Class web group is @ piazza.com

Link https://piazza.com/

Search for BIMU3009

~~pass~~ class code : signal123

Textbook :
"Signals and Systems",
Simon Haykin and Barry Van Veen,
2nd Ed, Wiley

What is a Signal

- Speech signals
- E-mails
- Heartbeats
- Radio (Telsiz)
- Fluctuations in the prices of stocks. →

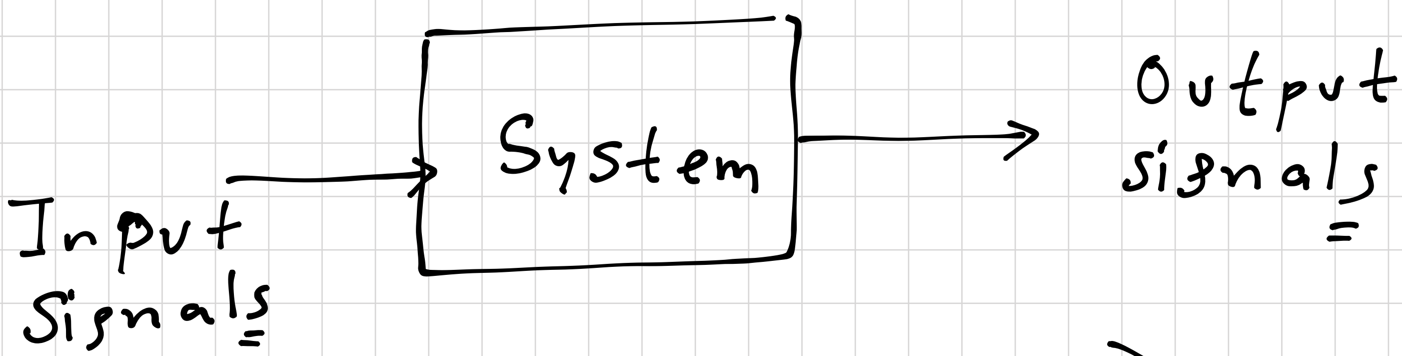
Formally : "A signal is formally defined as a function of one or more variables that conveys information on the nature of a physical phenomenon"

→ one dimensional signal
→ multidimensional "

Kitap : > Türkçe kitap
→ Oppenheim , "Sinyaller ve Sistemler",
→ Schaum's Outlines .. "

What is a system

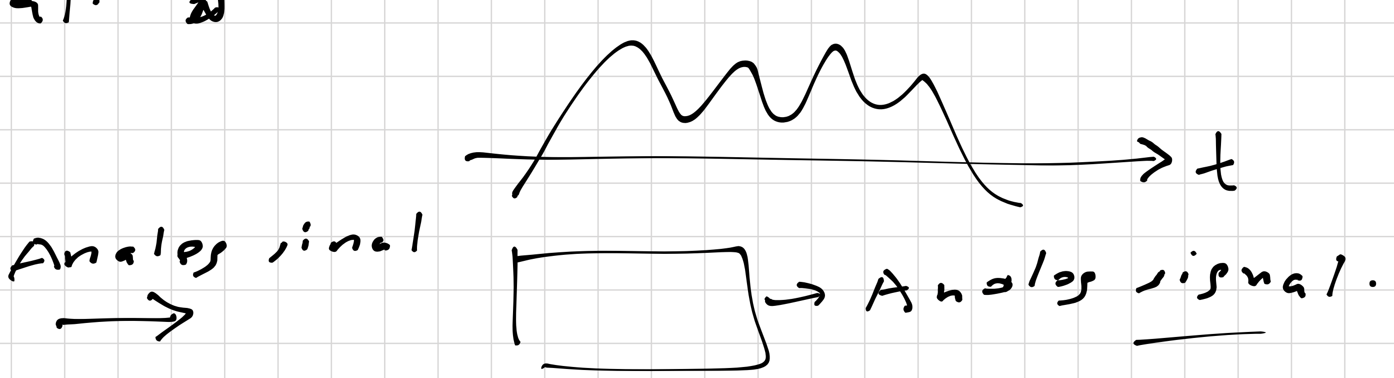
A system is an entity that manipulates one or more signals to accomplish a function, thereby yielding new signals.



