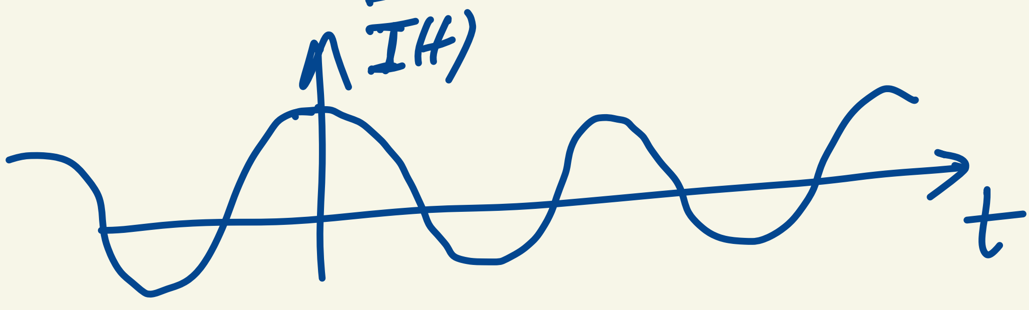
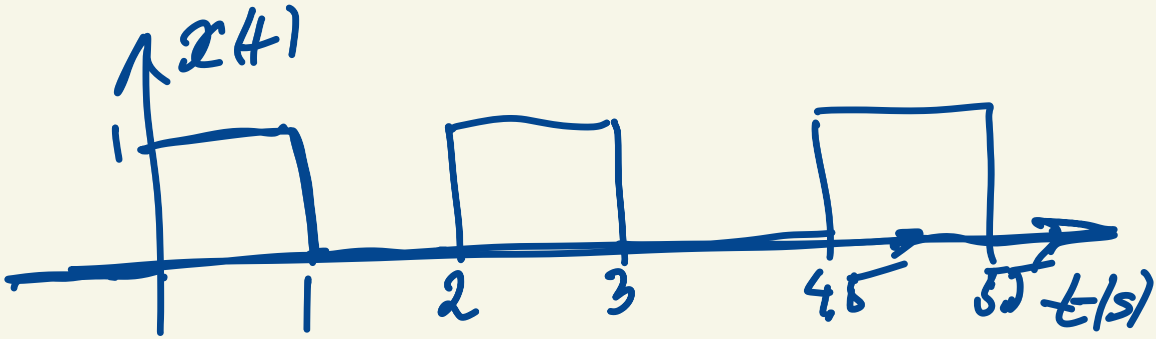
Welcome to ECE 102
Signals and Systems

Signals: temperature, pressure
current, voltage,
WiFi signal (EM wave)

in ECE 102 Signals are functions
of time.

