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ECE - Department

ANNA UNIVERSITY - 2021 Regulation

Anna University ECE - Reg 2021

1st Semester

- Professionsal English I
- Matrices and Calculas
- Engineering Physics
- Engineering Chemistry
- Problem Solving & Python Programming

2nd Semester

- Professional English II
- Statistics and Numerical Methods
- Engineering Graphics
- Physics for Electronics Engineering
- Electrical and Instrumentation Engineering
- Circuit Analysis

3rd Semester

- Random Process & Linear Algebra
- C Programming & Data Structures
- Signals and Systems
- Electronic Devices and Circuits
- Control Systems
- Digital Systems Designs

4th Semester

- Electromagnetic Fields
- Networks & Security
- Linear Integrated Circuits
- Digital Signal Processing
- Communication Systems
- Environmental Sciences & Sustainability

5th Semester

- Wireless Communication
- VLSI and Chip Design
- Transmission Lines & RF Systems
- Professional Elective I
- Professional Elective II
- Mandatory Course I

6th Semester

- Embedded System & IOT Design
- Artificial Intelligence & Machine Learning
- Open Elective I
- Professional Course III
- Professional Course IV
- Mandatory Course II

7th Semester

- Human Values & Ethics
- Elective Management
- Open Elective II
- Open Elective III
- Open Elective IV

8th Semester

- Project Work

EEE

ECE

CSE

Click on clouds to navigate other departments

MECH

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B.E. Electronics and Communication Engineering

Anna University Regulation: 2021

EC3354 – Signals and Systems

II Year / III Semester

Hand Written Notes

Unit – 1

Classification of Signals and Systems

UNIT- 1

Introduction to Signals & Systems:

What is signal?

→ Any time varying phenomenon that is intended to carry information is called as signal.

ex: human voice, electric signals, voltage on telephone wires, TV signals, Computer signals etc.

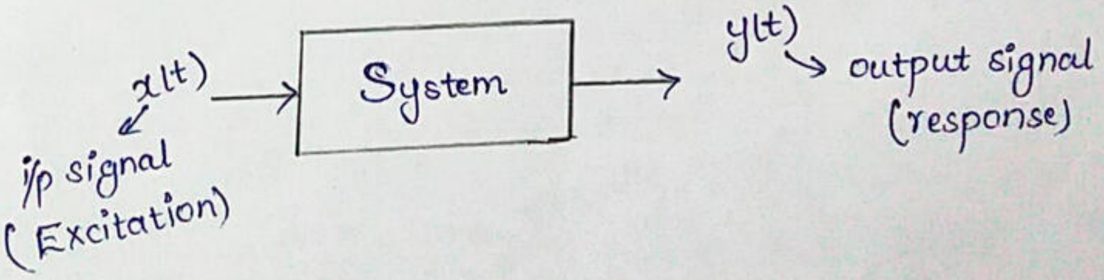
→ Signals are represented mathematically as a function of one or more independent variables

$$x(t),\ f(t),\ g(t),\ g(t_1, t_2),\ f(x_1, x_2, x_3)$$

What is System?

It is an interconnection of components, devices or subsystems and produces an output in response to an input

ex: Filters, Amplifiers, Fan, Computer.



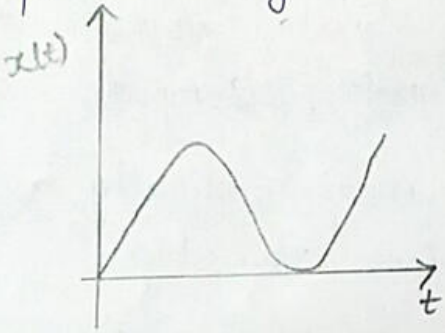
Types of Signals :-

1. Continuous Time Signal
2. Discrete Time Signal.

1. Continuous Time Signal (CT)

* Defined for all values of time (t)

* represented by $x(t)$



Ex: Speech Signal, Noise

2. Discrete Time Signal (DT)

Ex: census (population)

Salary credited (monthly wise)

* defined at discrete - instant of time

* represented by $x(n)$.

