AL- MUSTAQBAL UNIVERSITY COLLEGE
DEPARTMENT OF BIOMEDICAL ENGINEERING

Digital Signal Processing (DSP)

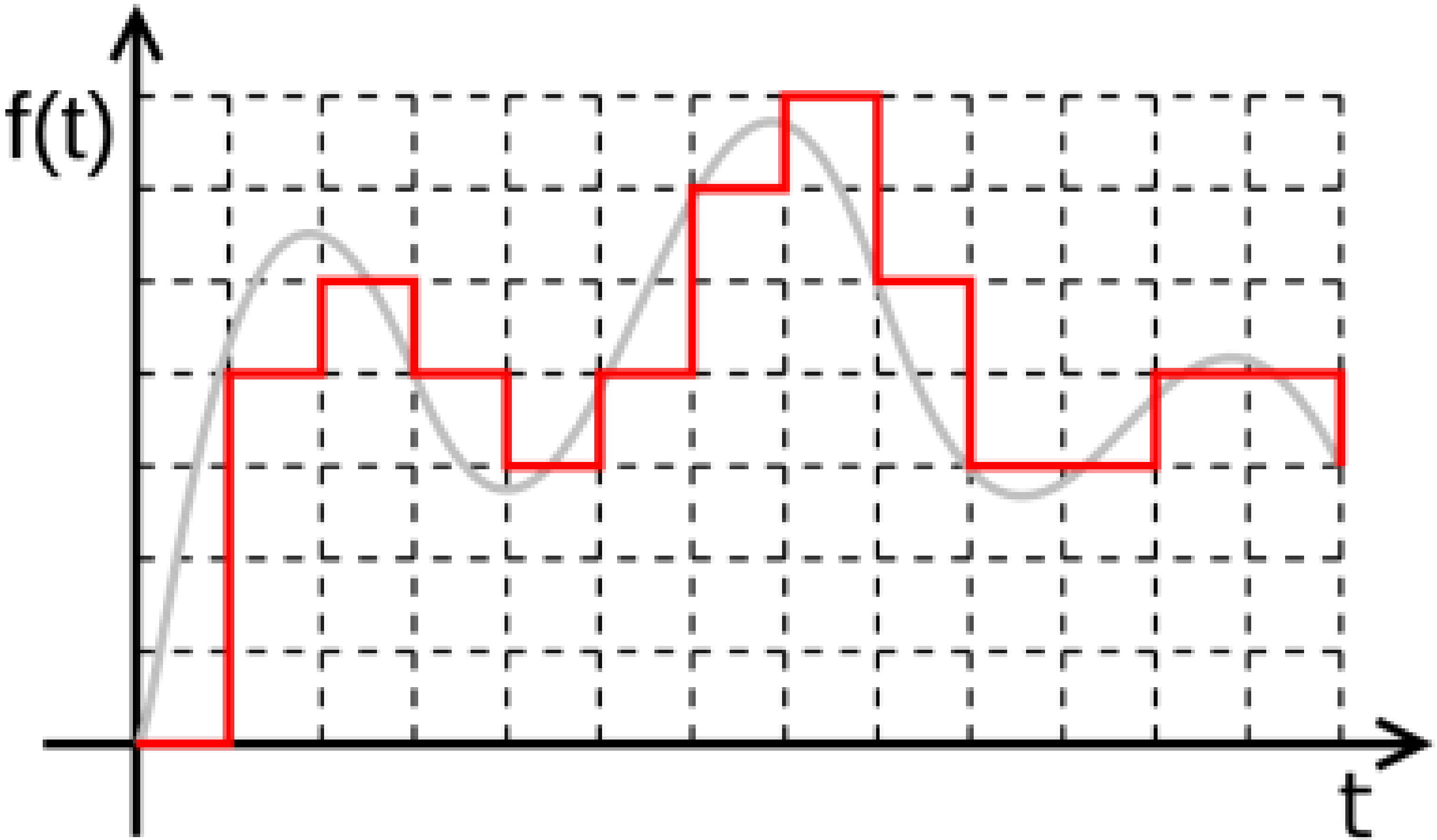
BME 312

Lecture 6

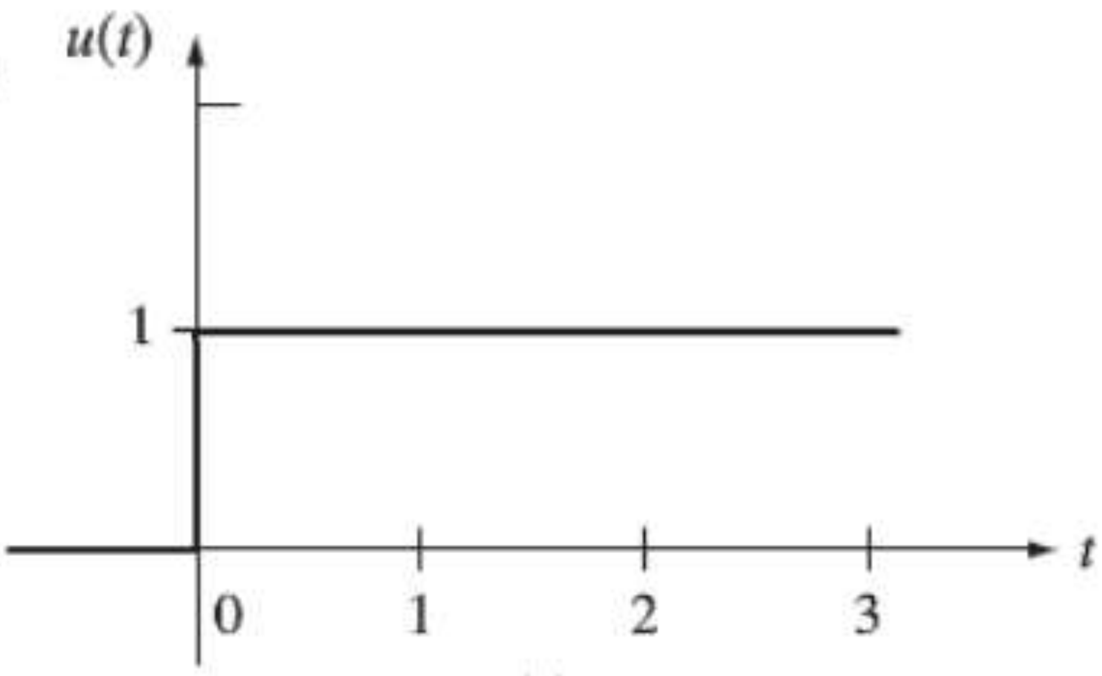
- Continuous Time Signal -

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

Continuous Time Signal

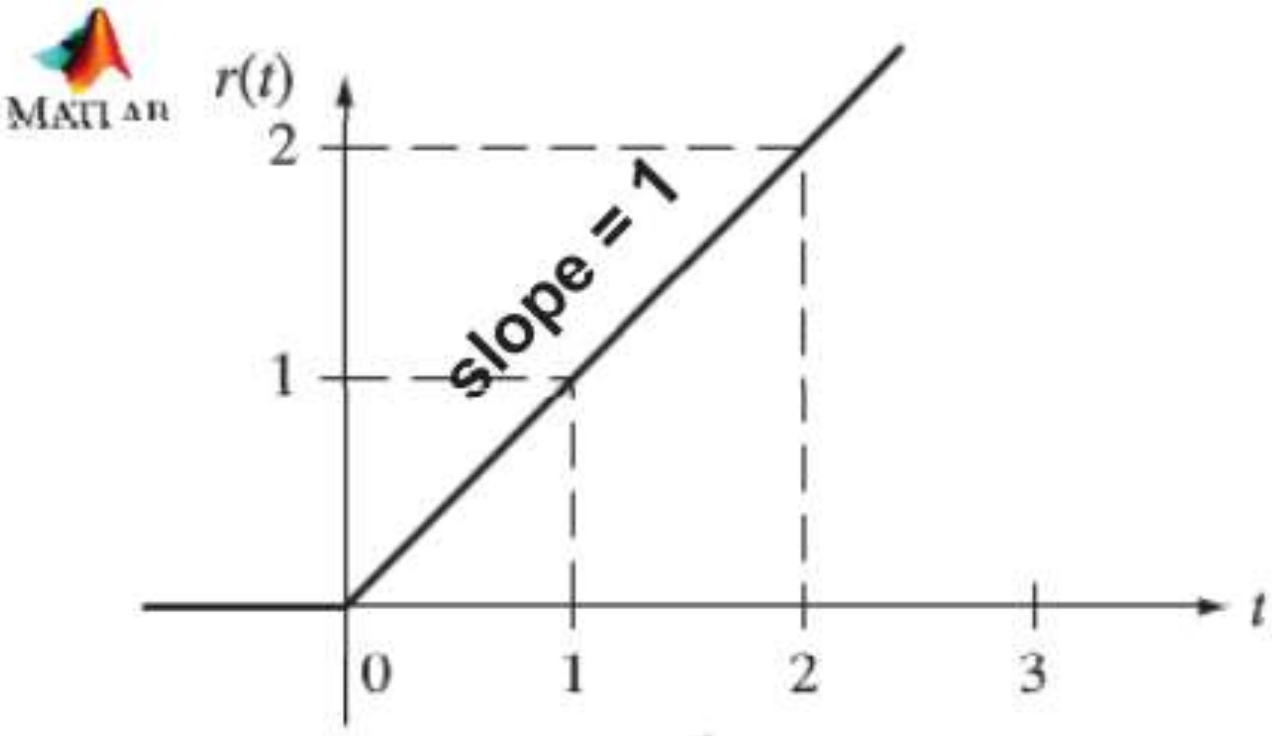


Unit - Step Function u(t)



$$u(t) = \begin{cases} 1, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

Unit - Ramp Function r(t)

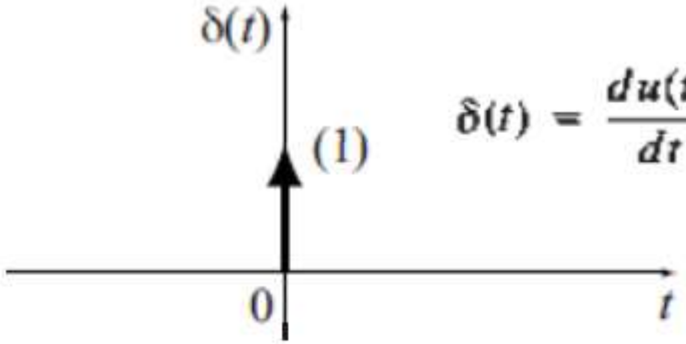