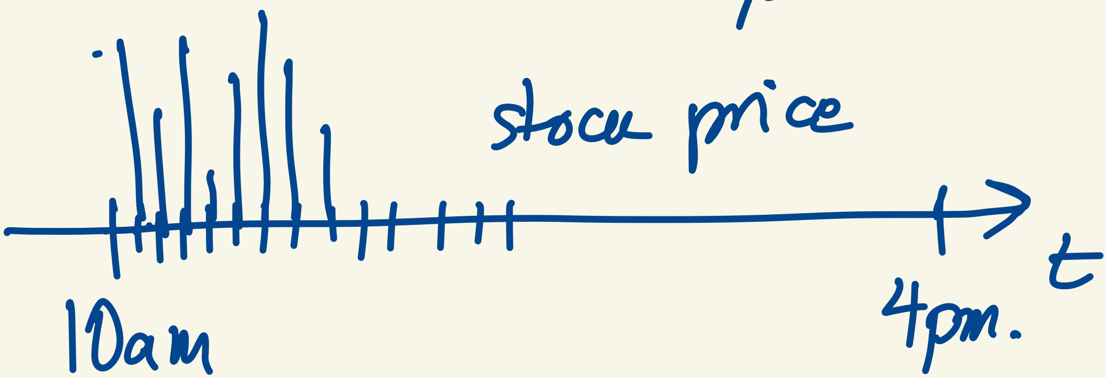
current: $I(t) = A\cos(2\pi \cdot 60t)$



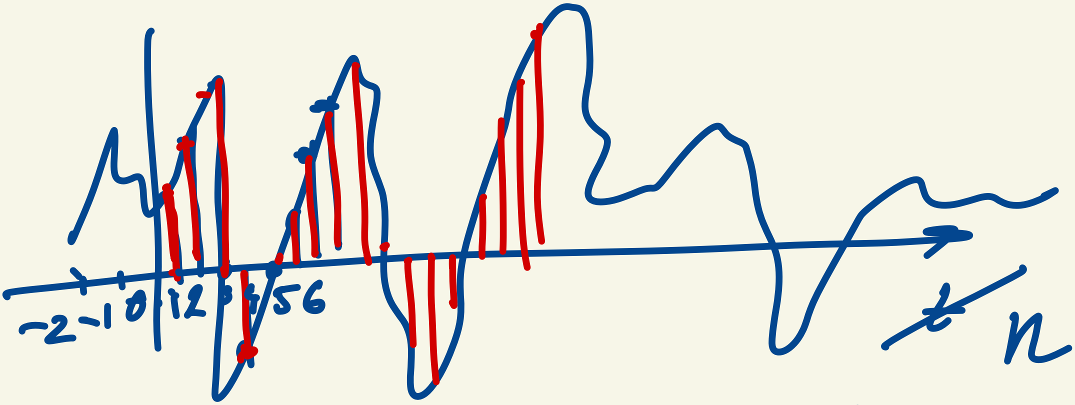


$t \in \mathbb{R}$ → continuous time.

in ECE 102 Continuous time signals.



t is discrete. (opposite from continuous time signal).



$n \in \mathbb{Z}$ discrete time signal.

ECE 113

<u>Values of signal</u> can be continuous or disrete.

$x(t) \in \mathbb{R}$, ($\mathbb{C}$)
complex signal.

$x(t) = e^{j2t}$

Euler's relationship.

$$e^{j2t} = \cos(2t) + j\sin(2t)$$

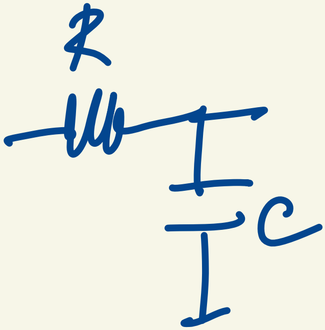
$$j = \sqrt{-1}$$

$$x(t) \xrightarrow{\text{sample}} x[n] \xrightarrow{\text{quantize}} x_q[n]$$

cont. time	discrete time	digital signal
102 ECE	113 ECE	M16 51A

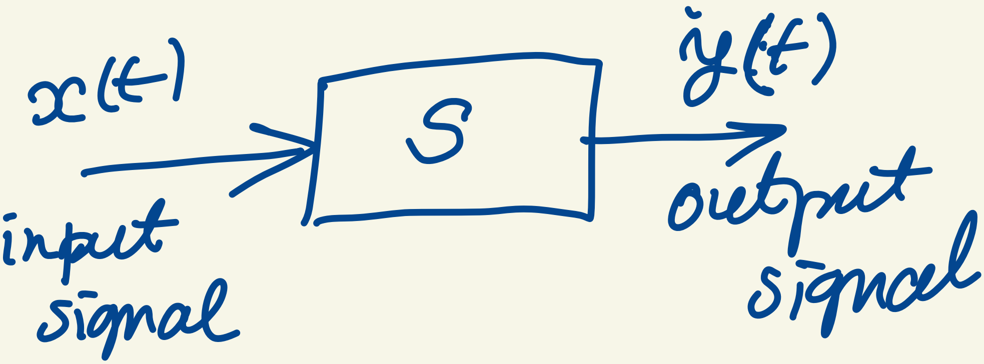
System: calculator, clock,
traffic light
M16

ECE 10. or 110.



System.