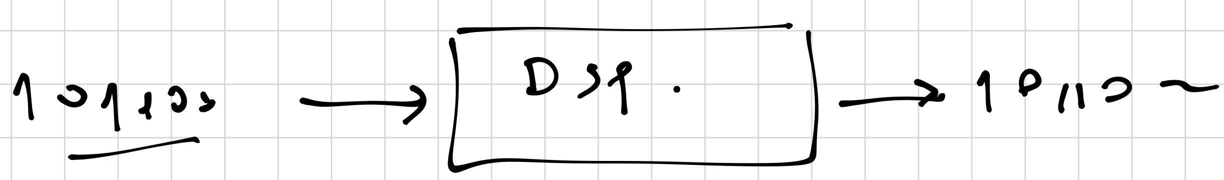
This process is called "Signal Processing"

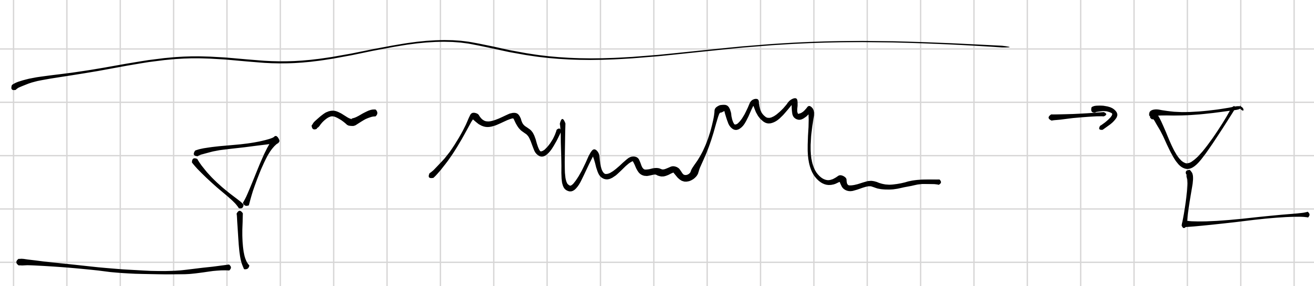
Analog vs Digital Signal Processing

~ Analog Signal Processing involves continuous ~~analog~~ signal.



~ D.S.P involves ~~disc~~ ~~discrete~~ Digital signals.



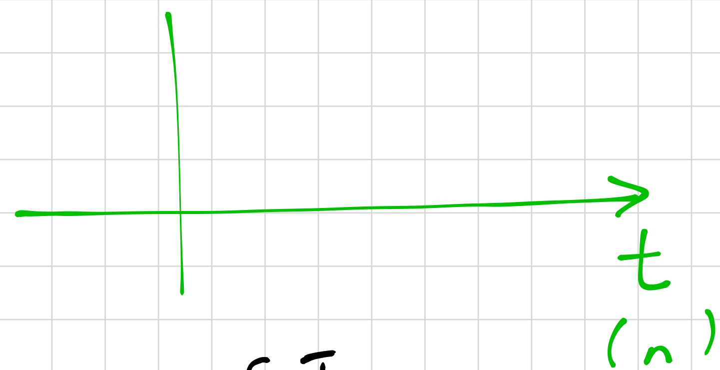


Classification of Signals

In this class:

