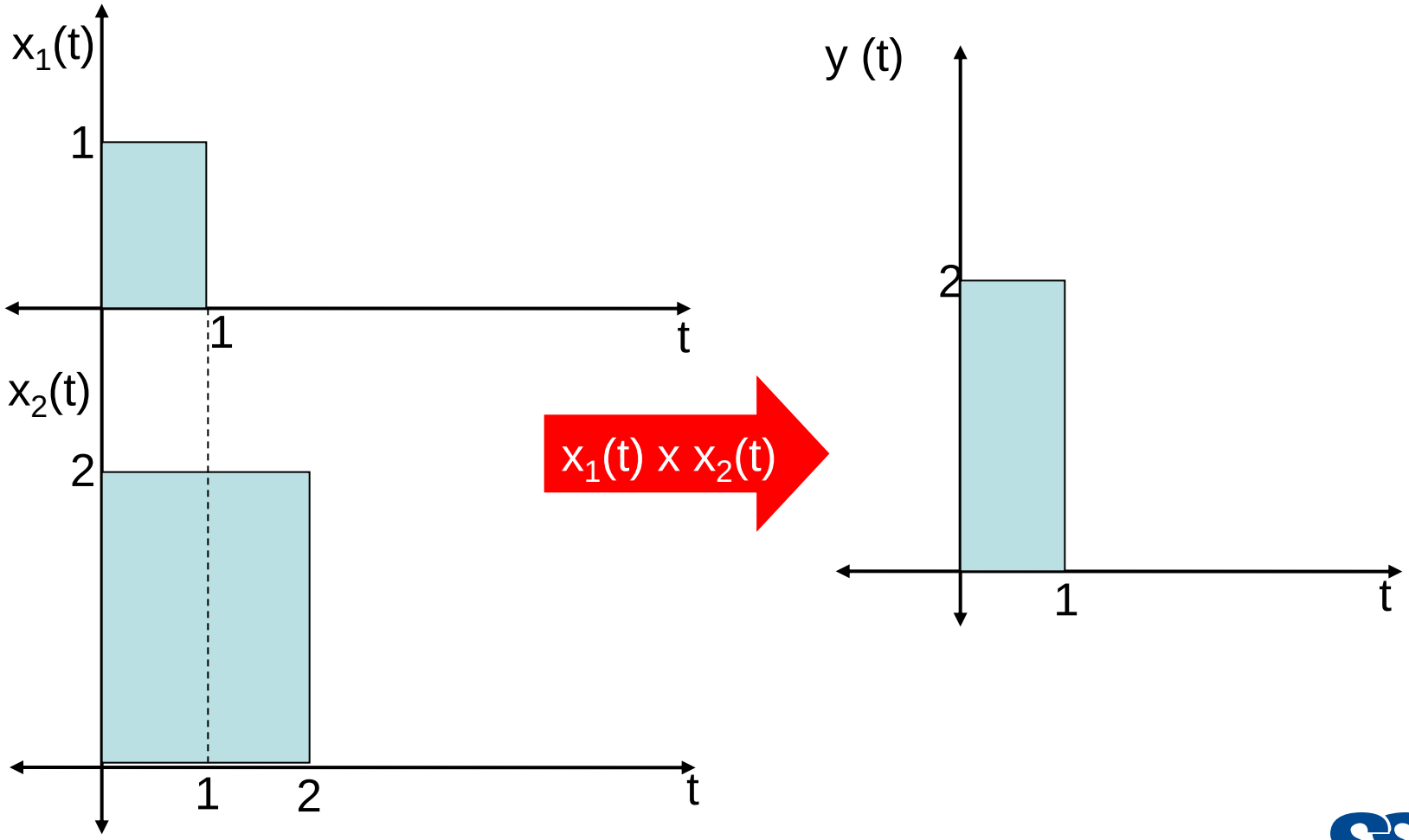
Addition: The addition of two signals is given by

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



Multiplication: The multiplication of two signals is given by

$$y(t) = x_1(t) \times x_2(t)$$



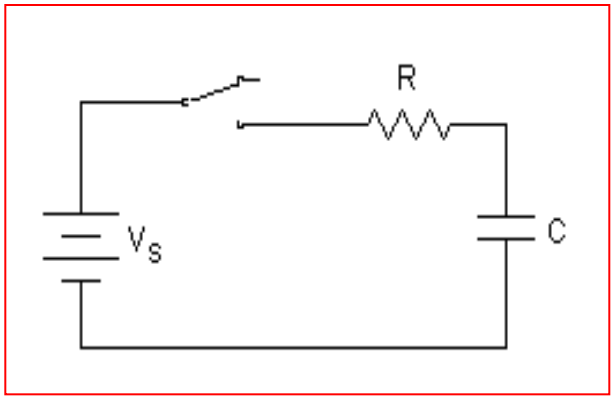
Differentiation and Integration

- Differentiation of a signal x(t) is expressed as

$$y(t) = \frac{dx(t)}{dt}$$

Voltage across the Capacitor $v_C(t)$ is expressed as

$$v_C(t) = V_s(1 - e^{-\frac{t}{RC}})$$



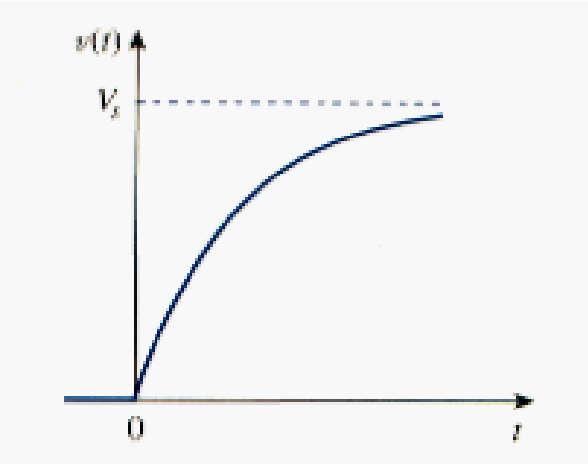
The current through the capacitor is expressed as