In ECE 102: System are

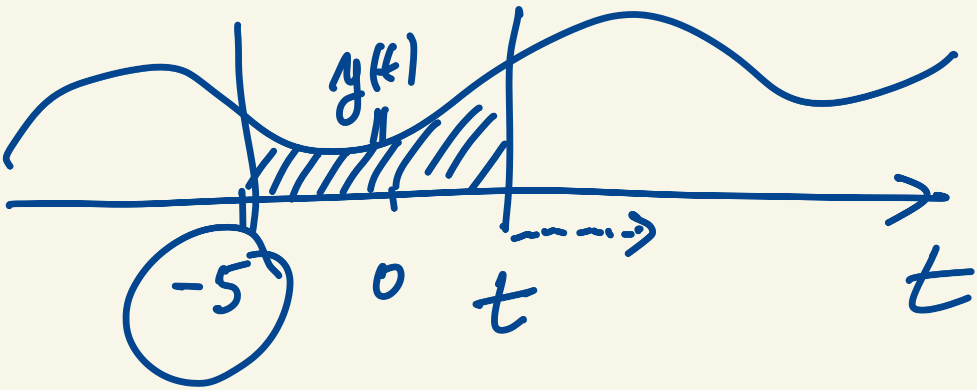


$$S: \; y(t) = S\{x(t)\}$$

e.g. $y(t) = 2x(t) + 3$

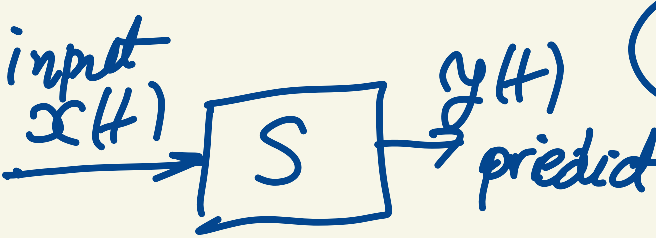
e.g. $y(t) = \frac{dx(t)}{dt}$

$\underline{y(t)} = \int_{-5}^{t} x(t)\,dt$



In 102: Systems are mathematically described by input output relationship

Analyze

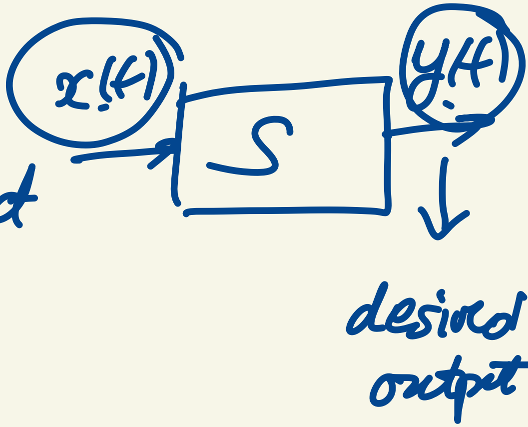


system $S\{x(t)\}$

predict for any $x(t)$ what is $y(t)$ going to be.

102, 113

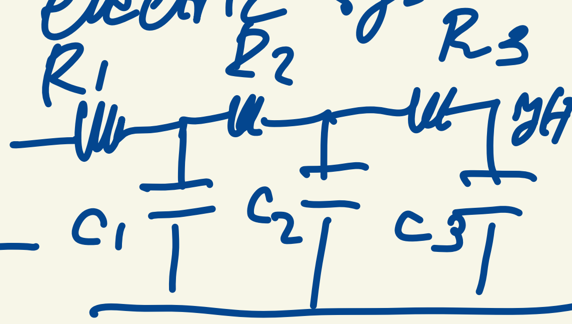
Design



115A

115C

use circuits elements to realize electric syst.



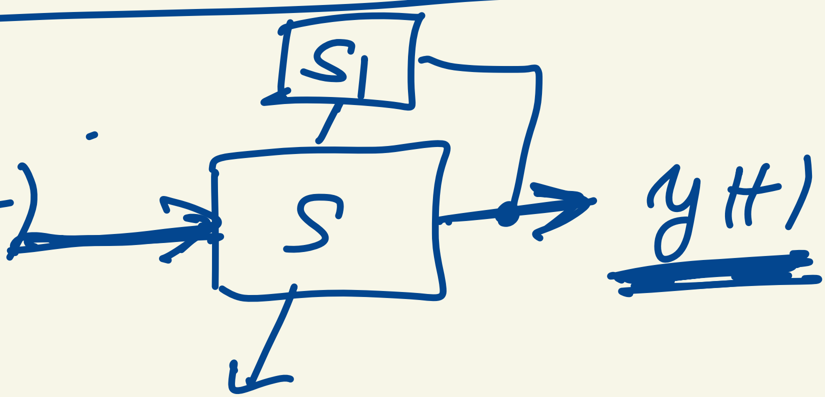
$y(t) = S\{x(t)\}$

$x(t) = 3\cos(2t) \rightarrow$ deterministic

$x(t) \rightarrow$ random signal.

probability 131A

communication systems 132A



feedback systems

ECE 141, 142

Time Domain : $x(t)$

Signals

operations

properties

1) Addition

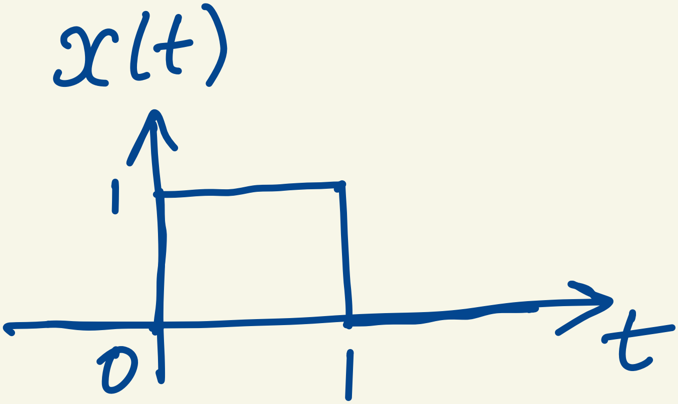
$x_1(t) + x_2(t)$

2) Constant multiplication

$\alpha x(t)$

3) Time - shifting.