Standard Signals :

For testing a system, standard signals are used.

1. Unit Step signal
2. Unit ramp signal
3. Unit Impulse signal
4. Exponential Signal
5. Signum function.

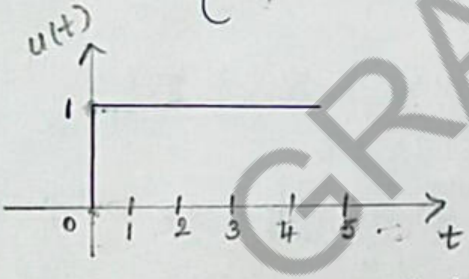
1. Unit Step Signal (u)

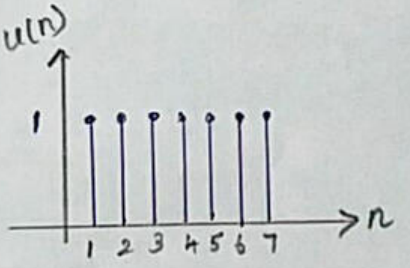
Unit step signal has amplitude of '1' for positive values & amplitude of '0' for negative values.

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

$\rightarrow t=0, t=1,2,3,4$

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





2. Unit ramp Signal (r)

Unit ramp signal linearly increases for positive values (+ve)

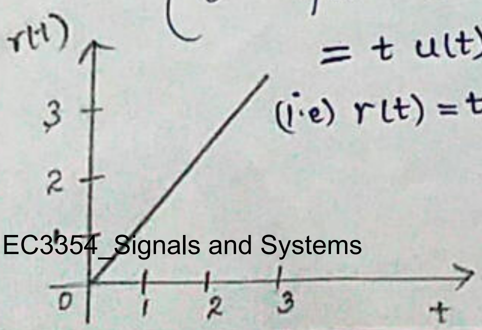
$$r(t) = \begin{cases} t & \text{for } t \geq 0 \\ 0 & \text{for } t < 0 \end{cases}$$

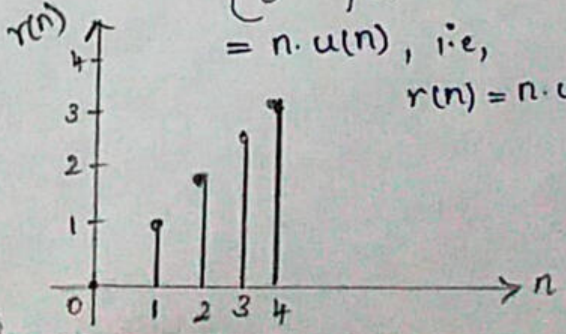
$= t\ u(t)$

(i.e) $r(t) = t \cdot u(t)$

$$r(n) = \begin{cases} n & \text{for } n \geq 0 \\ 0 & \text{for } n < 0 \end{cases}$$

$= n \cdot u(n)$, i.e, $r(n) = n \cdot u(n)$

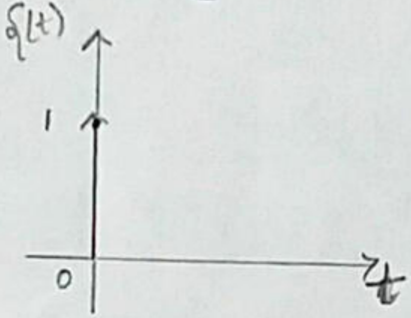


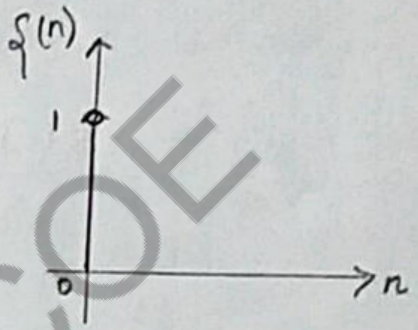


Unit Impulse Signal (δ)

Unit Impulse signal has the value '1' at $t=0$ & has the value '0', at all other values of t.

