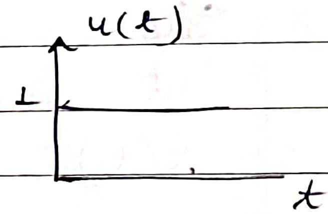
Types of Signals

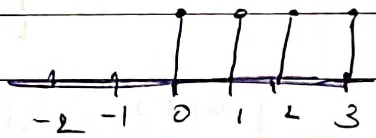
1) Unit Step Signal
2) Impulse function
3) Signum function
4) Exponential signal
5) Unit Ramp Signal
6) Parabolic Signal
7) Rectangular Pulse
8) Triangular Signal
9) Sinusoidal Signal
10) Sinc function
11) Sampling function

Unit Step Signal: It is denoted by $u(t)$ or $u(n)$

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



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



Properties

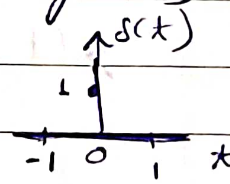
(i) $(u(t))^n = u(t)$

$\Rightarrow (u(t-t_0))^k = u(t-t_0)$

(ii) $u(at) = u(t)$

Impulse Function: It is denoted by $\delta(t)$

$$\delta(t) = \begin{cases} 1 & t = 0 \\ 0 & t \neq 0 \end{cases}$$



Properties

(i) $\int_{-\infty}^{\infty} \delta(t)\, dt = 1$

(ii) $\delta(n-k) = \begin{cases} 1 & n = k \\ 0 & n \neq k \end{cases}$

(iii) $\delta(n) = u(n) - u(n-1)$

(iv) $f(t)\,\delta(t) = f(0)$

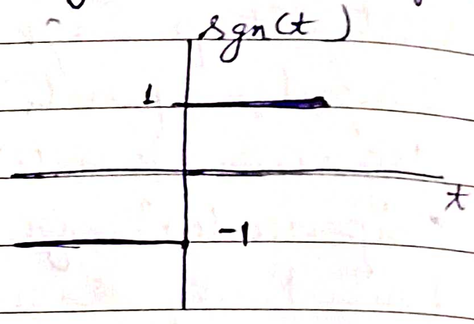
(v) $\delta(t-t_0)\, f(t) = f(t_0)$

(vi) $\delta(kt) = \frac{1}{|k|}\delta(t)$

(vii) $\delta(-t) = \delta(t)$

Signum Function: It is denoted by $sgn(t)$ or $sgn(n)$

$$sgn(t) = \begin{cases} 1 & t > 0 \\ 0 & t = 0 \\ -1 & t < 0 \end{cases}$$



$$sgn(t) = 2u(t) - 1$$

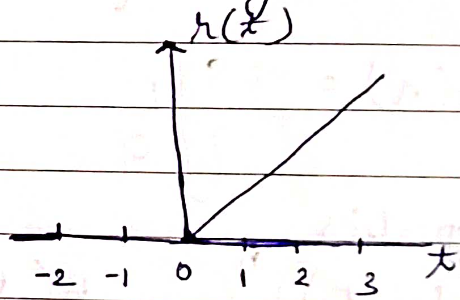
Exponential Signal: This signal is in the form

$$x(t) = e^{\alpha t}$$

~~The~~

Unit Ramp Signal: It is denoted by $r(t)$ or $r(n)$

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



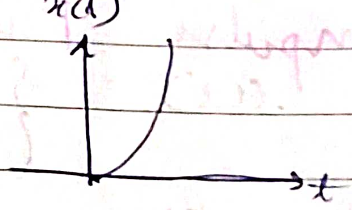
$$\int u(t) = r(t)$$

$$u(t) = \frac{d\, r(t)}{dt}$$

$$\int \delta(t) = u(t)$$

Unit Parabolic Signal:

$$x(t) = \begin{cases} \frac{t^2}{2} & t \geq 0 \\ 0 & t < 0 \end{cases}$$



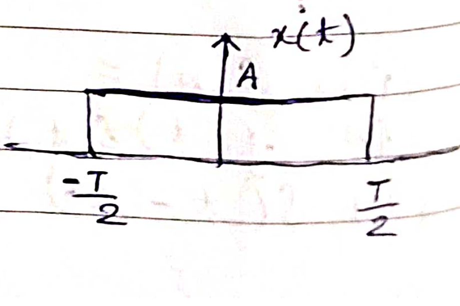
$$\int r(t) = x(t)$$

Rectangular Pulse: Denoted by $x(t)$

$$x(t) = A\, rect\left(\frac{t}{T}\right)$$

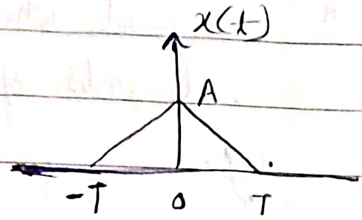
A = amplitude of rectangle

T = time period of rectangle



Triangular Signal: Denoted by $x(t)$

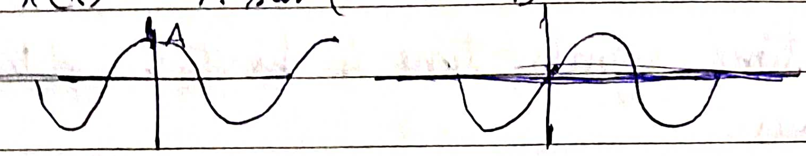
$$x(t) = A\left(1 - \frac{|t|}{T}\right)$$



Sinusoidal Signal:

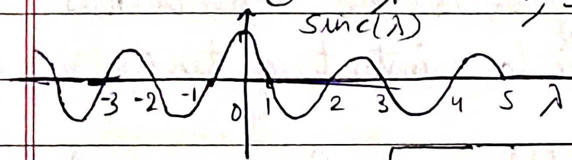
$x(t) = A\cos(\omega_0 t \pm \phi)$ or

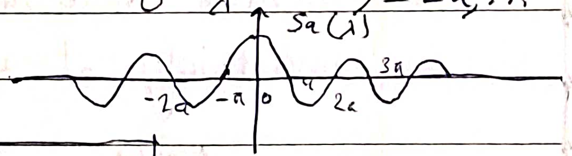
$x(t) = A\sin(\omega_0 t \pm \phi)$



Sinc and sampling function

Sinc	Sampling
* Denoted by $\text{sinc}(\lambda)$	Denoted with $Sa(\lambda)$
* Normalized function	Unnormalized sinc
* $\text{sinc}(\lambda) = \frac{\sin \pi\lambda}{\pi\lambda}$	$Sa(\lambda) = \frac{\sin\lambda}{\lambda}$
$= 0 \quad \lambda = \pm 1, \pm 2, \ldots$	$= 0 \quad \lambda = \pm\pi, \pm 2\pi, \ldots$





$$\boxed{\text{sinc}(0) = Sa(0) = 1}$$

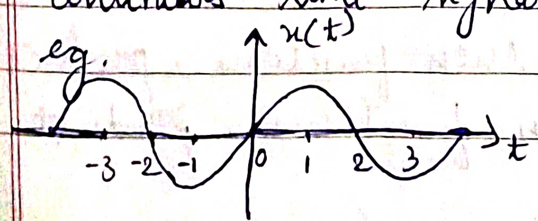
Classification of signals

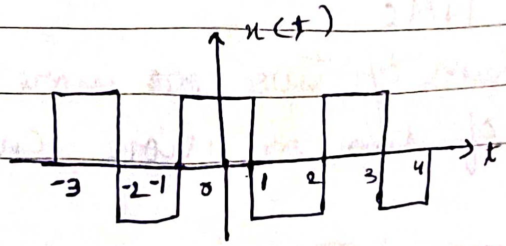
1. Continuous time and discrete time signals
2. Deterministic and non deterministic (Random) signals
3. Even and Odd signals
4. Periodic and Aperiodic signals
5. Energy and Power signals
6. Real and imaginary

1. Continuous and Discrete time signals

* A signal which is defined for all values of t is called continuous time signal

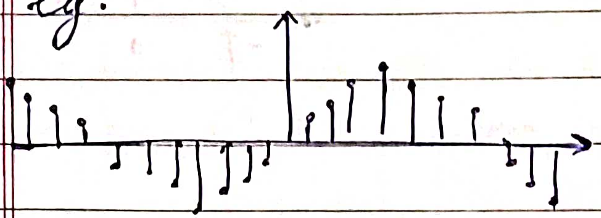
eg.