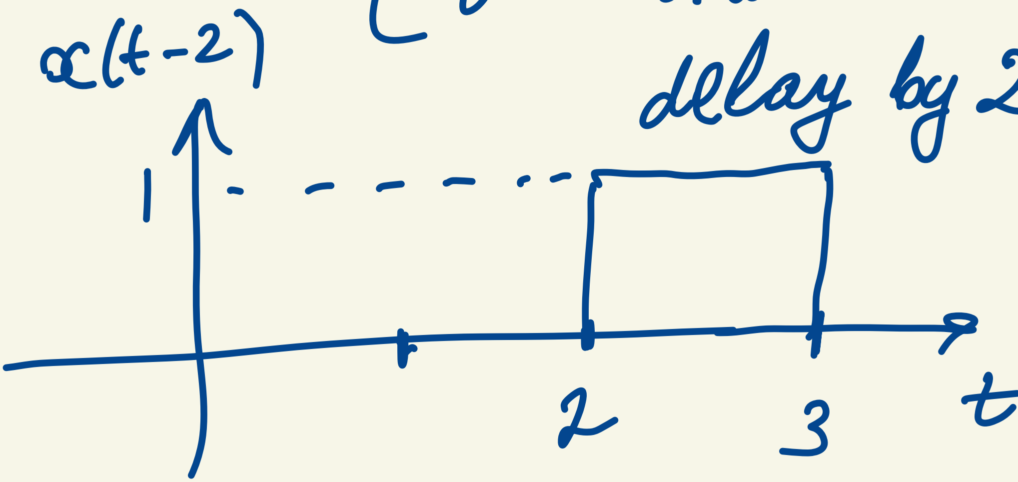
delaying or advancing.



$$x(t) = \begin{cases} 1 & 0 \le t \le 1 \\ 0 & \text{o.w.} \end{cases}$$

$$x(t-2) = \begin{cases} 1 & \left(\begin{matrix} 0 \le t-2 \le 1 \\ 2 \le t \le 3 \end{matrix}\right) \\ 0 & \text{o.w.} \end{cases}$$

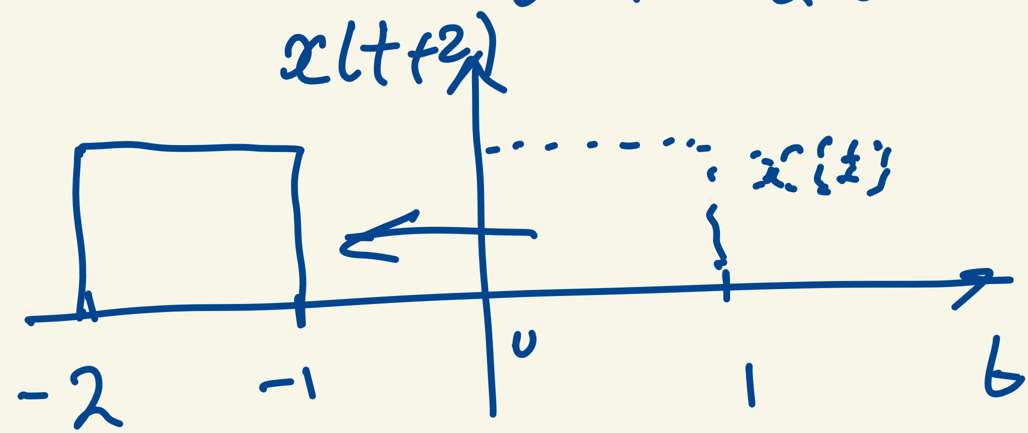
delay by 2



$x(t-\tau)$; $\tau > 0$ delay by τ

$x(t+2)$

$$x(t+2) = \begin{cases} 1 & 0 \le t+2 \le 1 \\ & -2 \le t \le -1 \\ 0 & \text{o.w.} \end{cases}$$



advance by 2.

$x(t+\tau)$; $\tau > 0$ advance by τ

$x(t-\tau)$ $\tau<0$ advance by 2

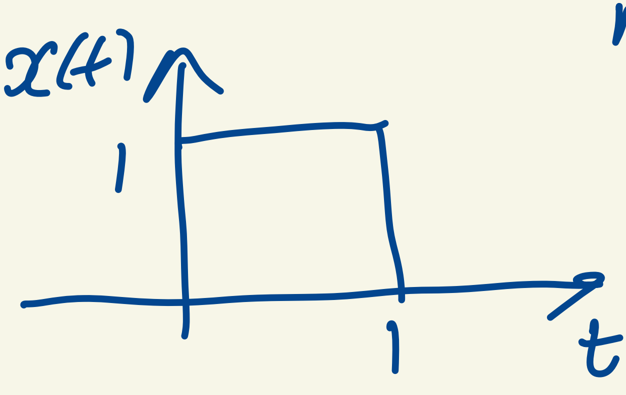
$x(t+\tau)$ $\tau<0$ delay by 2

τ is constat.