$$r(t) = \begin{cases} t, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

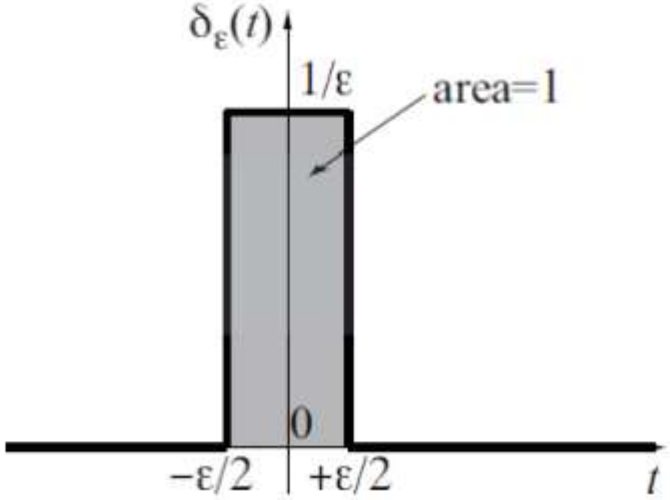
Unit Impulse

The unit impulse also called the delta function or the Dirac distribution, is defined by

$$\delta(t) = 0 \text{ for } t \neq 0$$



$$\delta(t) = \frac{du(t)}{dt}$$



$$\delta[n] = \begin{cases} 1 & n = 0 \\ 0 & n \neq 0 \end{cases}$$

where $$\delta(t) = \lim_{\varepsilon \to 0} \delta_\varepsilon(t),$$

$$\delta_\varepsilon(t) = \begin{cases} 1/\varepsilon, & -\varepsilon/2 \leq t \leq \varepsilon/2 \\ 0, & |t| > \varepsilon/2 \end{cases}$$