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





4)

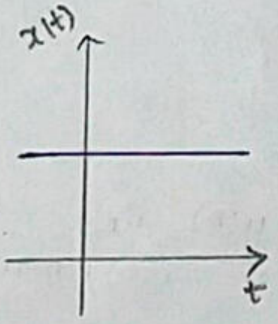
Real & Complex Exponential Signals.

Real exponential CT :-

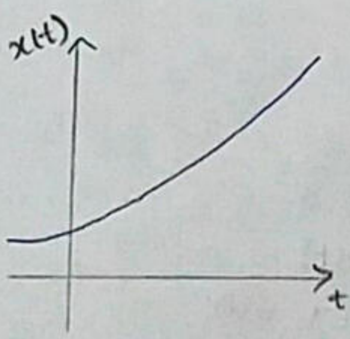
It is exponentially growing or decaying signal.

$$\boxed{x(t) = a.e^{bt}} \text{, where } a \,\&\, b \rightarrow \text{real numbers}$$

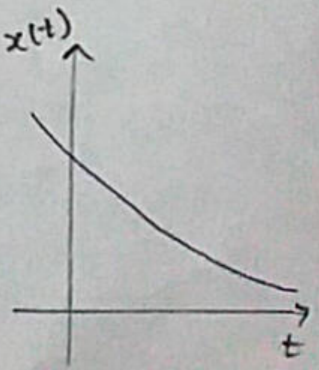
(i) $b=0$ (ii) $b=$ positive (+ve) (iii) $b=$ negative (−ve)



a) dc signal



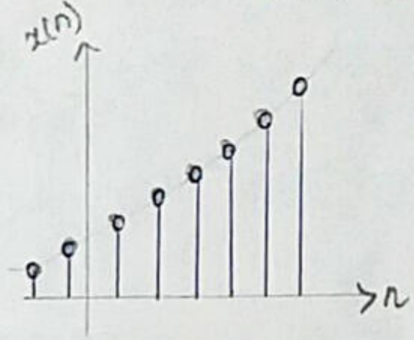
b) growing Signal



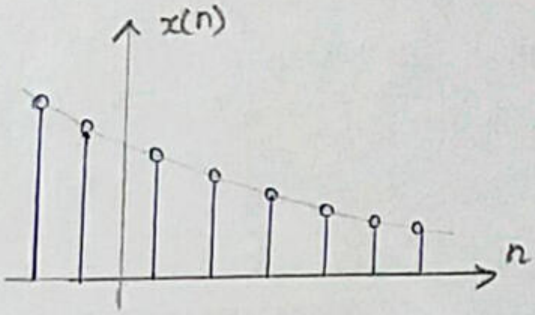
c) decaying signal.

Real exponential DT

$x(n) = a \cdot e^{bn}$, where a & b → real



(a) for growing signal



(b) for decaying signal.

Complex exponential Signal :-

when exponent is purely imaginary, then the Signal is complex exponential signal.