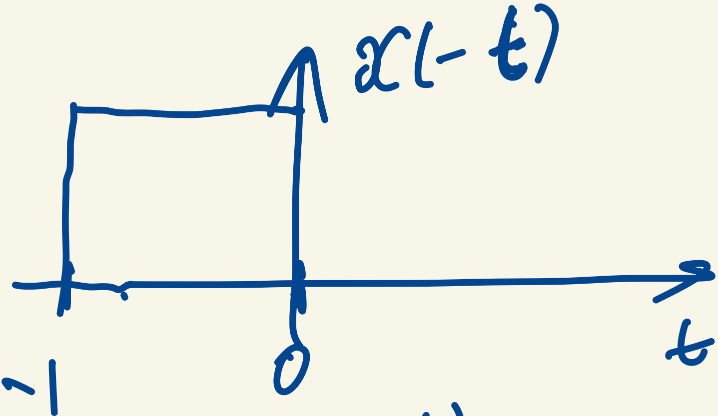
④ Time-scaling

$x(at)$ a is constant

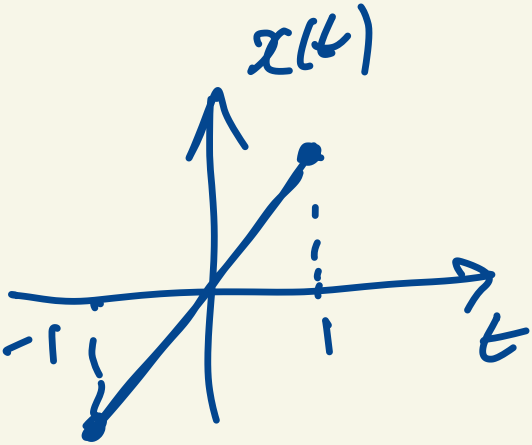
$a=-1 \rightarrow$ signal is reflected

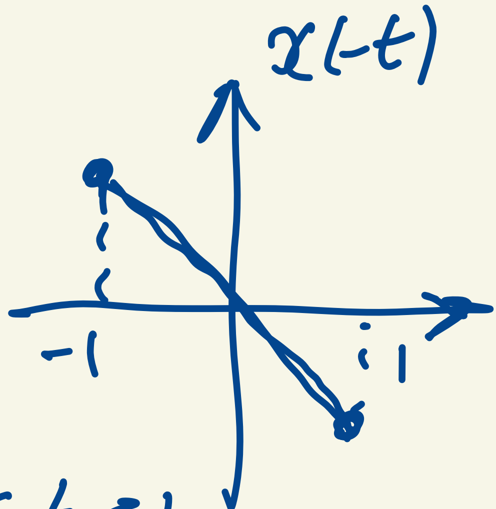


$$x(-t) = \begin{cases} 1 & 0 \le -t \le 1 \\ & -1 \le t \le 0 \\ 0 & \text{o.w.} \end{cases}$$



signal is reflected

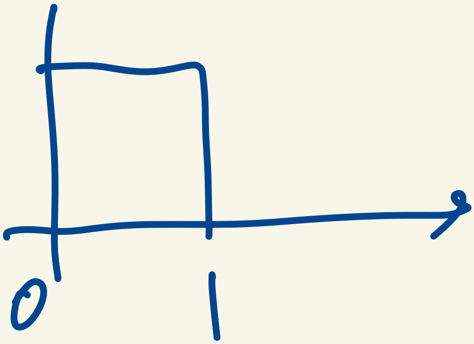




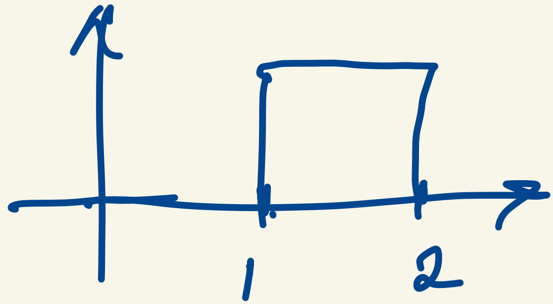
$$x(t) = \begin{cases} 1 & 0 \le t \le 1 \\ 0 & \text{o.w.} \end{cases}$$

$$x(-t+2) = \begin{cases} 1 & 0 \le -t+2 \le 1 \\ & 1 \le t \le 2 \\ 0 & \text{o.w.} \end{cases}$$

$x(t)$



$x(-t+2)$



reflected and delayed by 2.