→ One dimensional single valued signals

→ Represent signals as a function of time



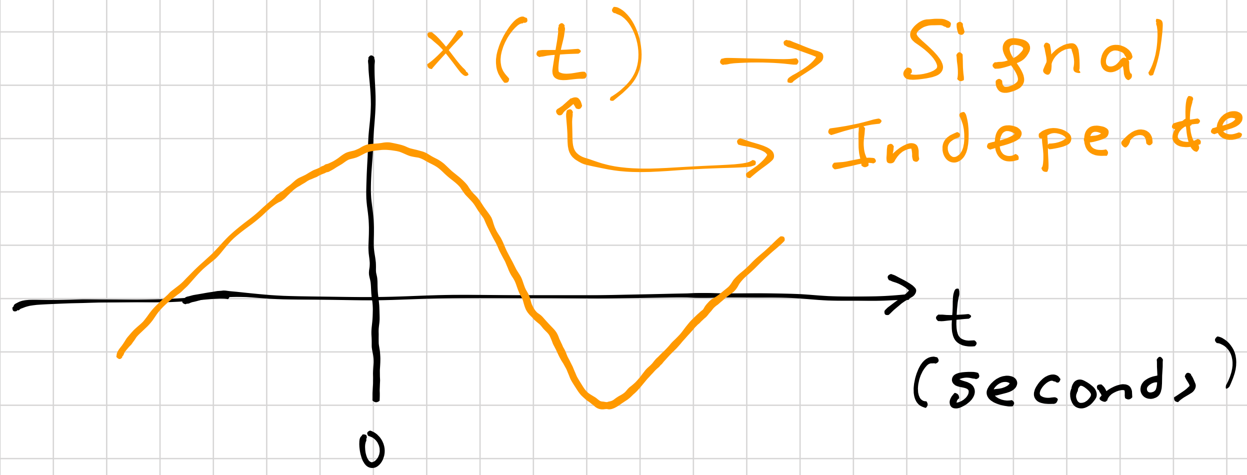
CT

① Continuous-Time and Discrete-Time Signals

DT

$x(t)$ → Signal

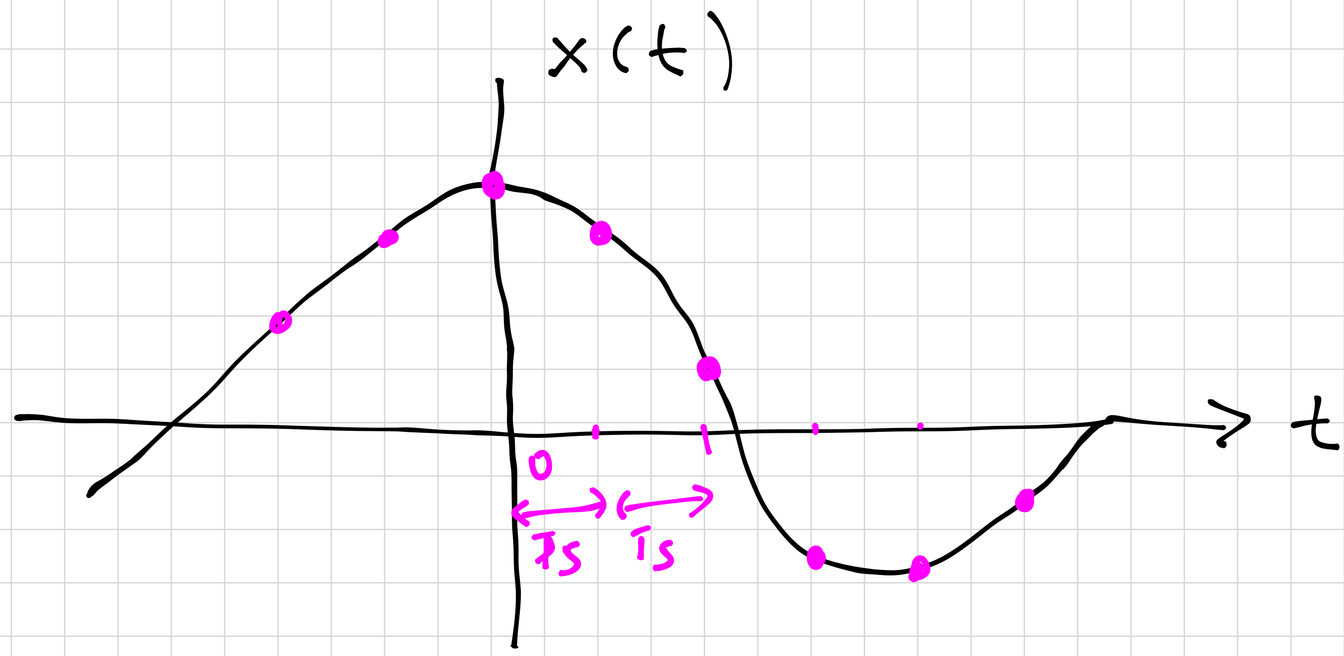
t → Independent variable



→ A CT signal, $x(t)$, is defined for all time, t.

