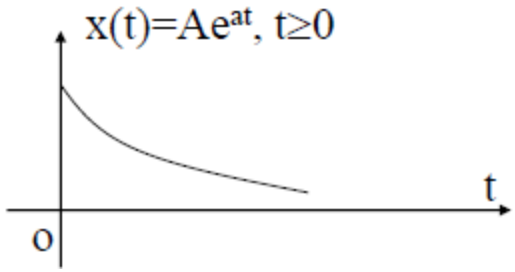
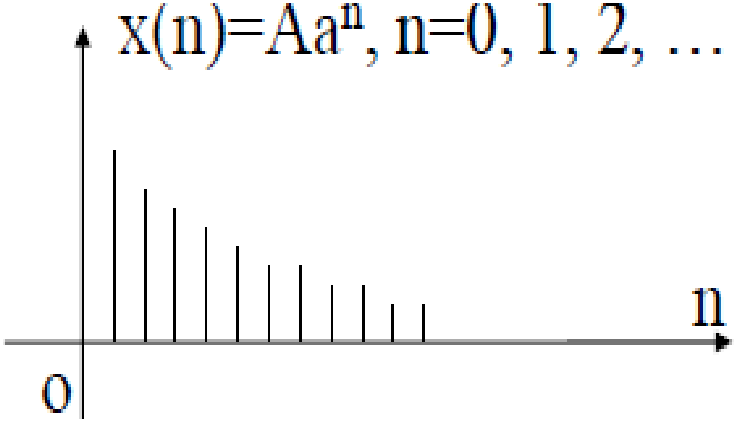
Definition, types of signals and their representations

Introduction to Signals

- A Signal is the function of one or more independent variables that carries some information to represent a physical phenomenon.
- A continuous-time signal, also called an analog signal, is defined along a continuum of time.



A discrete-time signal is defined at discrete times.



Elementary Signals

Sinusoidal & Exponential Signals

- Sinusoids and exponentials are important in signal and system analysis because they arise naturally in the solutions of the differential equations.
- Sinusoidal Signals can expressed in either of two ways :

  cyclic frequency *form*- A sin $2\Pi f_o t$ = A sin$(2\Pi/T_o)t$

  radian frequency form- A sin $\omega_o t$

  $\omega_o = 2\Pi f_o = 2\Pi/T_o$

  T_o = Time Period of the Sinusoidal Wave

Sinusoidal & Exponential Signals Contd.

$$x(t) = A \sin(2\Pi f_o t + \theta) = A \sin(\omega_o t + \theta)$$

Sinusoidal signal

$$x(t) = Ae^{at}$$

Real Exponential

$$= Ae^{j\omega t} = A[\cos(\omega_o t) + j \sin(\omega_o t)]$$

Complex Exponential

θ = Phase of sinusoidal wave

A = amplitude of a sinusoidal or exponential signal

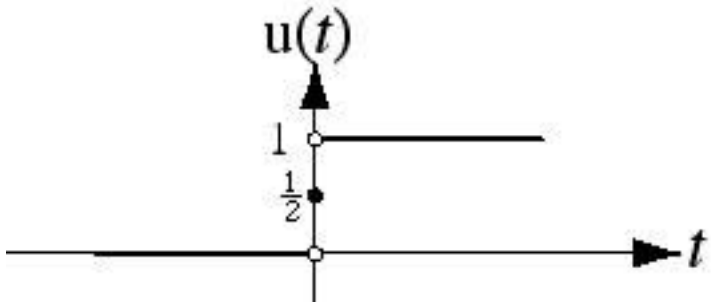
f_o = fundamental cyclic frequency of sinusoidal signal