CT

$x(t) = e^{j\omega t}$

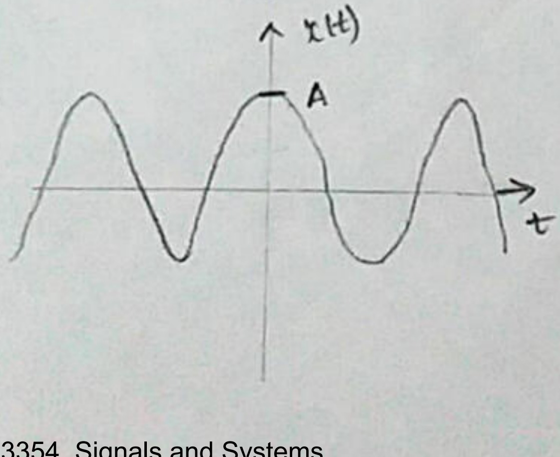
DT

$x(n) = e^{j\omega n}$

Sinusoidal Signal :-

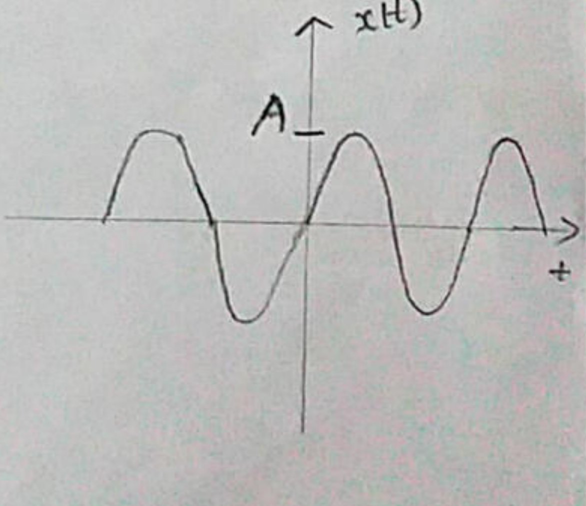
cos

$x(t) = A \cos(\omega_0 t + \phi)$



sine

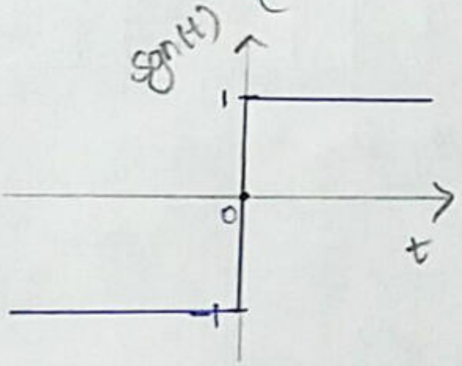
$x(t) = A \sin(\omega_0 t + \phi)$



Signum Function

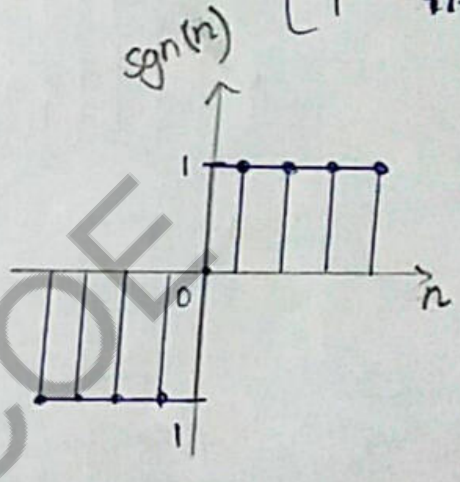
CT

$$x(t) = \mathrm{Sgn}\,(t) = \begin{cases} 1 \;; & t > 0 \\ 0 \;; & t = 0 \\ 1 \;; & t < 0 \end{cases}$$



DT

$$x(n) = \mathrm{Sgn}\,(n) = \begin{cases} 1 & n > 0 \\ 0 & n = 0 \\ 1 & n < 0 \end{cases}$$



Basic Operations on Signals:-

1) Time Operations performed on signals (or) Transformation of signals.

On Dependent Variables

1. Amplitude Scaling
2. Addition
3. Multiplication
4. Integration
5. Differentiation

On independent Variables.