Unit Impulse

If x(t) is a signal that is continuous at t = 0, then

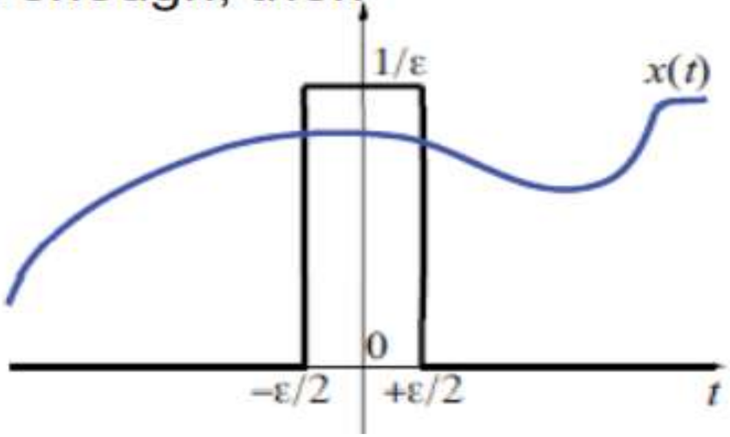
$$x(t)\delta(t) = x(0)\delta(t)$$

In particular,

$$\int_{-a}^{a} x(t)\delta(t)dt = x(0) \qquad \text{for any } 0 < a \leq +\infty.$$

You can convince yourselves of this by approximating ð(t) with a pulse, such as $ð_s(t)$, and using the fact that, if s is small enough, then

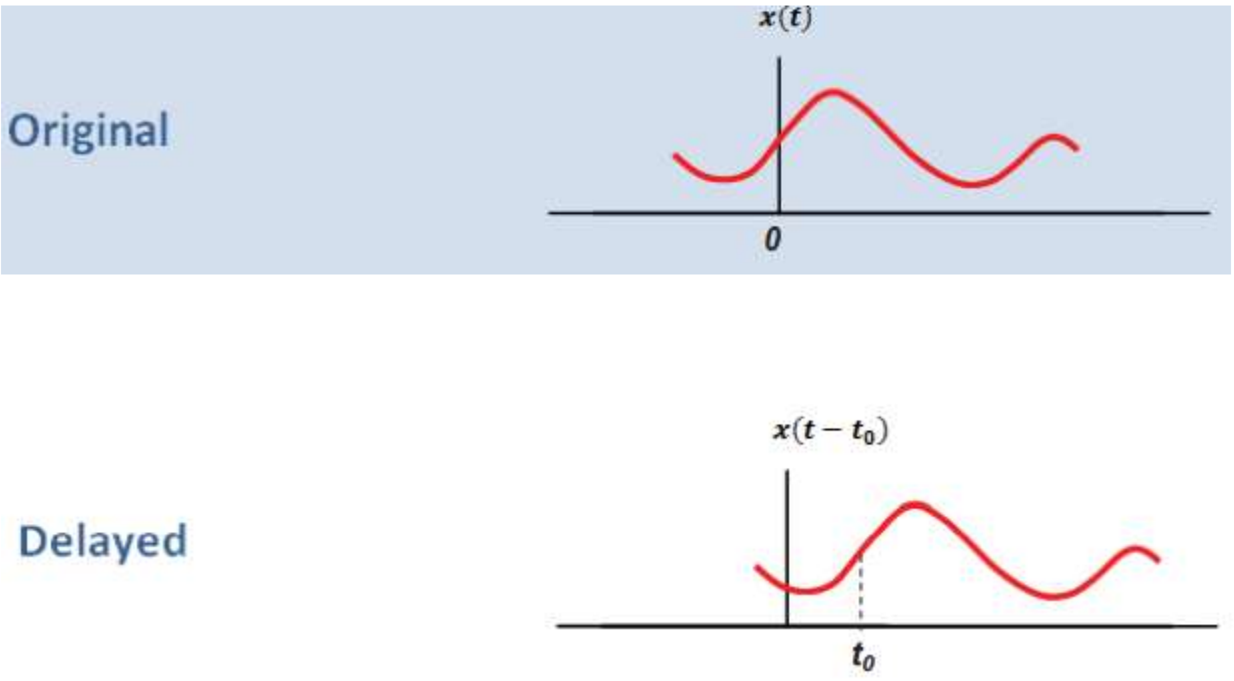
$$x(t) \approx x(0) \qquad \text{for } -\varepsilon/2 \leq t \leq \varepsilon/2.$$



Transformations of time: Time-Shifted Signals

To consider the time-shifted version of x(t), use the following rules:

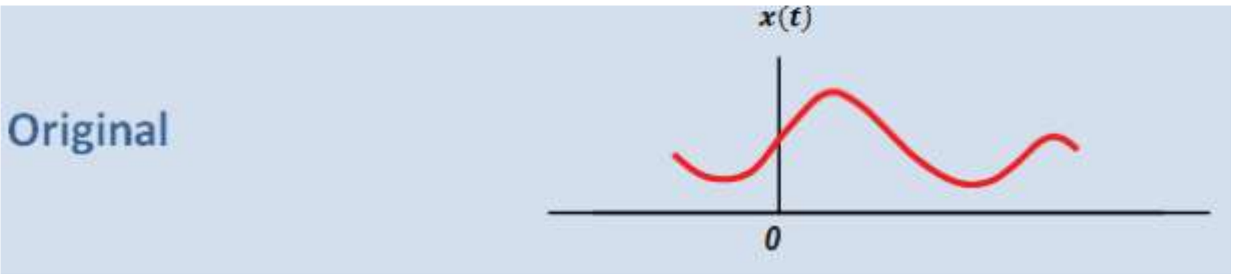
The signal $x(t - t_0)$ is x(t) shifted to the right by t_0 seconds.