★ A signal which is defined only at discrete intervals of time is called discrete signal

eg.



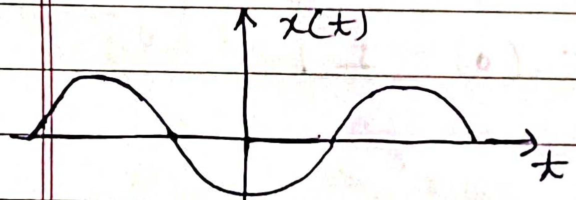
★ For discrete time signals, time is discrete ; amplitude is continuous.

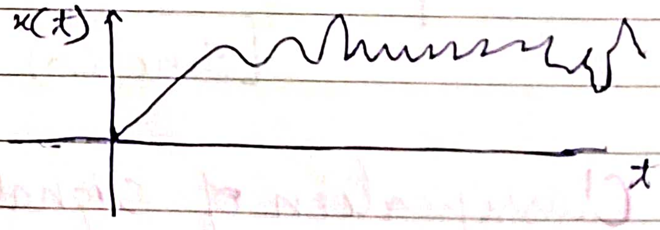
★ For digital signal both amplitude & time are discrete

2. Deterministic and Non Deterministic (Random) Signals

★ A signal is said to be deterministic if there is no uncertainty with respect to its value at any instant of time.

★ A non deterministic signal is one which has uncertainty at any particular instant of time





Deterministic

3. Even and Odd Signals

★ A signal is said to be even when it satisfies the condition $x(t) = x(-t)$

eg. $\cos t$, t^2, t^4, etc.

★ A signal is said to be odd when it satisfies the condition

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

eg. $\sin t$, t, t^3, t^5, etc

★ Note:

★ Sum of two ~~ore~~ more even functions, product of two or more even functions, product of even number of odd functions results even functions

* Sum of two or more odd functions, product of odd number of odd functions results odd function.

Even and Odd Components of a Signal.

$$x_e(t) = \frac{x(t) + x(-t)}{2}$$

$$x_o(t) = \frac{x(t) - x(-t)}{2}$$

4. Periodic and Aperiodic Signal

* A signal $x(t)$ is said to be periodic if it satisfies the condition $x(t) = x(t+T)$
* The smallest value of T which satisfies the above condition is called "fundamental time period".
* When two signals of same frequency are added, the resultant signal is also sinusoidal and periodic.
* When two signals of different frequency are added, the resultant may be periodic or non periodic.

5. Energy and power signale

* A signal is said to be energy signal if its total energy E is finite i.e. $0 < E < \infty$. For an energy signal average power. $P = 0$. Non periodic signals are example of energy signals.
* A signal is said to be power signal if its average power P is finite. i.e $0 < P < \infty$. For a power signal total energy $E = \infty$. Periodic signals are example of power signal.

$$E = \int_{-T}^{T} x^2(t)\, dt \quad \text{[Finite duration]}$$

$$E = \lim_{T \to \infty} \int_{-T}^{T} x^2(t)\, dt \quad \text{[Infinite Duration]}$$

$$E = \int_{-\infty}^{\infty} |x(t)|^2\, dt$$

$$P = \frac{1}{T}\int_{-T/2}^{T/2} x^2(t)\,dt \quad \text{[Finite Duration]}$$

$$P = \lim_{T\to\infty} \frac{1}{T}\int_{-T/2}^{T/2} x^2(t)\,dt \quad \text{[Infinite Duration]}$$

Note:

Power of energy signal $= 0$

Energy of power signal $= \infty$

* If energy of $x(t) = E$ then energy of $x(at) = E/a$

6. Real and Imaginary Signal

* A signal is said to be real when it satisfies $x(t) = x^*(t)$.
* A signal is said to be imaginary when it satisfies the condition $x(t) = -x^*(t)$
* For a real signal imaginary part must be zero.
* For an imaginary signal real part must be zero.