1. Time shifting
2. Time Reversal
3. Time Scaling.

1. Time shifting :

Consider a signal $x(t)$, mathematically represent by

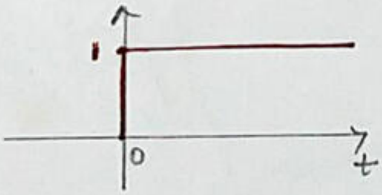
$$y(t) = x(t-T)$$

If T is positive, the shifting delays the signal (to righ

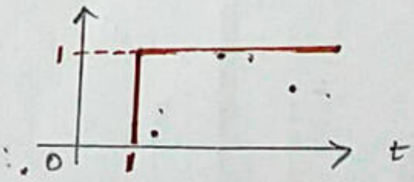
If T is negative, the shifting delays the signal (to left).

Now $x(t) = u(t)$ (Unit step Signal)

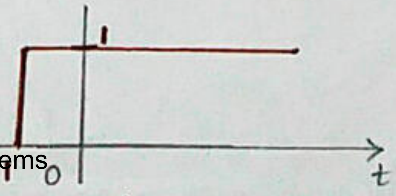
(i) Continuous Time



(i) $x(t) = u(t)$



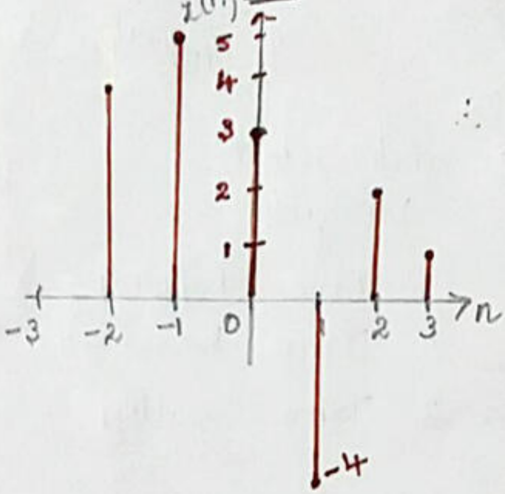
(ii) $x(t-1)$



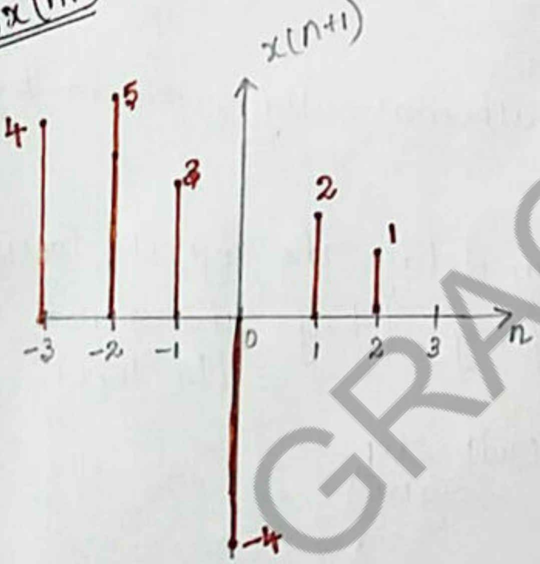
(iii) $x(t+1)$

Discrete Time

(i) $x(n)$ ex: $x(n) = [4, 5, \underset{\overset{\uparrow}{n=0}}{3}, -4, 2, 1]$



(ii) $x(n+1)$



$x(n+1)$

when $n=0$, $x(0+1) = x(1) = -4$