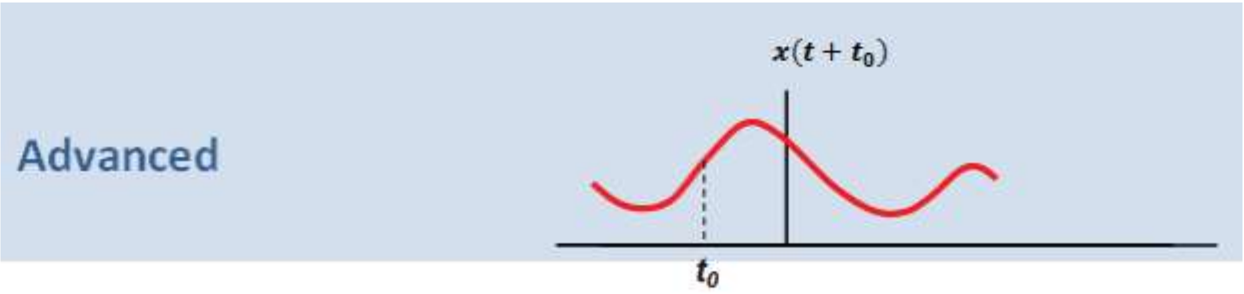


Transformations of time: Time-Shifted Signals

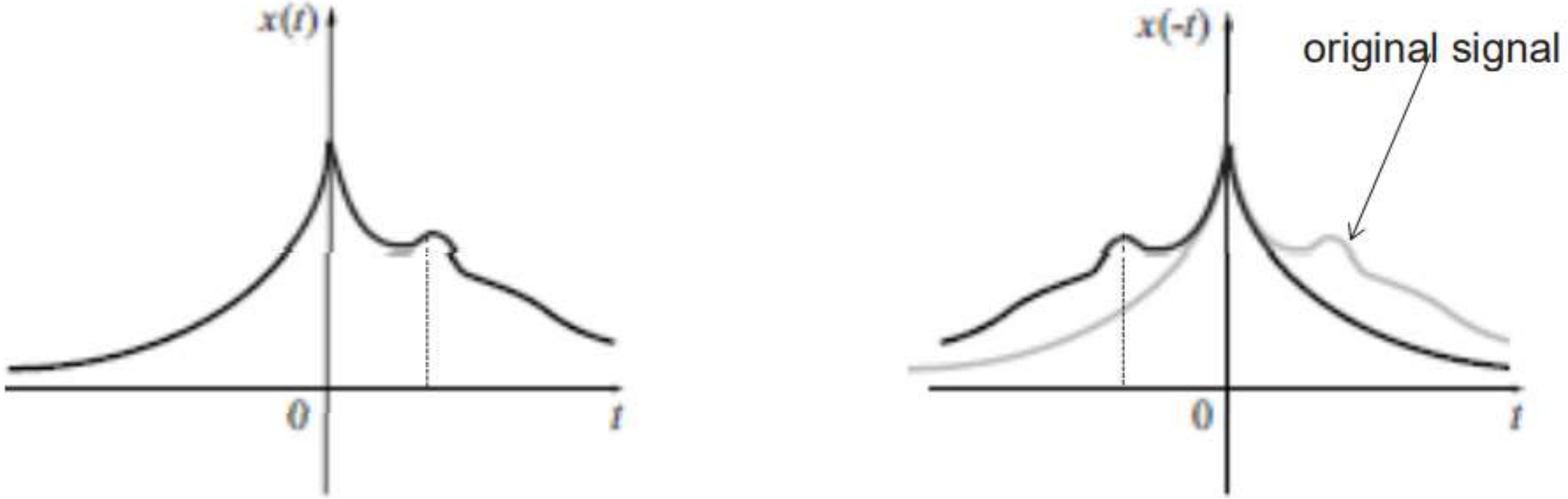
To consider the time-shifted version of x(t), use the following rules:

The signal $x(t + t_0)$ is x(t) shifted to the left by t_0 seconds.



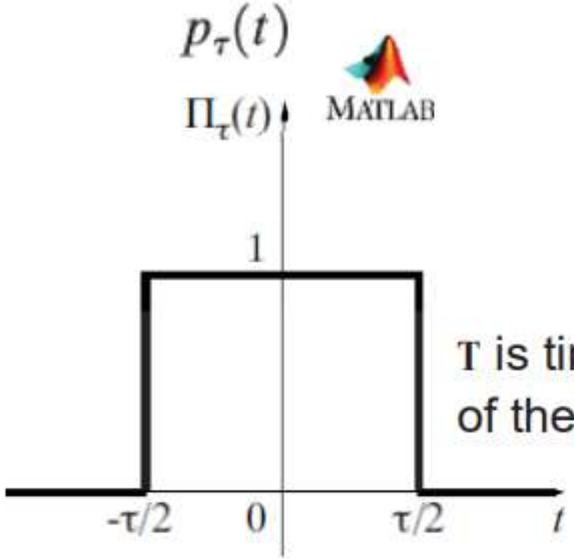


Transformations of time: Time reversal (Reflection)



Rectangular pulse function

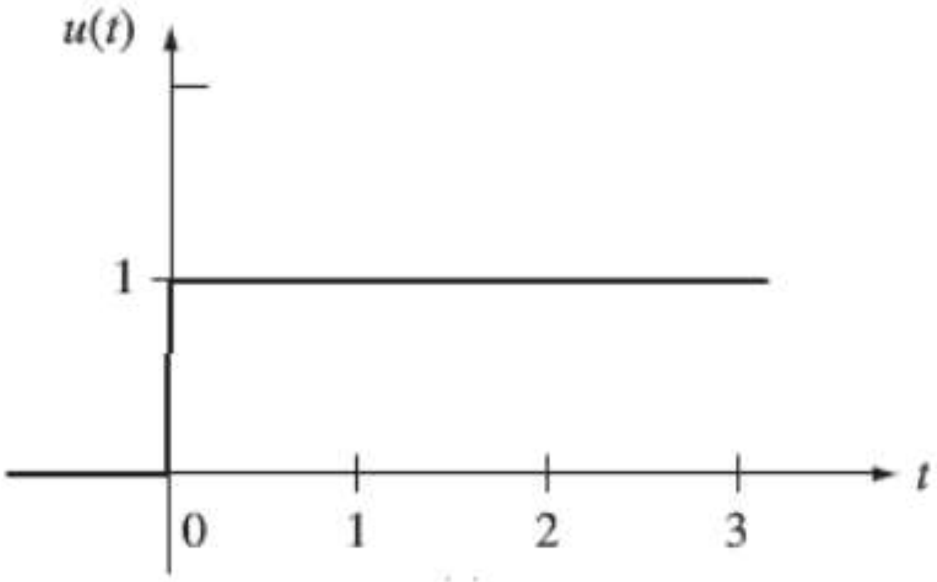
$$p_\tau(t) = \begin{cases} 1, & \frac{-\tau}{2} \le t < \frac{\tau}{2} \\ 0, & t < \frac{-\tau}{2}, t \ge \frac{\tau}{2} \end{cases}$$