→ A DT signal is defined only at discrete instants of time.

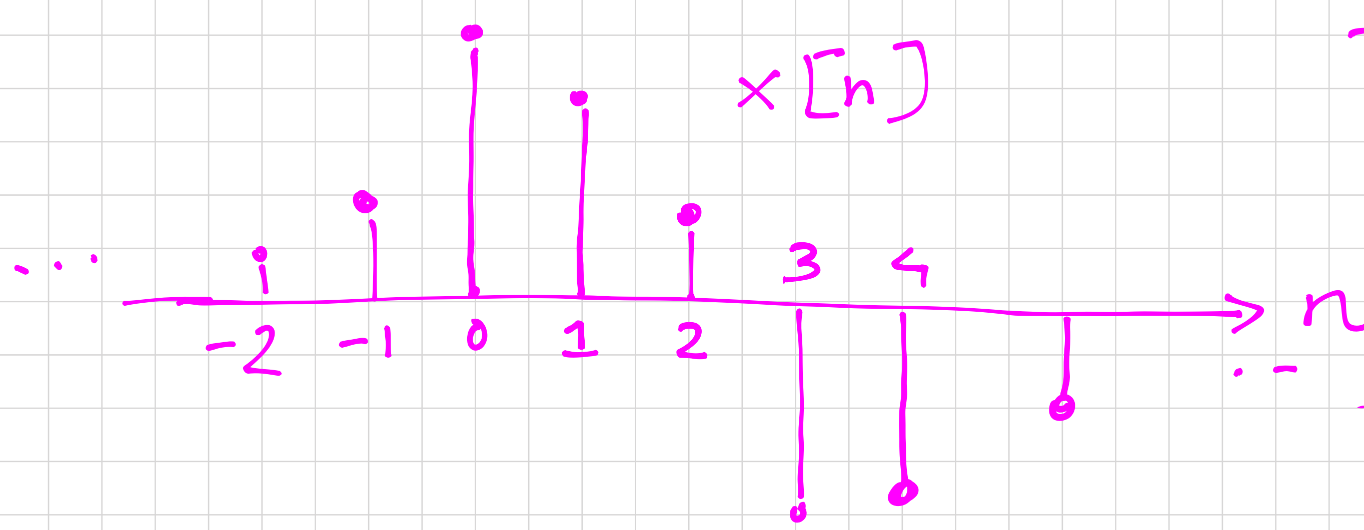
→ A DT time signal is derived from a CT signal by sampling (örnekleme) it at a uniform rate.



T_s : sampling rate (: sample the signal at every T_s seconds)

$x(nT_s)$; $n = 0, \mp 1, \mp 2$

$x[n] = x[nT_s]$



A DT Signal.

$x[n]$

$\uparrow$ independent variable.

② Even vs. Odd Signals

A CT signal $x(t)$ is said to be an <u>even signal</u> if

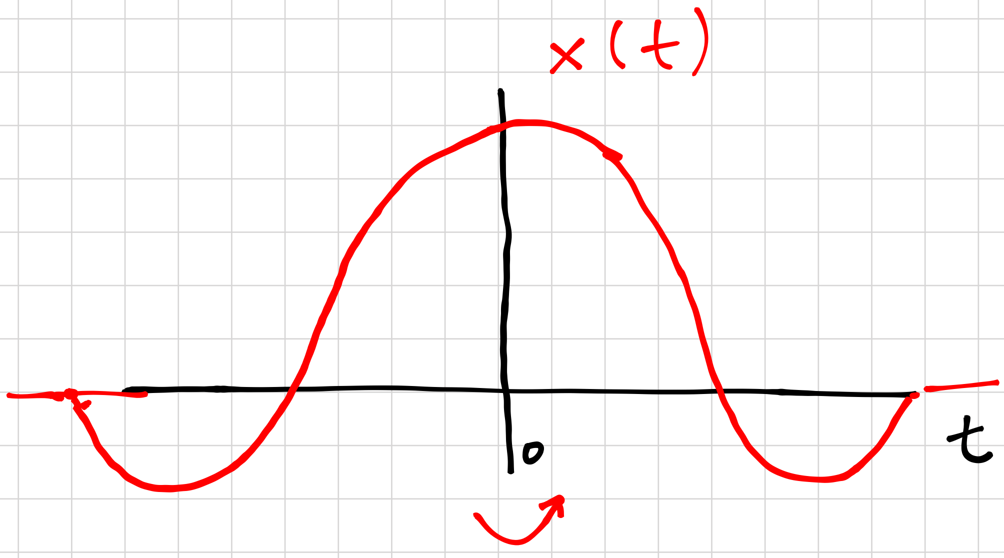
$$x(-t) = x(t) \quad \text{for } \forall t$$