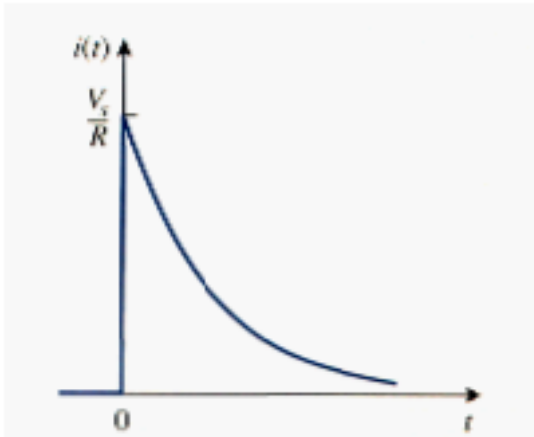
$$i_C(t) = \frac{dv_c(t)}{dt}$$

Therefore, The current $i_c(t)$ is

$$i_C(t) = \frac{V_S}{R} e^{-\frac{t}{RC}}$$

The voltage and current waveforms





Operations on Independent variable

- Time Shifting
- Time reversal or Reflection or Flipping
- Time Scaling

Time Shifting:

This operation shifts the signal either to left or right.

Mathematically,

$$y(t) = x(t \pm T)$$

The signal is delayed,