$n=1$, $x(1+1) = x(2) = 2$

$n=2$, $x(2+1) = x(3) = 1$

$n=3$, $x(3+1) = x(4) = 0$

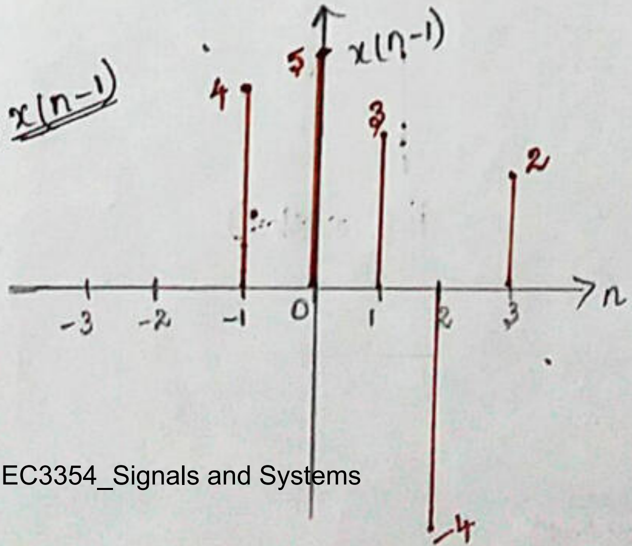
when $n=-1$, $x(-1+1) = x(0) = 3$

$n=-2$, $x(-2+1) = x(-1) = 5$

$n=-3$, $x(-3+1) = x(-2) = 4$

$\therefore x(n+1) = [4 \;\; 5 \;\; 3 \;\; \underset{\overset{\uparrow}{n=0}}{-4} \;\; 2 \;\; 1]$

(iii) $x(n-1)$

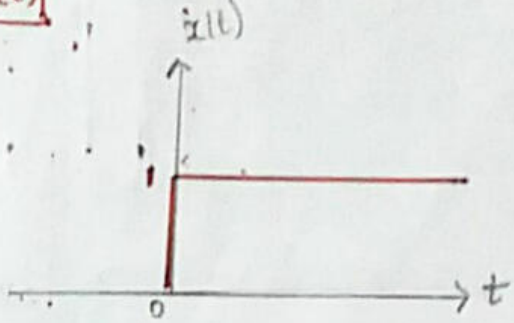


2) Time Reversal $[x(t) \rightarrow x(-t)]$

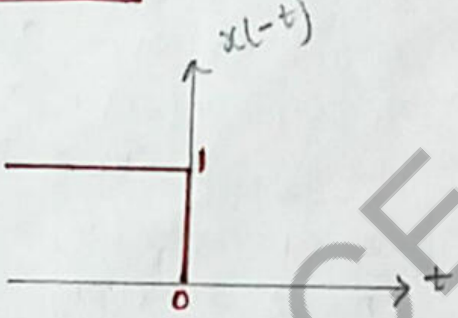
For Continuous Time

Let $x(t) = u(t)$ (i.e) $u(t)$ is a step signal.

(i) $\boxed{x(t) = u(t)}$

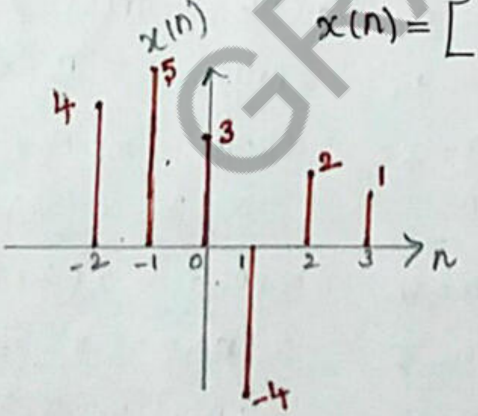


(ii) $\boxed{x(-t) = u(-t)}$



For Discrete Time

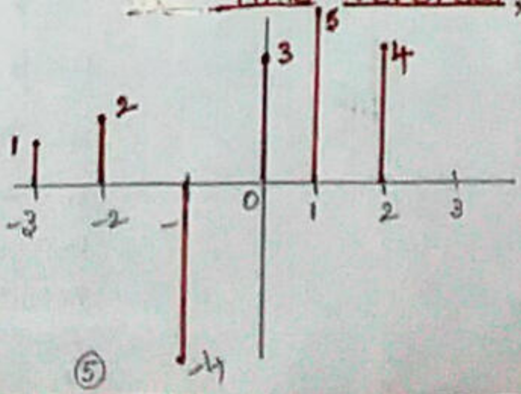
$$x(n) = [4, 5, \underset{\substack{\uparrow \\ n=0}}{3}, -4, 2, 1]$$