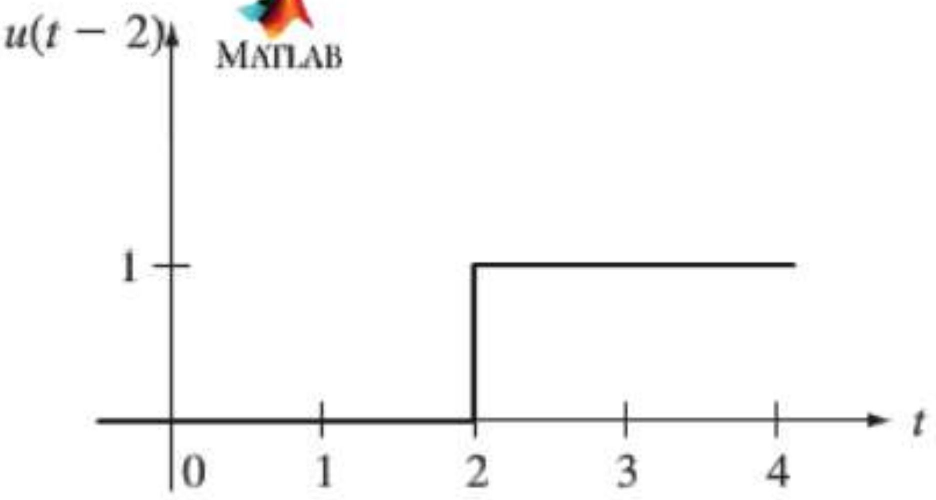


τ is time duration of the pulse

$p_\tau(t)$ can be expressed in the form $\Pi_\tau(t) = u\left(t + \frac{\tau}{2}\right) - u\left(t - \frac{\tau}{2}\right)$

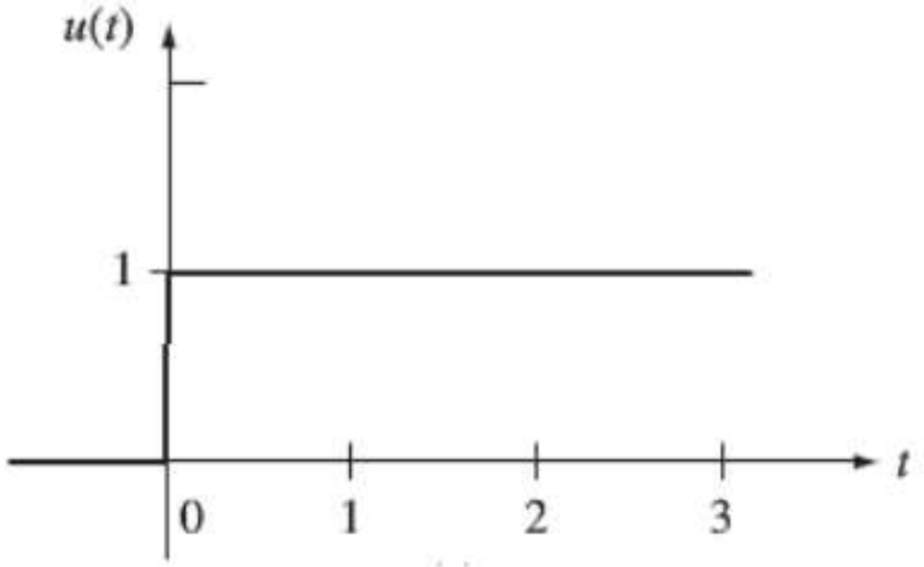
Delayed

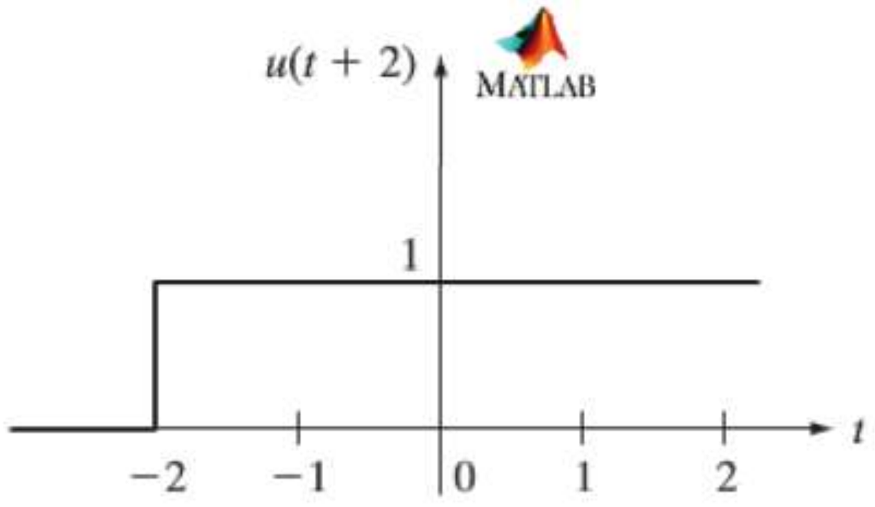




2 second right shift of u(t)