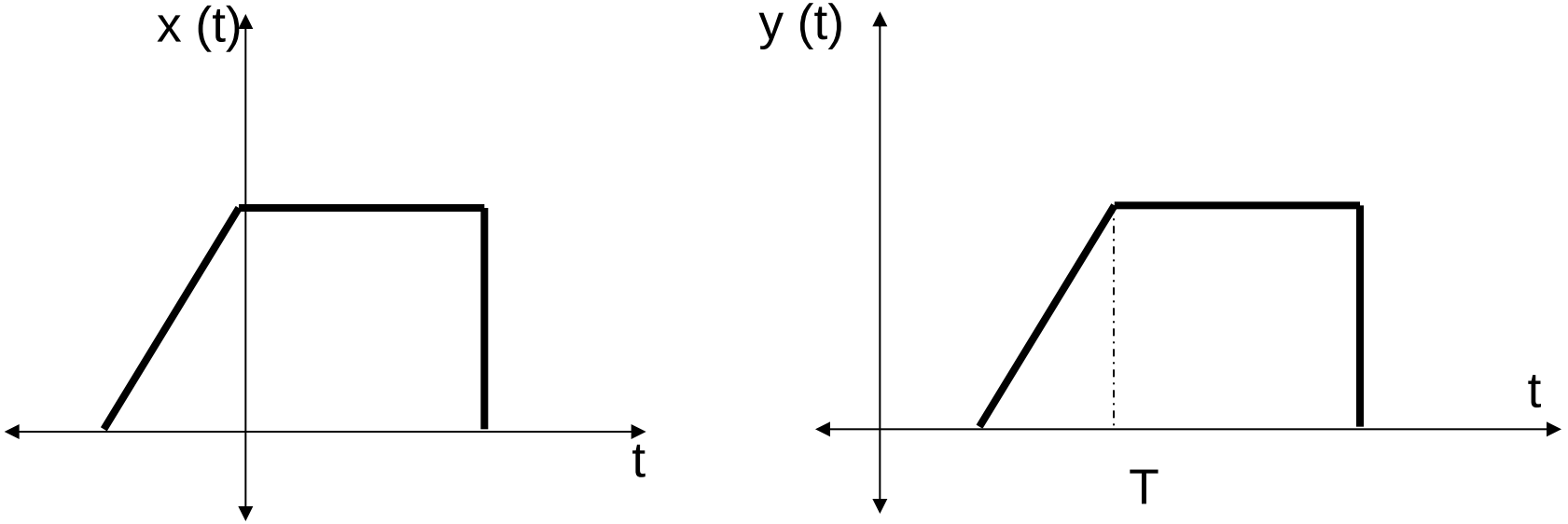
$$y(t) = x(t - T)$$

The signal is advance

$$y(t) = x(t + T)$$

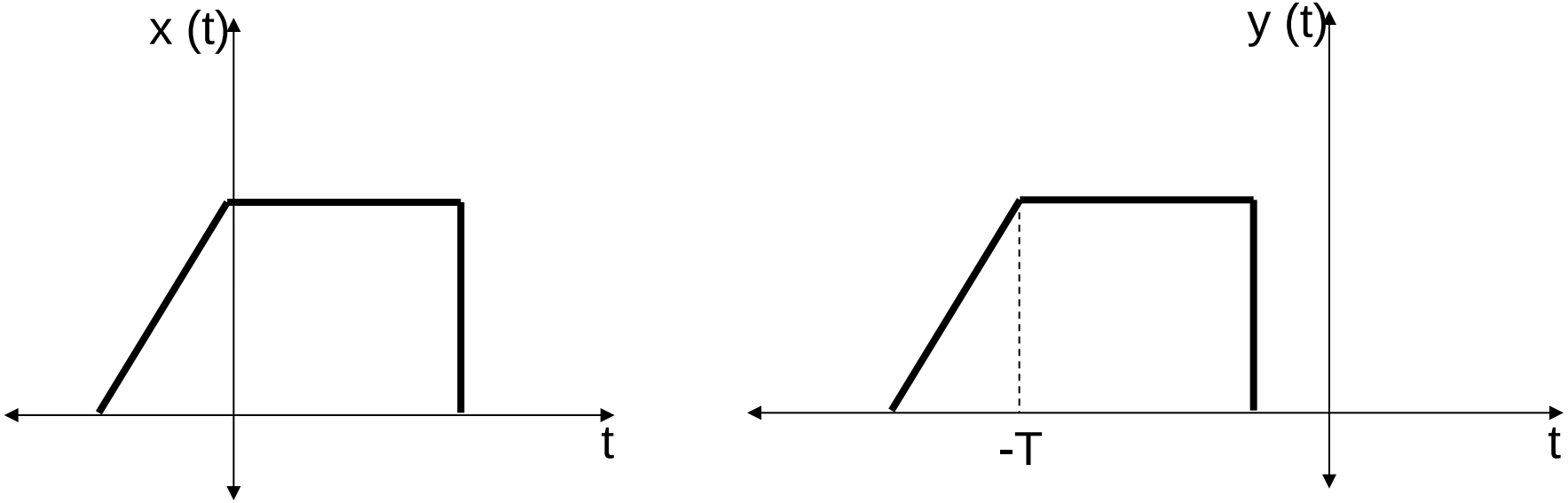
Shifting x(t) by a value T to the right side i.e., delaying is expressed as

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



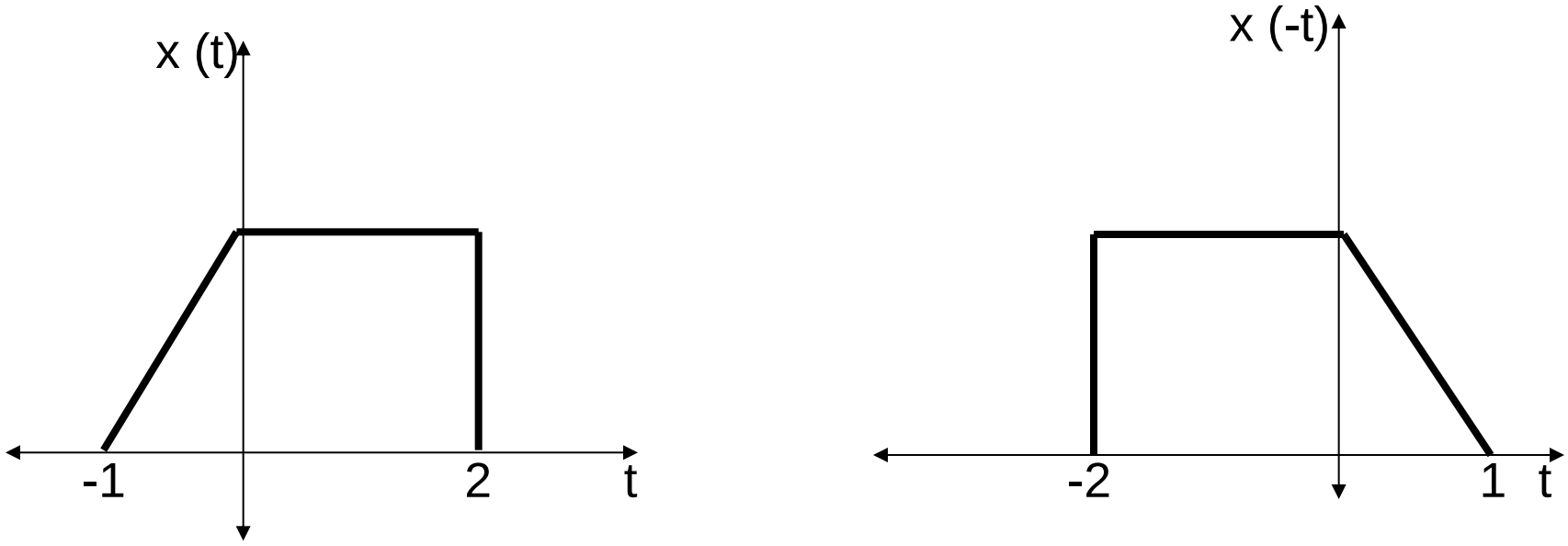
Shifting the signal to the left i.e., advancing is expressed as

$$y(t) = x(t+T)$$



Reflection:

If x(t) is a signal, Then its reflection is x (-t).