$x(-t \underbrace{+\tau})$ $\tau > 0$

reflected and delayed by τ

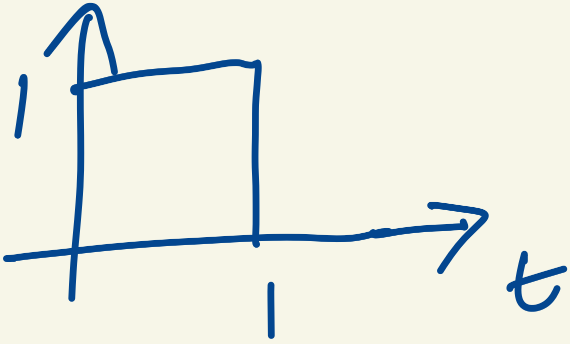
remember

$\underbrace{x(t+\tau)}$ $\tau > 0$ advance by τ

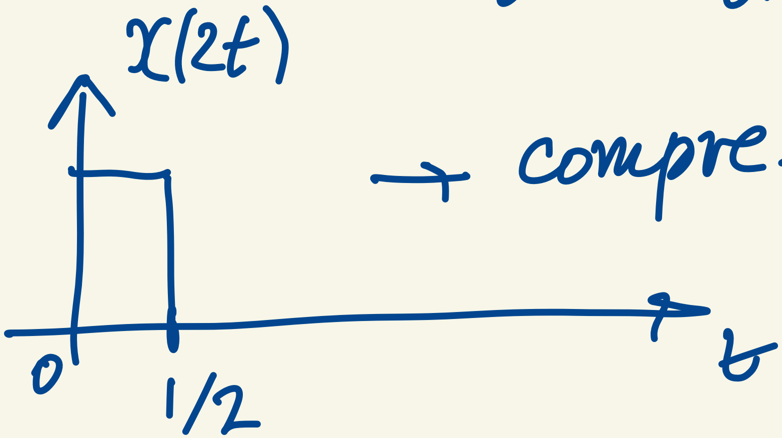
similarly

$x(-t-\tau)$ $\tau > 0$ reflected and advanced by τ

$a = 2$



$$x(2t) = \begin{cases} 1 & 0 \leq 2t \leq 1 \\ & 0 \leq t \leq \frac{1}{2} \\ 0 & \text{o.w.} \end{cases}$$

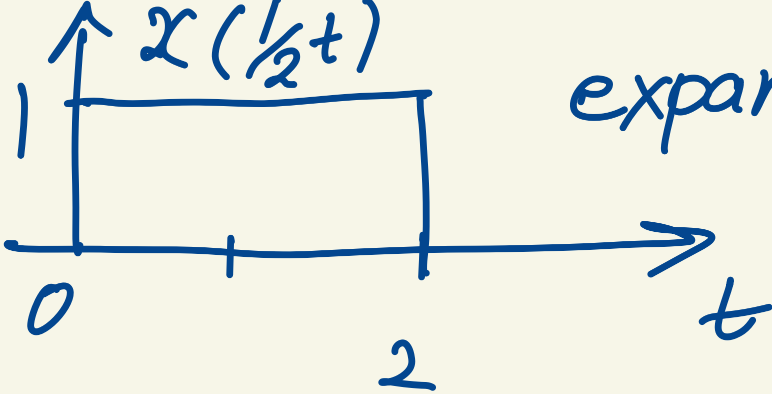


→ compressed in time.