$$u(t) = \begin{cases} 1, & t \geq 0 \\ 0, & t < 0 \end{cases}$$



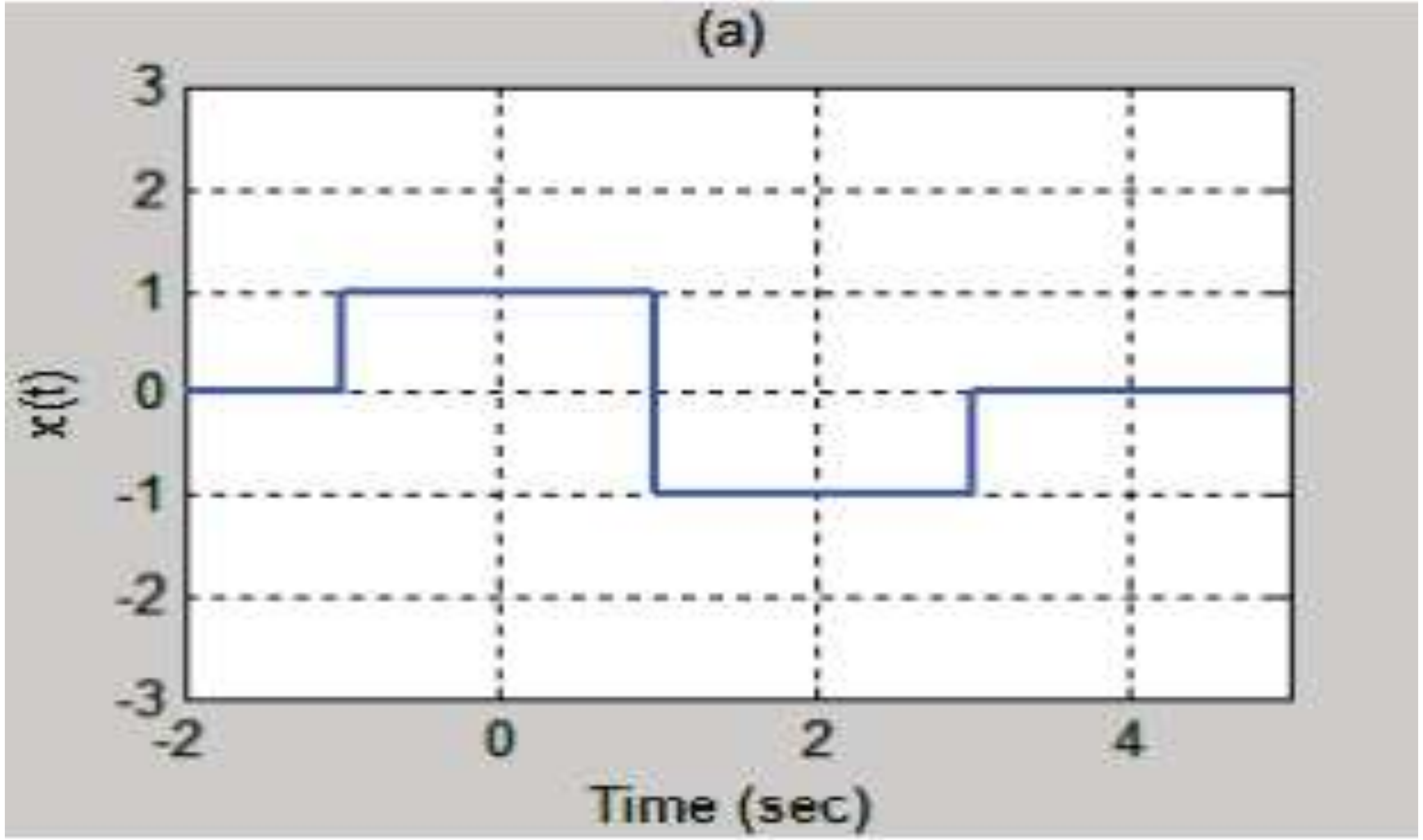


2 second left shift of u(t)