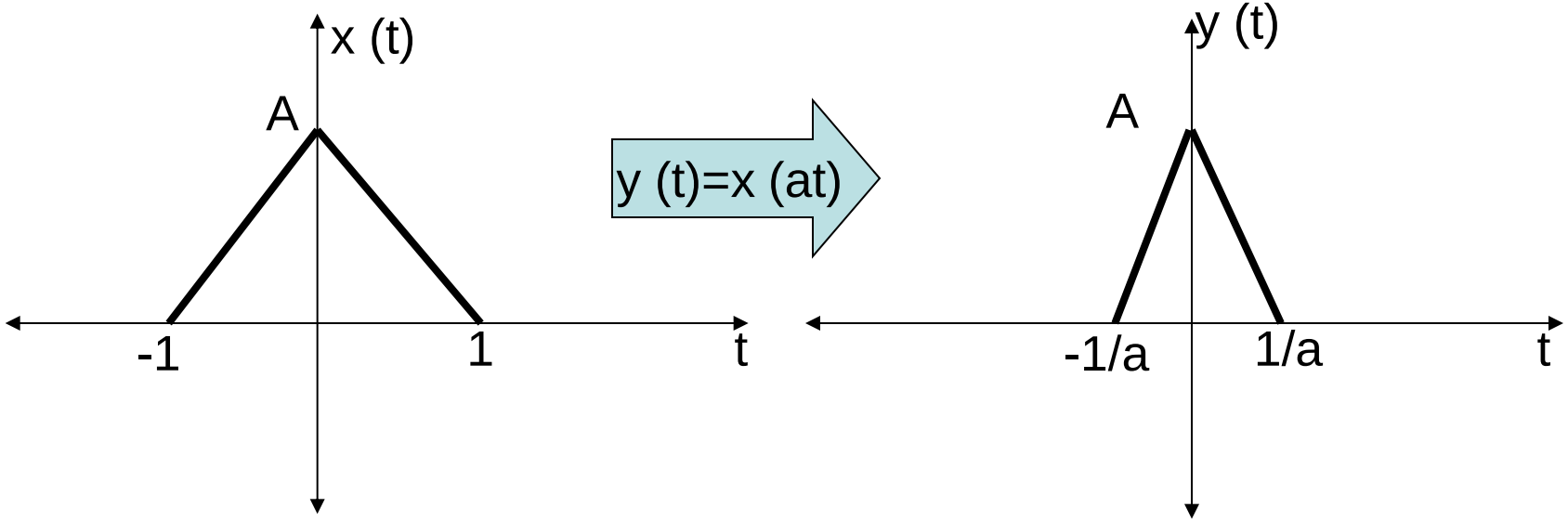


Time Scaling:

It is mathematically expressed as

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

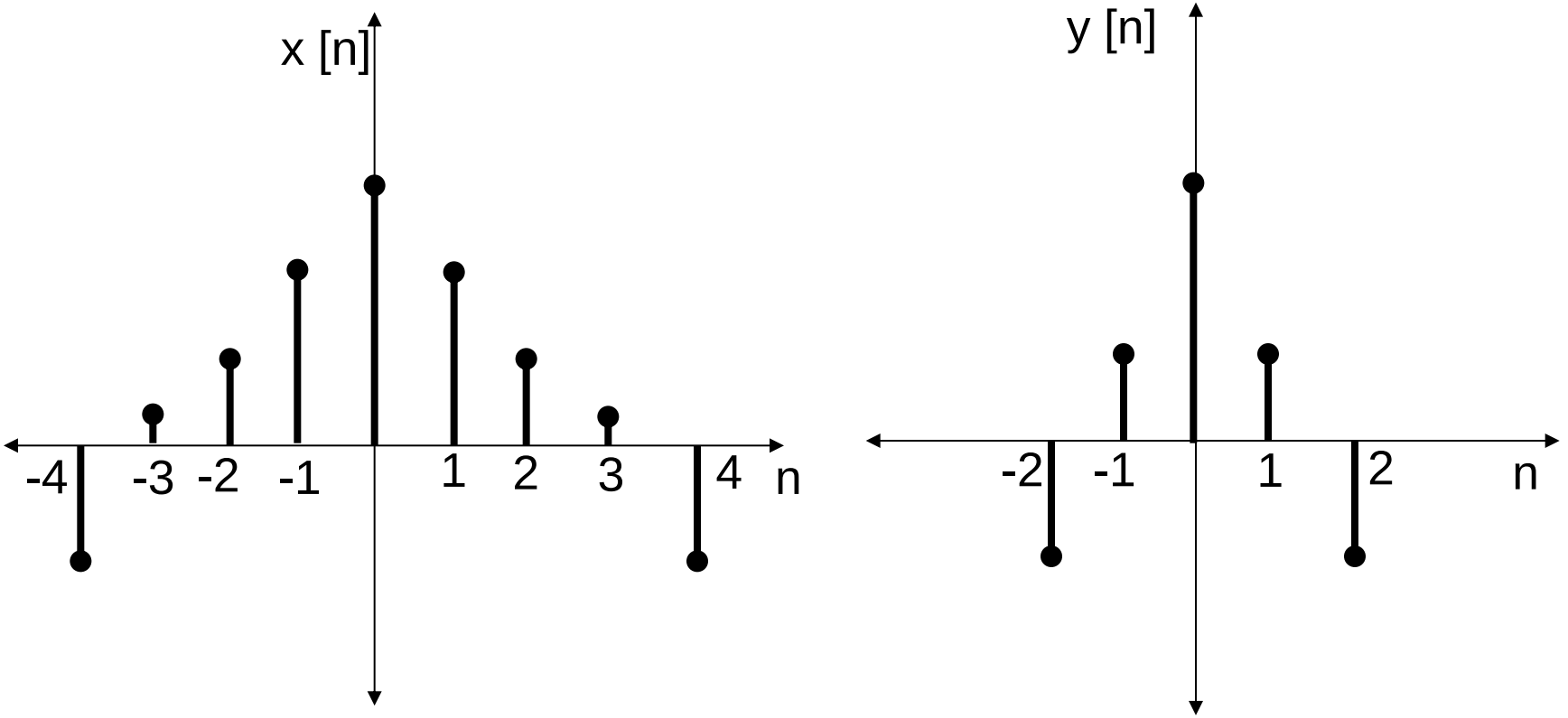
1. If a > 1 , then y(t) is a compressed signal of x(t).