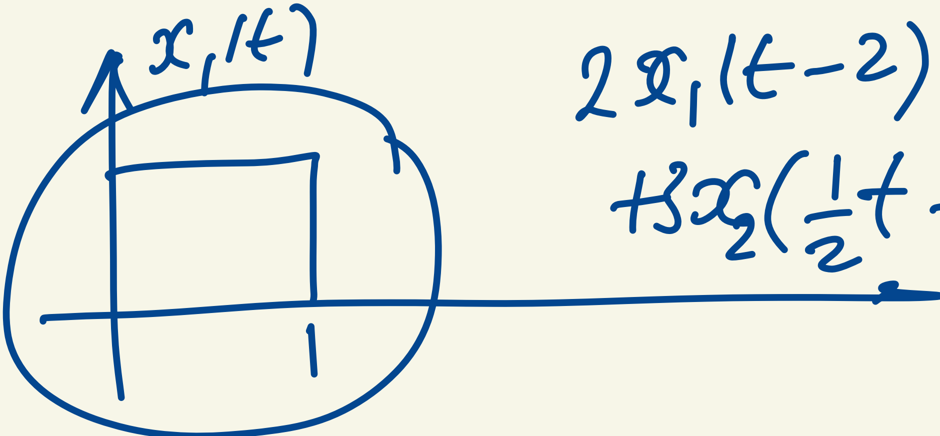
$a > 1$

$a = \frac{1}{2}$

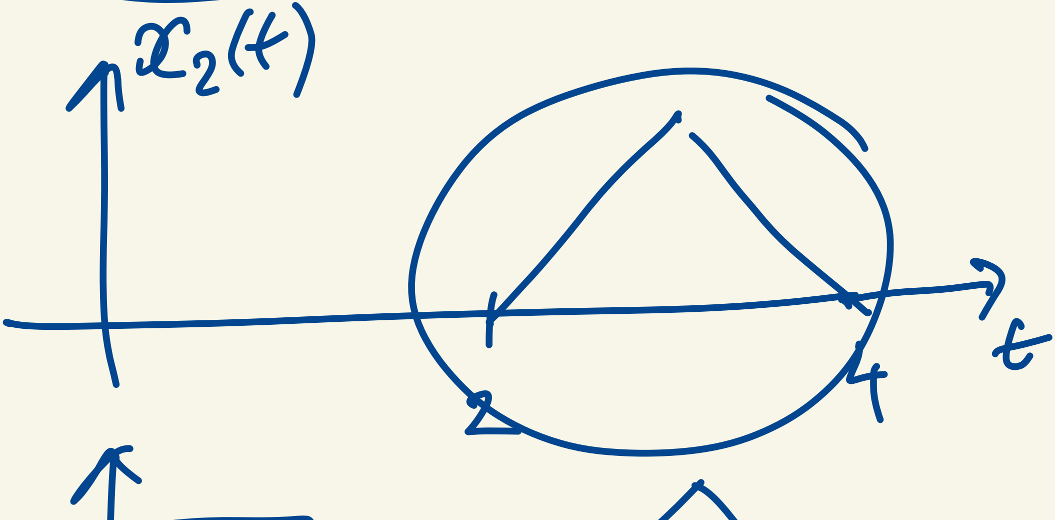
$$x\left(\frac{1}{2}t\right) = \begin{cases} 1 & 0 \leq \frac{t}{2} \leq 1 \\ & 0 \leq t \leq 2 \\ 0 & \text{o.w.} \end{cases}$$



expanded in time.



$2x_1(t-2)$
$+3x_2(\frac{1}{2}t+3)$

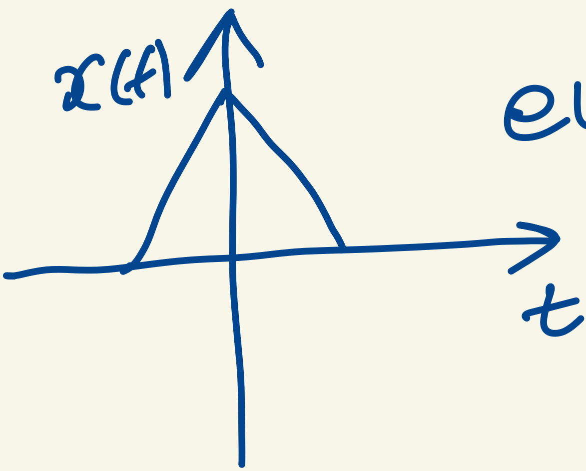


Signal Properties

- odd or even
- periodic or non-periodic
- power
- energy

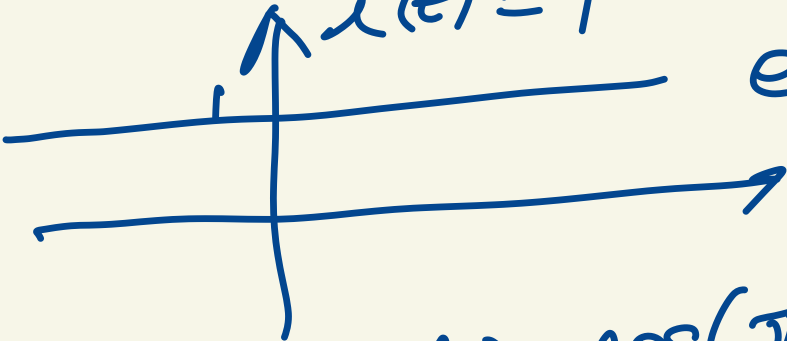
Def. Signal is even iff.

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



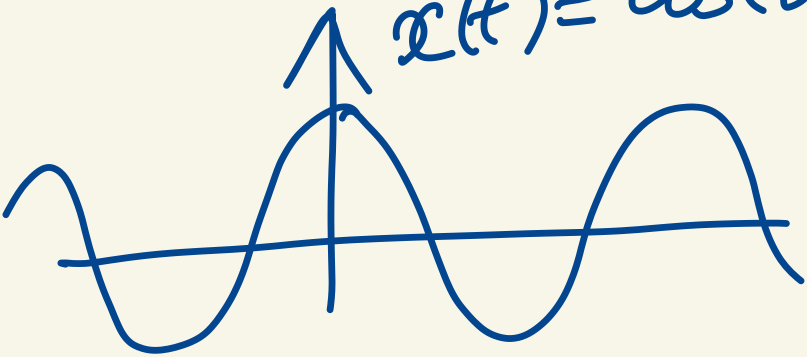
even

$x(t) = 1$



even

$x(t) = \cos(\pi t)$

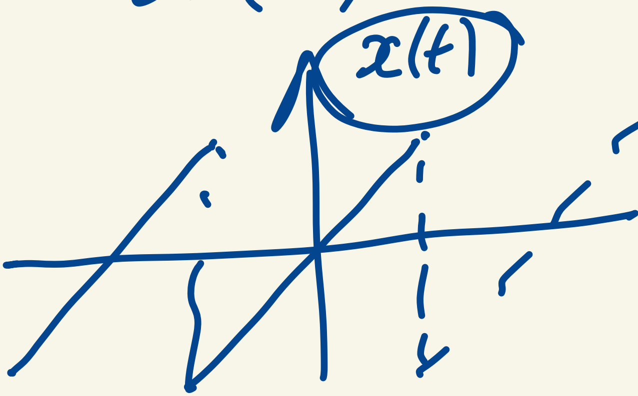


even.