A CT signal $x(t)$ is said to be an <u>odd</u> signal if

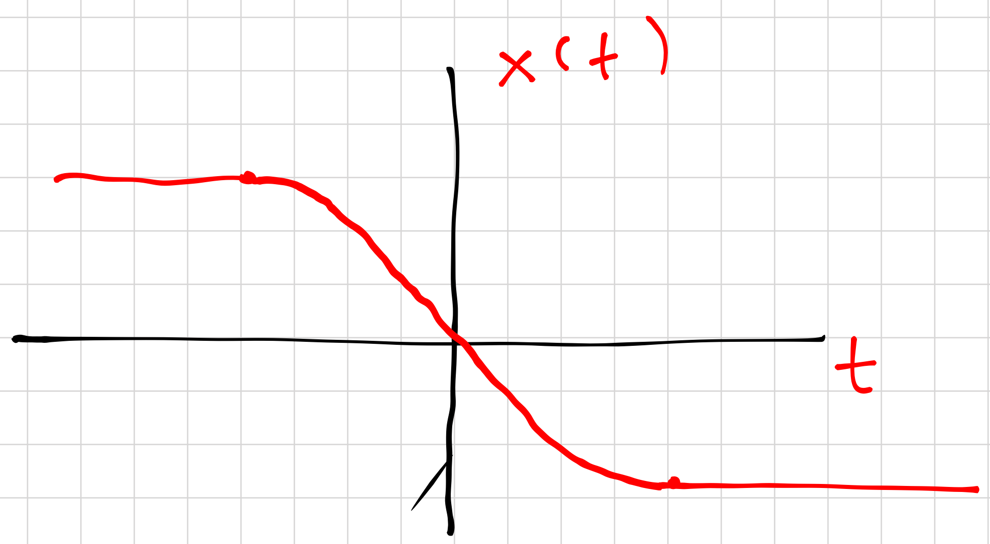
$$x(-t) = -x(t), \quad \forall t$$

→ Even signals are symmetric about the vertical axis. Odd signals are "antisymmetric"

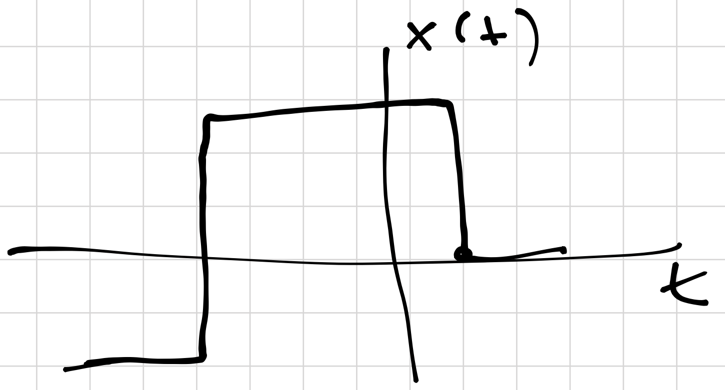
Similar remarks apply to DT signals



even signal!



odd signal



neither odd nor even

Ex

Consider the signal

$$x(t) = \begin{cases} \sin(\pi t/T), & -T \leq t \leq T \\ 0, & \text{otherwise} \end{cases}$$

Is $x(t)$ an odd signal or an even signal?

$$x(-t) = \begin{cases} \sin\left(-\frac{\pi t}{T}\right), & -T \leq t \leq T \\ 0, & \text{otherwise} \end{cases}$$

$$= \begin{cases} -\sin(\pi t/T), & -T \leq t \leq T \\ 0, & \text{otherwise} \end{cases}$$

$$= -x(t)$$ $\therefore$ $x(t)$ is ODD!