For discrete time signals,

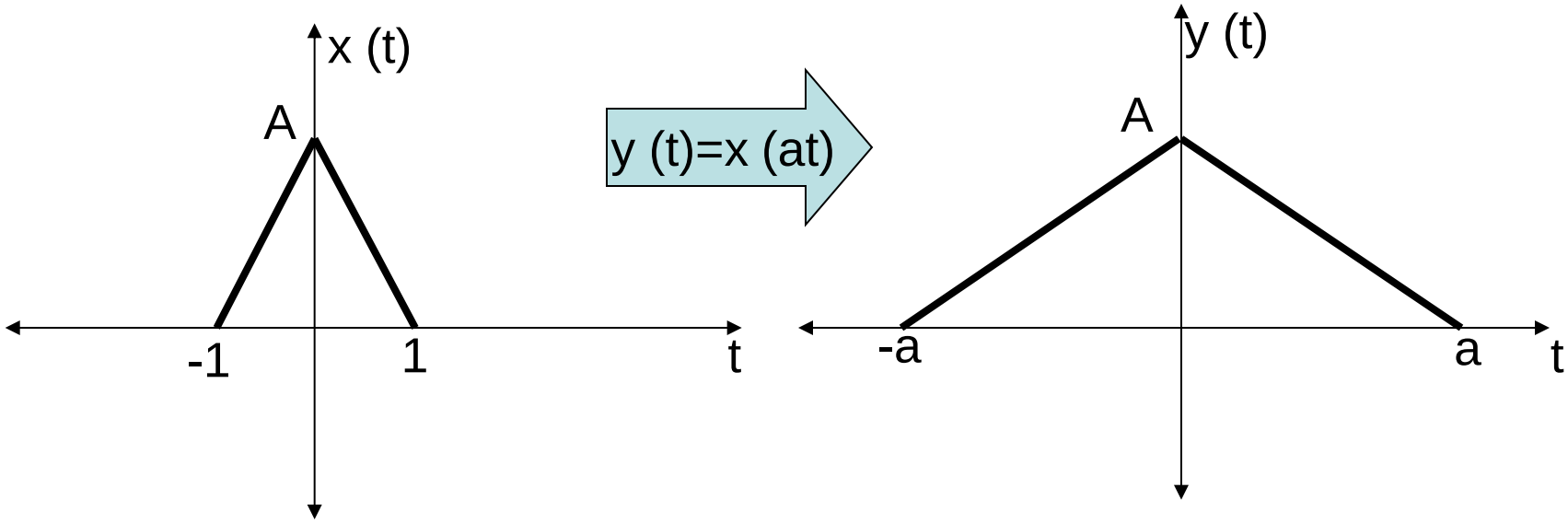
$$y[n] = x[an]$$

If a=2, y [n] is a compressed signal



* This operation is also called as Decimation.

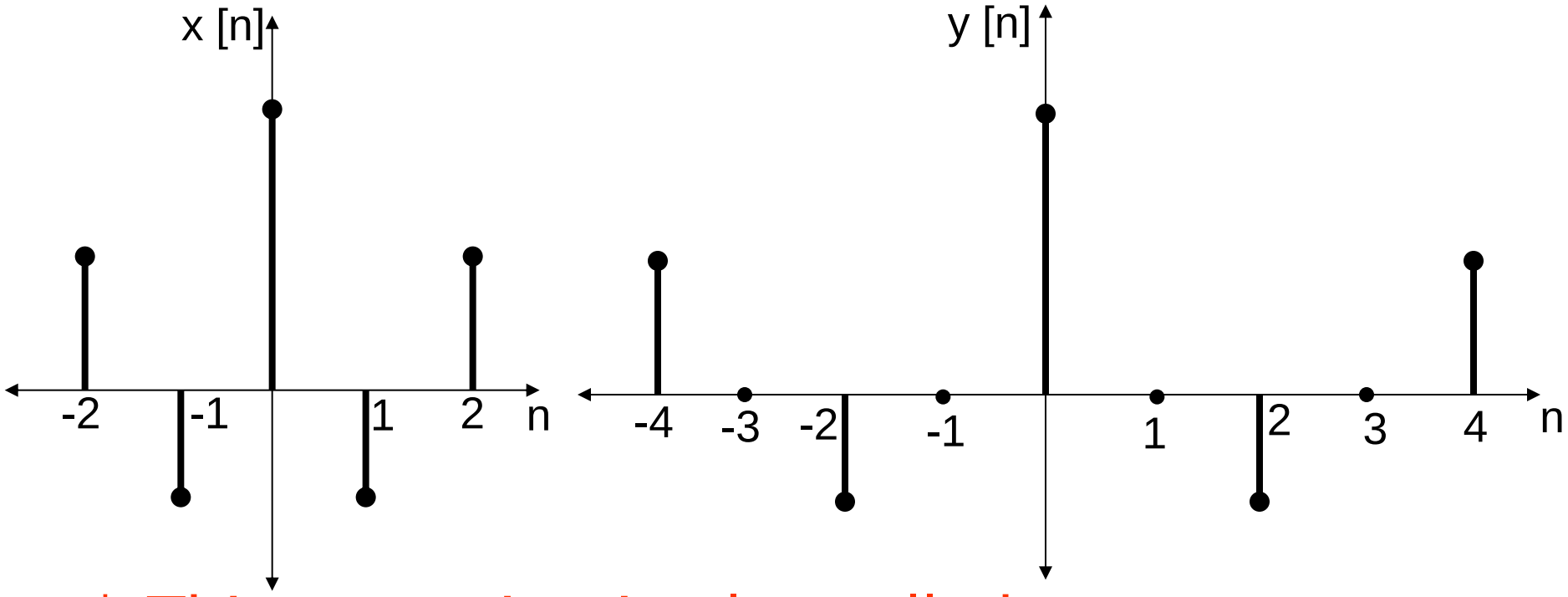
2. If 0< a < 1, then y (t) is a expanded signal of x(t).