$$u(t) = \begin{cases} 1, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

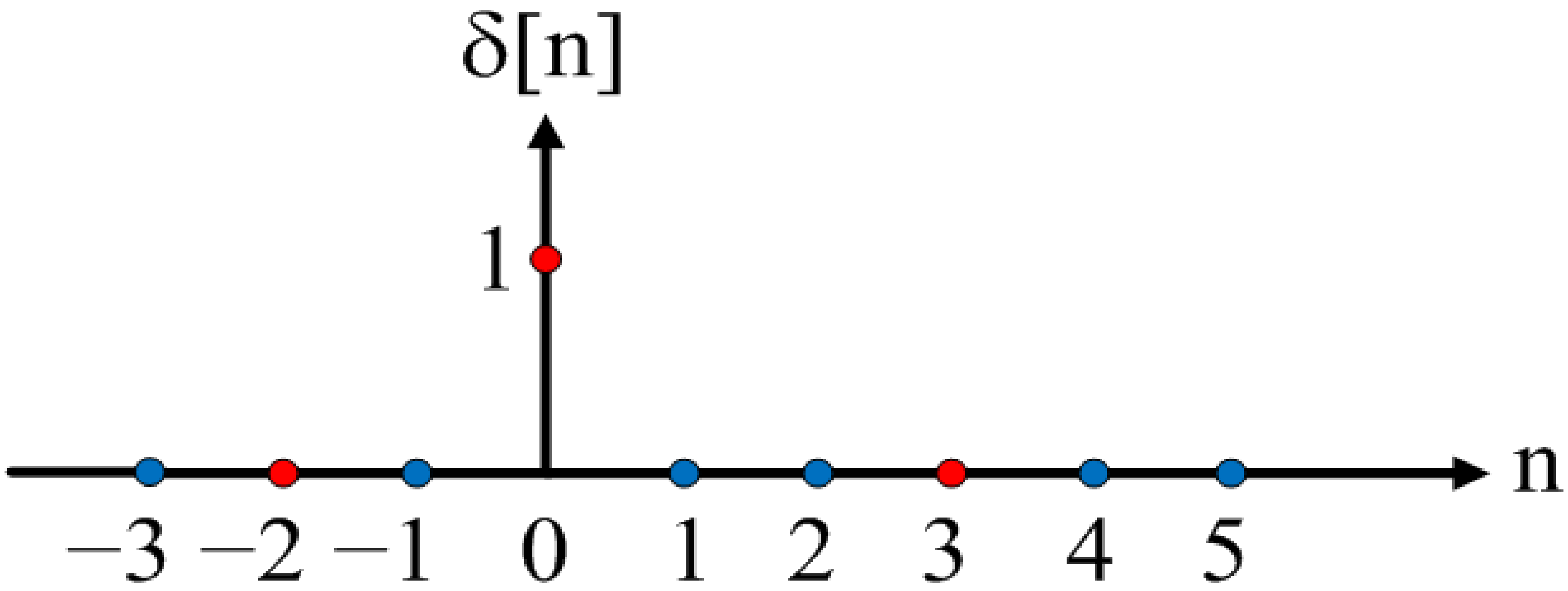
Example 1

$$x(t) = u(t+1) - 2u(t-1) + u(t-3)$$



Example 2

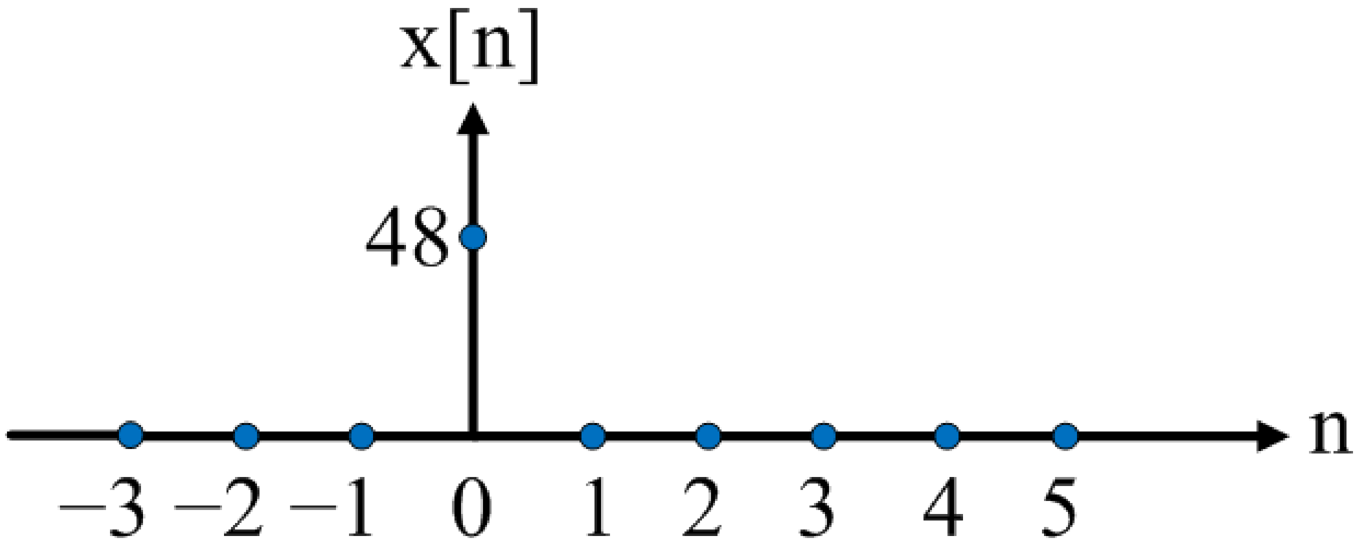
Determine the values δ[0], δ[3] and δ[–2].