Even/odd Decomposition

An arbitrary signal, $x(t)$, can be decomposed into its even and odd components.

① $$x(t) = \underbrace{x_e(t)}_{\text{even}} + \underbrace{x_o(t)}_{\text{odd}}$$

$$x_e(t) = x_e(-t)$$

$$x_o(t) = -x_o(-t)$$

$$x(-t) = x_e(-t) + x_o(-t)$$

② $$x(-t) = x_e(t) - x_o(t)$$

$$\Rightarrow \boxed{\begin{aligned} x_e(t) &= \frac{1}{2}\left[x(t) + x(-t)\right] \\ x_o(t) &= \frac{1}{2}\left[x(t) - x(-t)\right] \end{aligned}}$$

Ex

$$x(t) = e^{-2t}\cos(t)$$

$$\boxed{\frac{1}{2}(e^{-a} + e^{a}) = \cosh(a)}$$

Find the even and odd components of $x(t)$

$$x(-t) = e^{2t}\cos(-t)$$
$$= e^{2t}\cos(t)$$

$$x_e(t) = \frac{1}{2}\left[e^{-2t}\cos t + e^{2t}\cos t\right]$$
$$= \frac{1}{2}\underbrace{(e^{-2t} + e^{2t})}_{\cosh(2t)}\cos t = \cosh(2t) \cdot \cos(t)$$

$$x_o(t) = \frac{1}{2}\left[e^{-2t} \cos t - e^{2t} \cos t \right]$$

$$= -\sinh(2t) \cdot \cos(t)$$

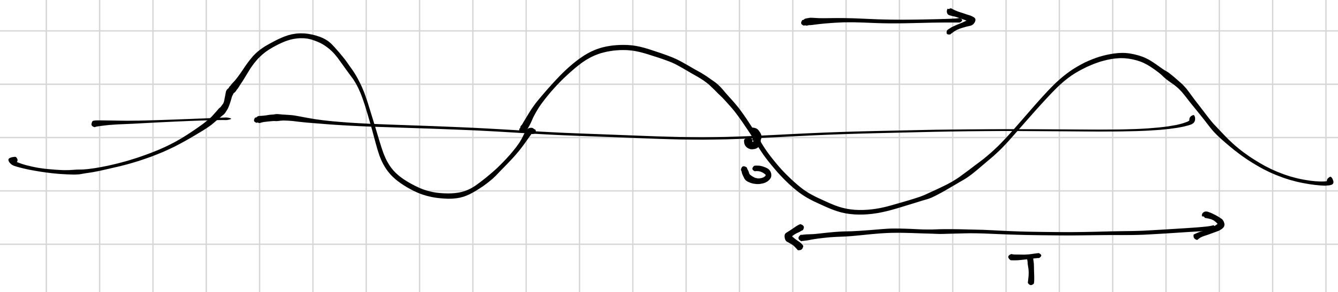
Same for DT

③ Periodic Signals vs Nonperiodic Signals

A periodic signal $x(t)$ is a function of time that satisfies the condition

$$x(t) = x(t+T) \quad \text{for all } t$$

where T is a positive constant.