For discrete time signals,

$$y[n] = x[an]$$

If a =2, then y[n] is an expanded signal



* This operation is also called as interpolation.

Rule of Precedence

1. Shifting
2. Scaling
3. Reflection

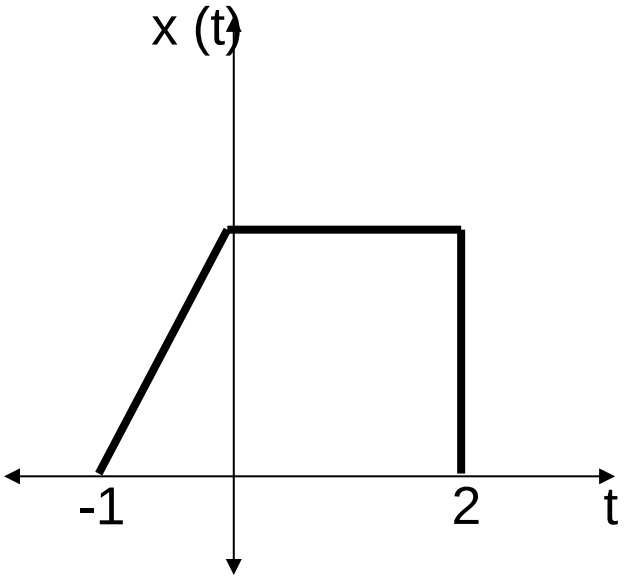
OR

1. Reflection
2. Shifting
3. Scaling

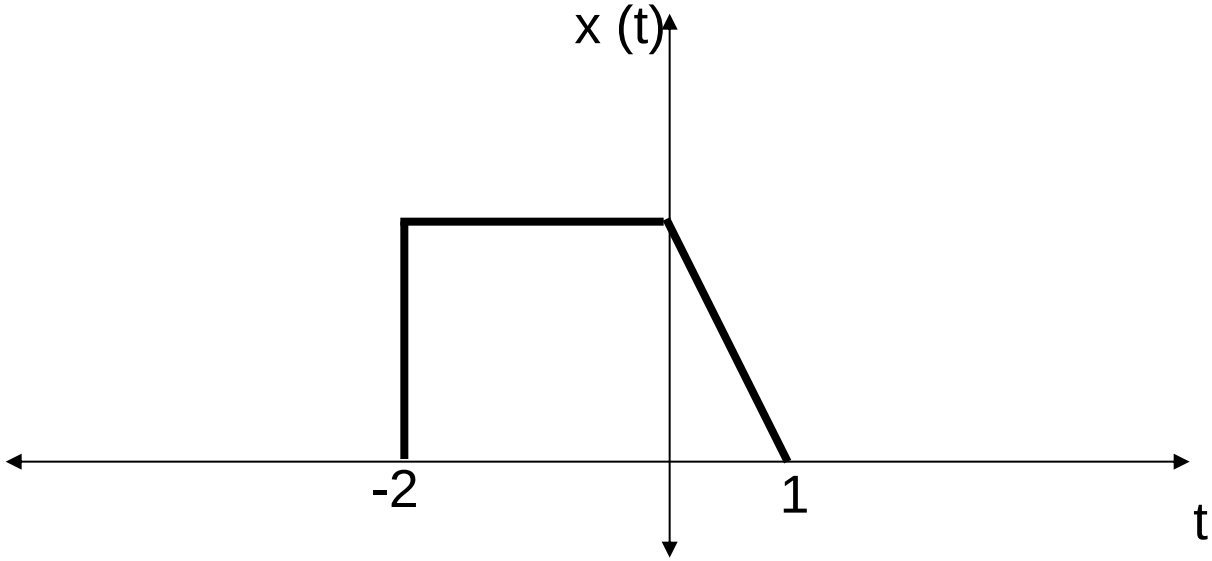