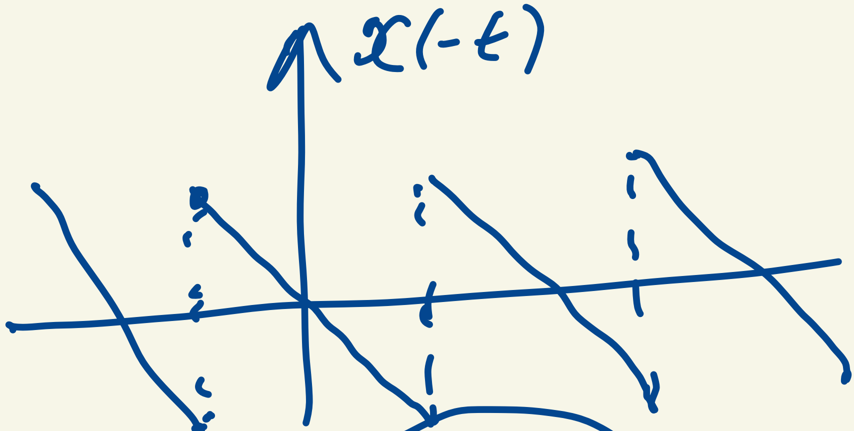
Def. Signal is odd iff.

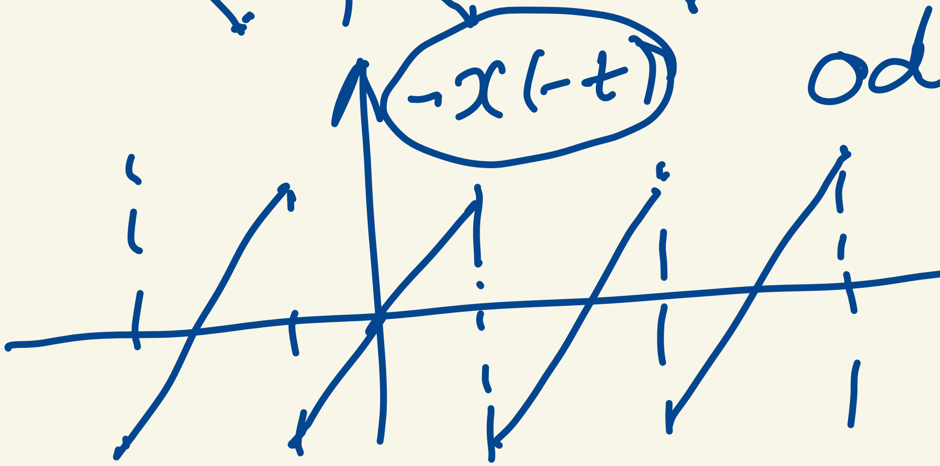
$$x(t) = -x(-t)$$

$$\Updownarrow$$



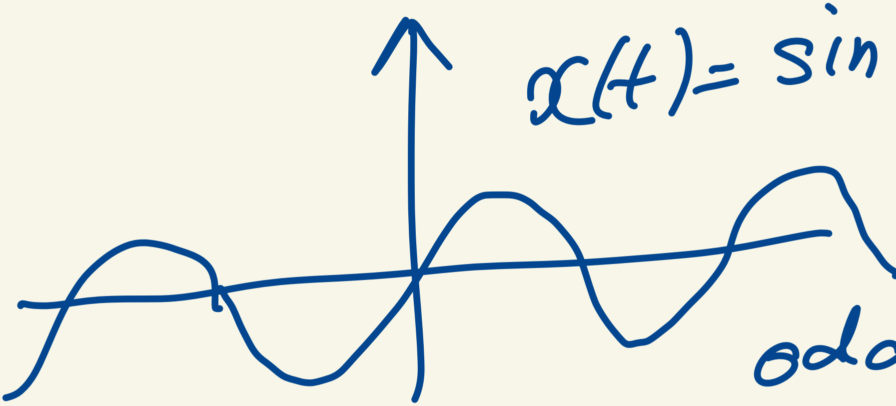
$$x(-t) = -x(t)$$





odd.

$x(t) = \sin(2\pi t)$



odd.

Theorem: Any signal can be decomposed into even and odd signal components.

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

any signal

even component: $x_e(t) = x_e(-t)$

odd component: $x_o(t) = -x_o(-t)$