ω_o = radian frequency

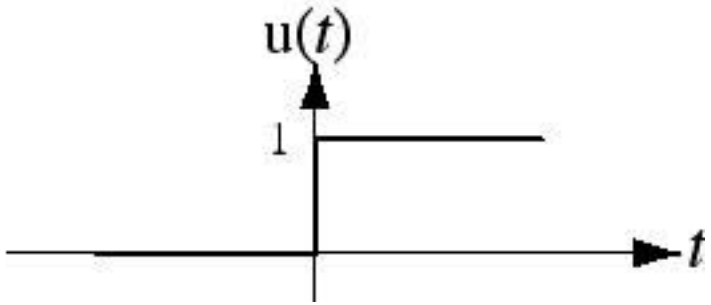
Unit Step Function

$$u(t)=\begin{cases}1 & , \quad t>0\\ 1/2 & , \quad t=0\\ 0 & , \quad t<0\end{cases}$$

Precise Graph



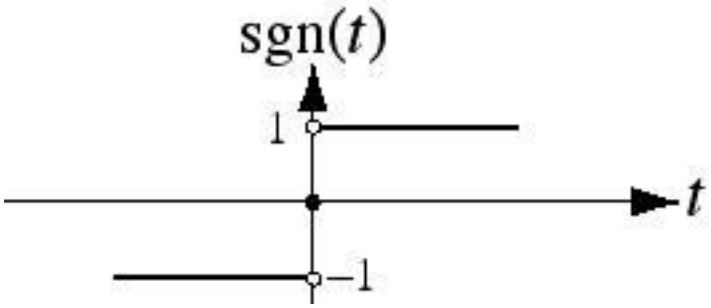
Commonly-Used Graph



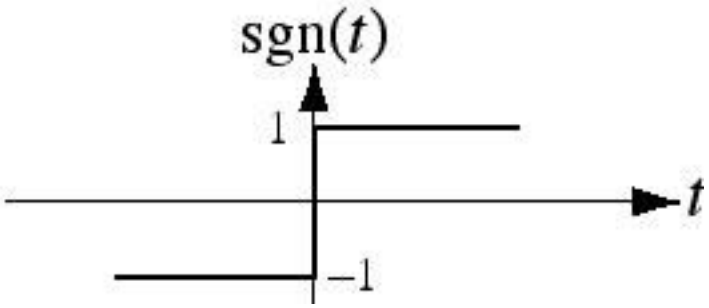
Signum Function

$$\operatorname{sgn}(t) = \begin{cases} 1 & , \ t > 0 \\ 0 & , \ t = 0 \\ -1 & , \ t < 0 \end{cases} = 2\,\mathrm{u}(t) - 1$$

Precise Graph

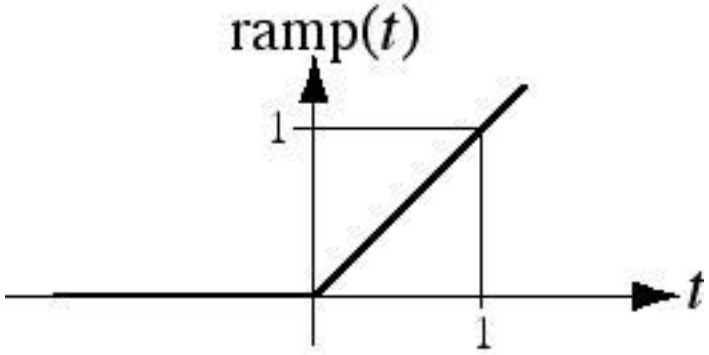


Commonly-Used Graph



The signum function, is closely related to the unit-step function.

Unit Ramp Function



$$\text{ramp}(t) = \begin{cases} t & , \quad t > 0 \\ 0 & , \quad t \le 0 \end{cases} = \int_{-\infty}^{t} \text{u}(\lambda)\, d\lambda = t\,\text{u}(t)$$

- The unit ramp function is the integral of the unit step function.
- It is called the unit ramp function because for positive t, its slope is one amplitude unit per time.

Rectangular Pulse or Gate Function

Rectangular pulse,

$$\delta_a(t) = \begin{cases} 1/a & , \ |t| < a/2 \\ 0 & , \ |t| > a/2 \end{cases}$$