for example,

$$y(t) = x(-at + b)$$

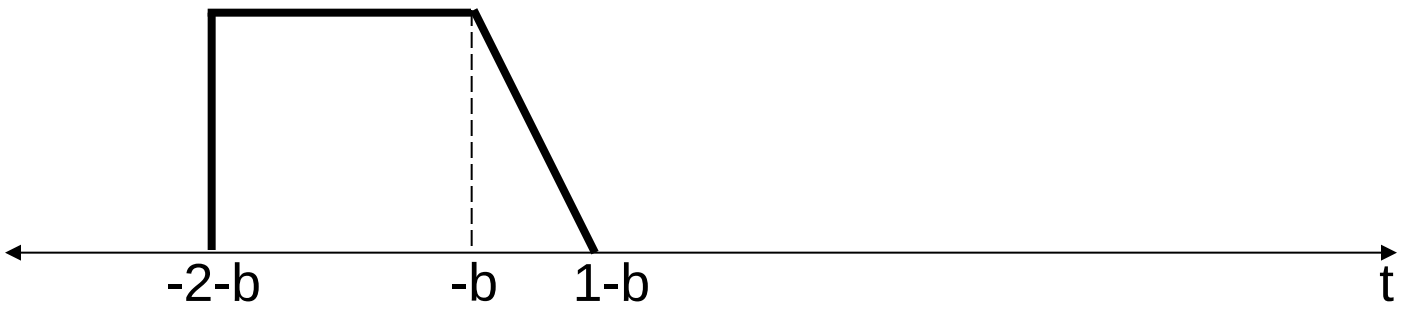
Let the signal x(t) be



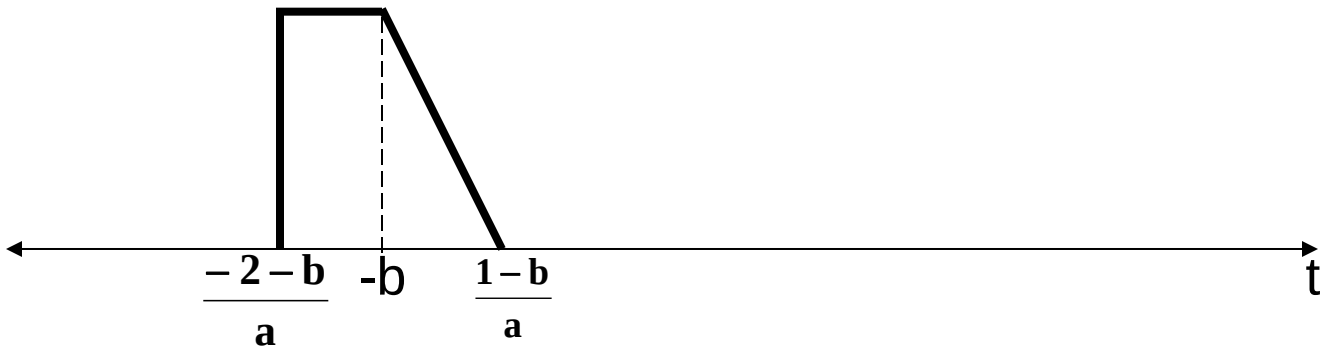
1. After Reflection the signal x(t) is



2. After Shifting x(t) becomes

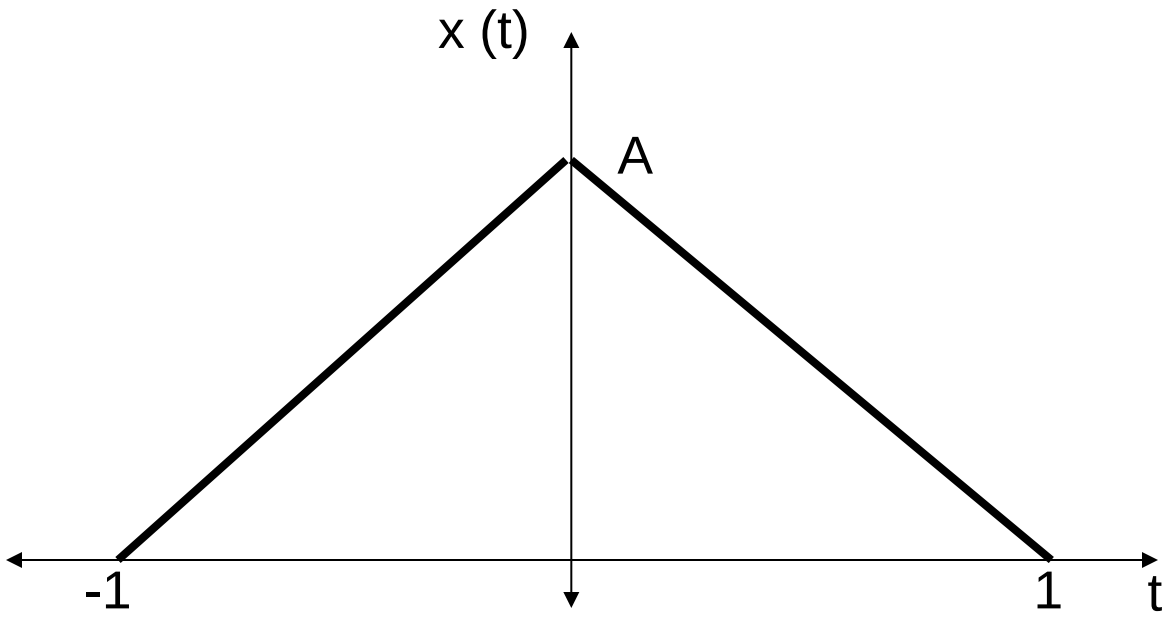


3. After scaling, the signal y (t) is