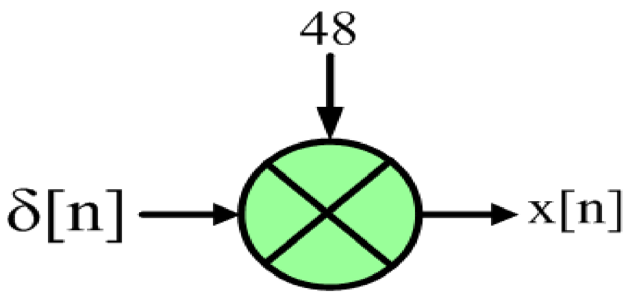


$\delta[0] = 1$, $\delta[3] = 0$ and $\delta[-2] = 0$

Example 3

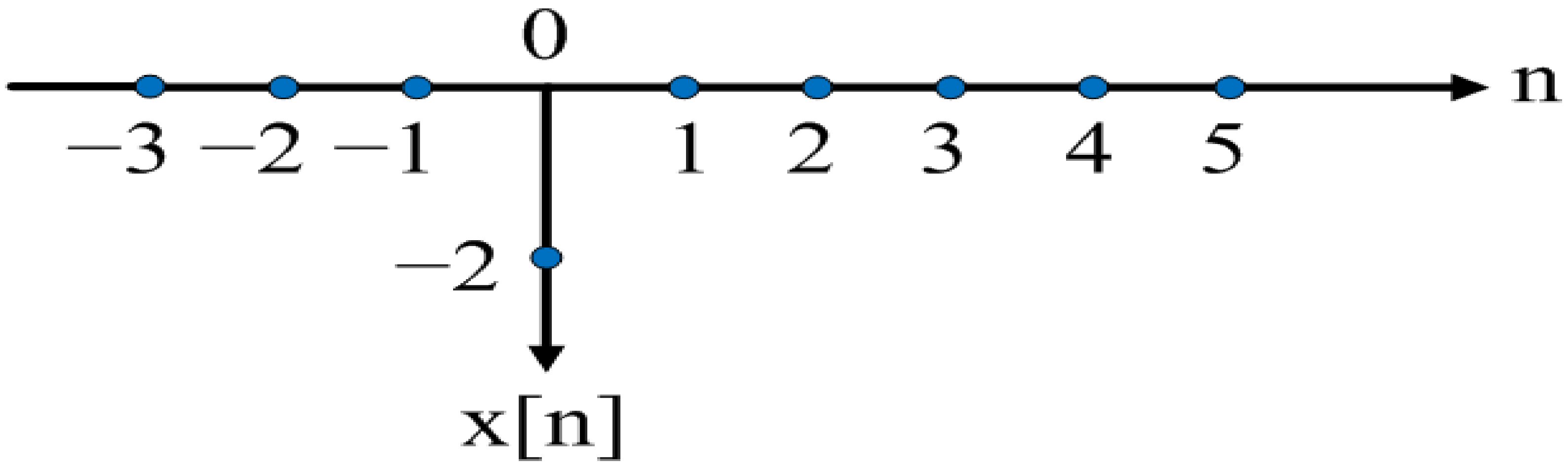
$$x[n] = 48\delta[n]$$

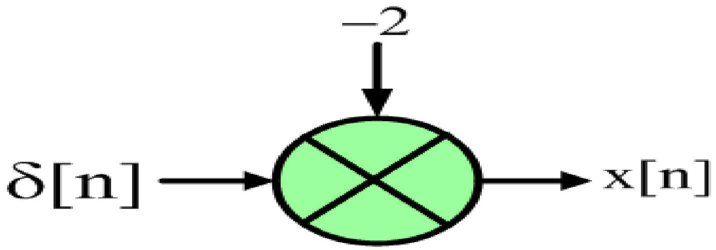




Example 4

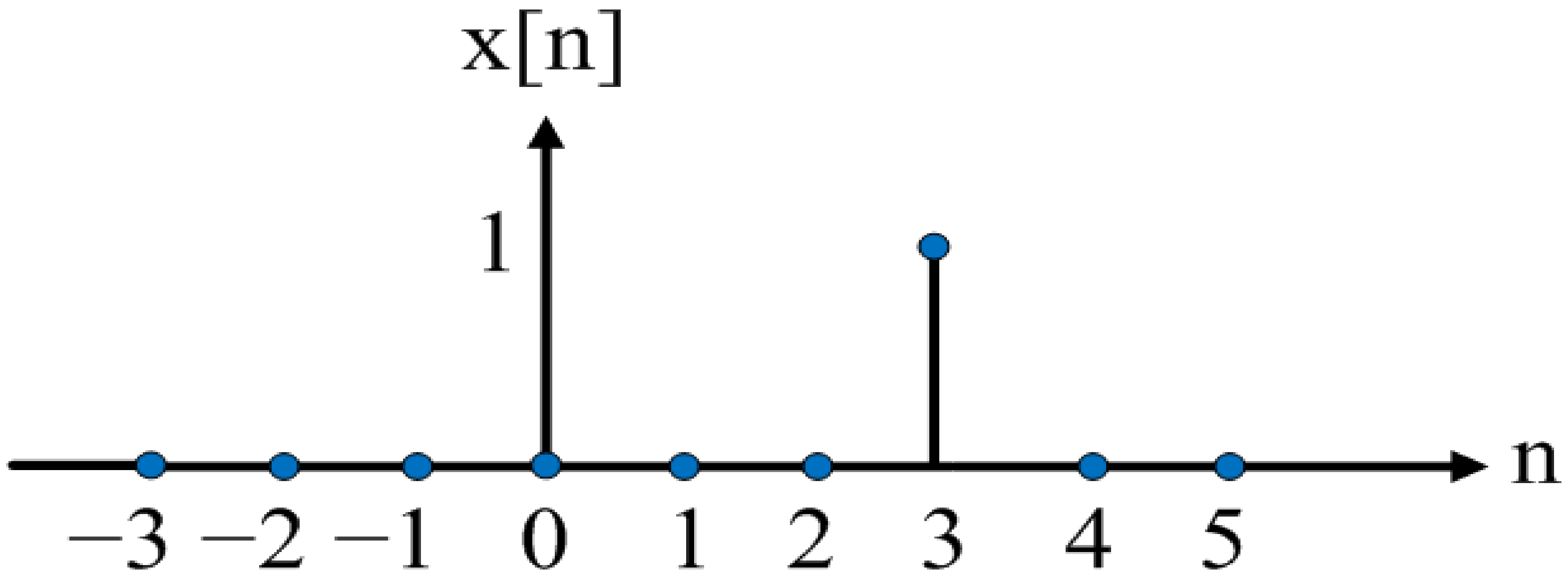
$$x[n] = -2\delta[n]$$

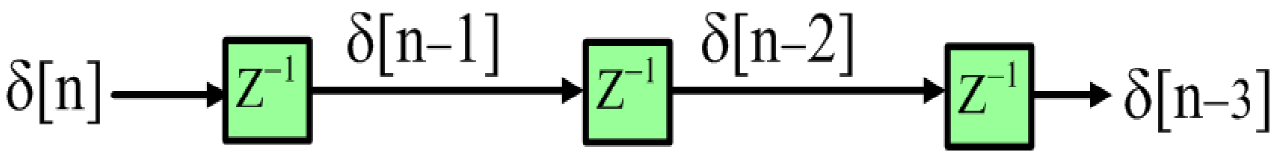




Example 5

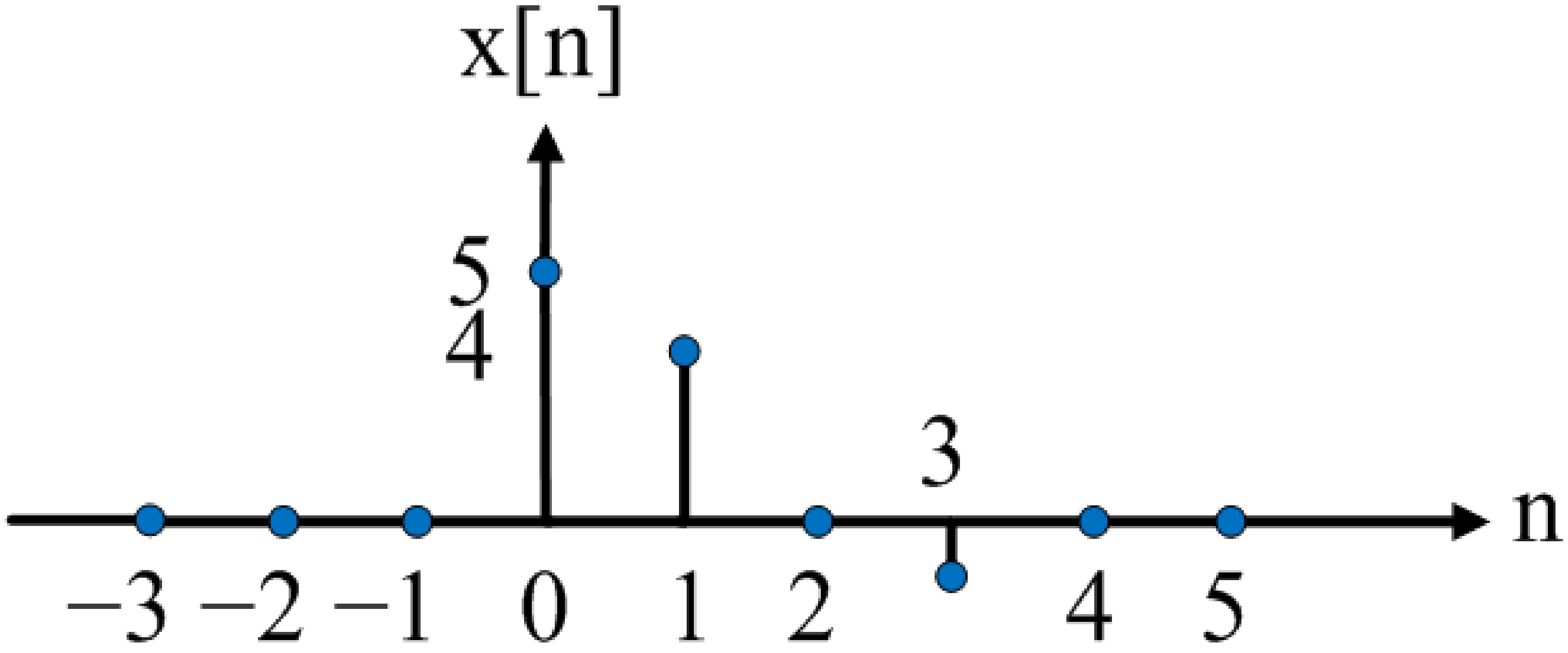
$$x[n] = \delta[n - 3]$$





Example 6

$$x[n] = 5\delta[n] + 4\delta[n-1] - \delta[n-3]$$



Example 6

$$x[n] = 5\delta[n] + 4\delta[n-1] - \delta[n-3]$$