If $T = T_0$ then the condition is satisfied for $T = 2T_0, 3T_0, \ldots$

The smallest value of T that satisfies this condition is called the fundamental period of $x(t)$

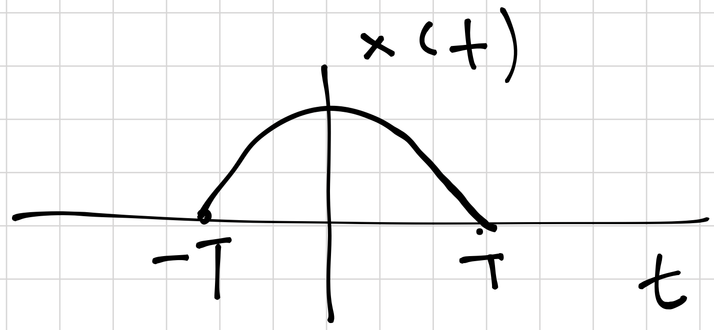
Fundemantal frequency $\Big\}$ $\boxed{f = \frac{1}{T}}$

T: seconds
f: Hertz

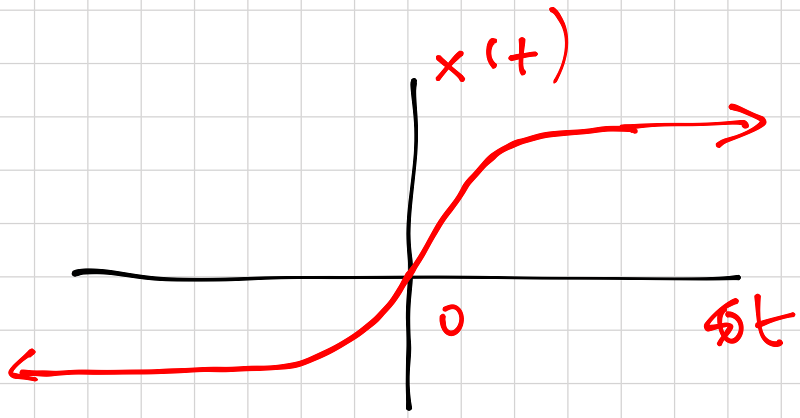
w: radians/sec.

Angular frequency $\Big\}$ $\omega = 2\pi f = \frac{2\pi}{T}$

Any signal $x(t)$ for which no value of T satisfies this condition is called an aperiodic or nonperiodic signal.



$x(t)$ is an ~~aperidic~~ signal
(nonperiodic)



$x(t)$ an ~~aperiodic~~ signal
(nonperiodic)

a periodic
~~aperiodic~~

For DT signals

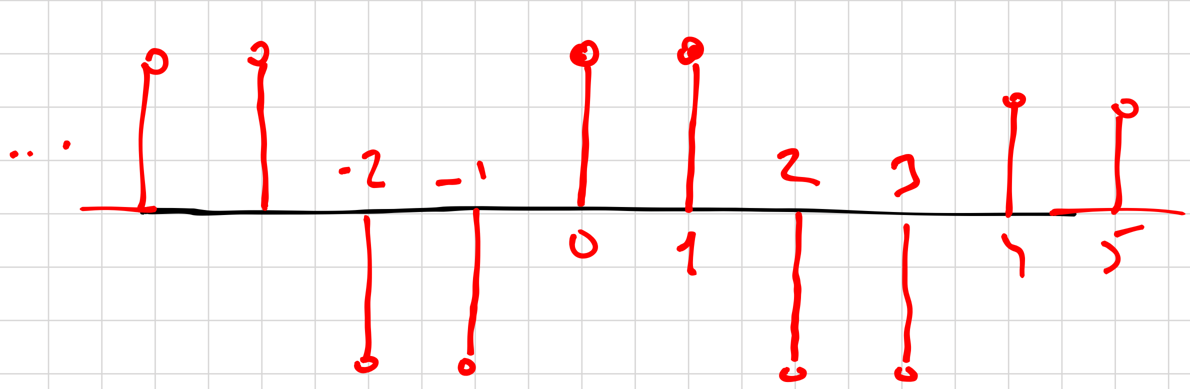
$x[n]$ is said to be periodic if
in
$\exists N \in \mathbb{Z}^+ : \quad x[n] = x[n+N] \;, \; \forall n \in \mathbb{Z}$

there exists — positive integer — for all — in — integer

The smallest N that satisfies this condition is called the fundamental period.

Fundamental (angular) frequency

$$\Omega = \frac{2\pi}{N} \quad : \text{radians.}$$



peidic.