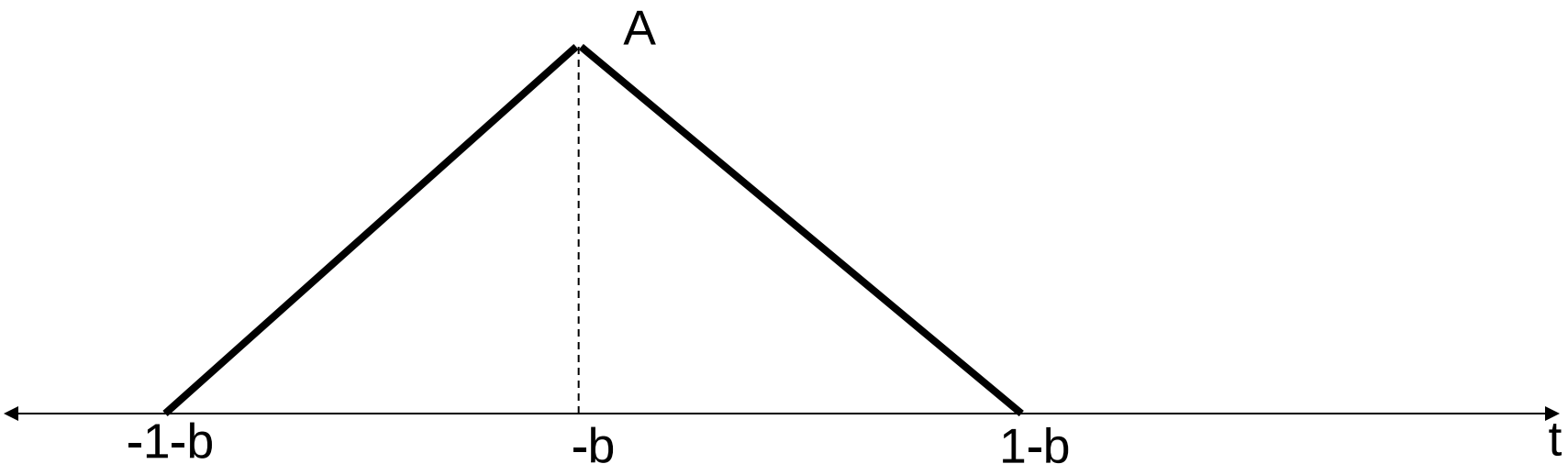


Example 2: $\mathbf{y(t) = x(at + b)}$

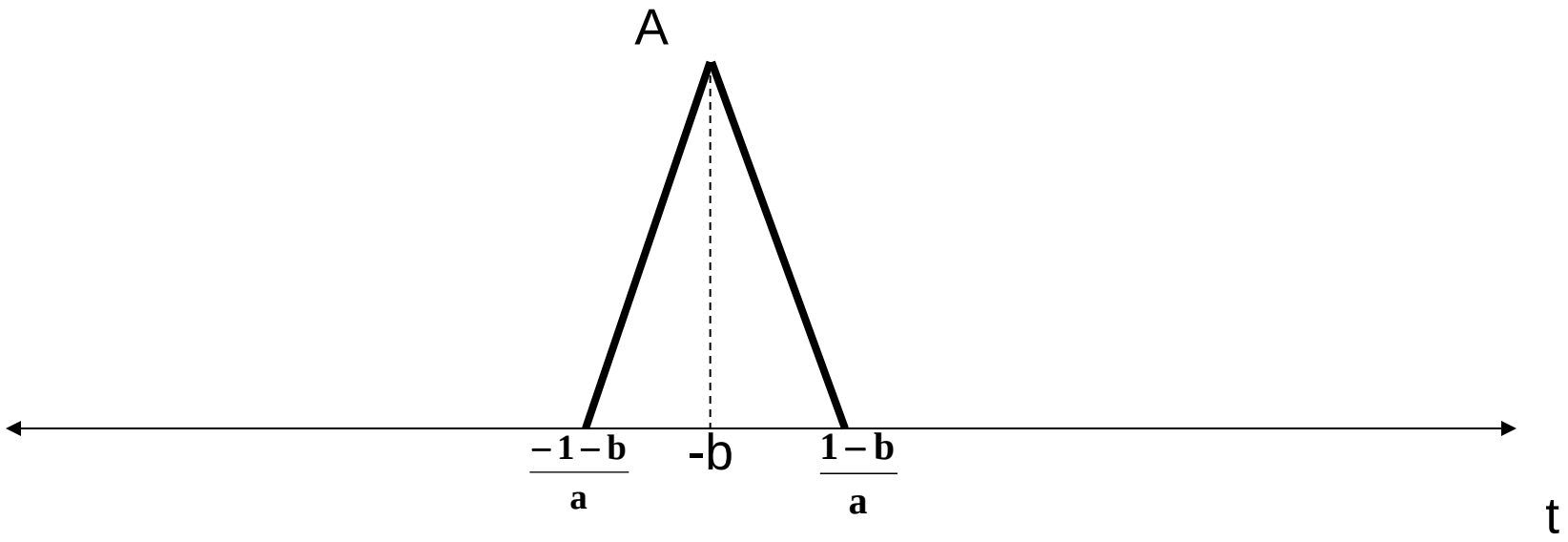
Let x(t) be



1. Shifting



2. Scaling:



Test your understanding

- What are all the basic operations performed on a signal.

- Let $x(t) = 1$ $t < 1$
  0 $t > 1$

  Determine the signal $y(t) = x(3t + 2)$