Time Reversal, $x(n) = x(-n)$

$x(1) = x(-1)$

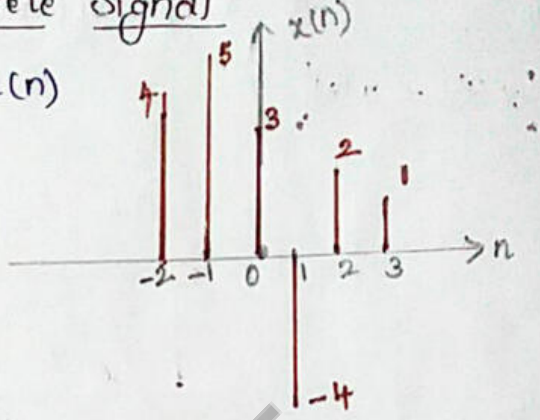
$x(2) = x(-2)$



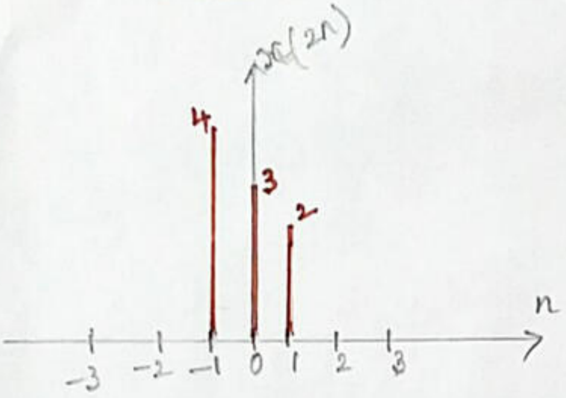
3) Time Scaling Operation

For Discrete Signal

Given: $x(n)$



(Time Compression)



$x(2n)$

$n = 0, \quad x(2n) = x(0) = 3$

$n = 1, \quad x(2n) = x(2) = 2$

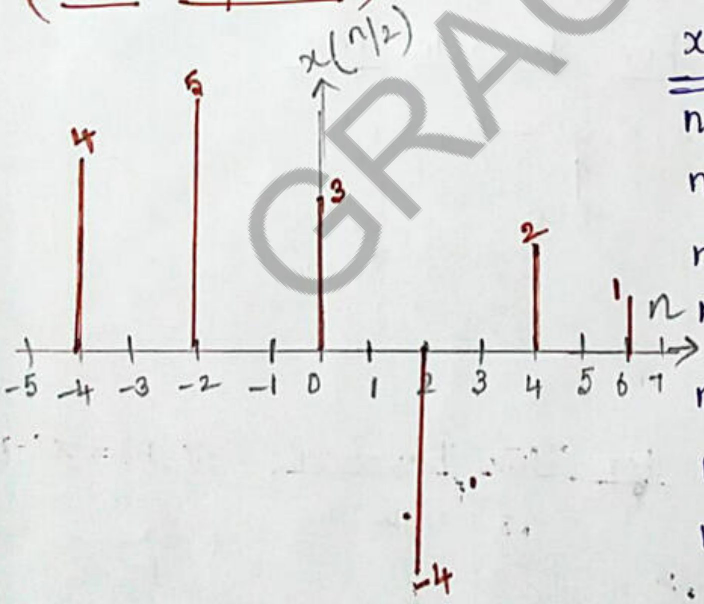
$n = 2, \quad x(2n) = x(4) = 0$

$n = 3, \quad x(2n) = x(6) = 0$

$n = -1 \Rightarrow x(2n) = x(-2) = 4$

$n = 2 \Rightarrow x(2n) = x(-4) = 0.$

(Time Expansion)



$x(n/2)$

$n = 0, \quad x(n/2) = x(0) = \cancel{0}3$

$n = 1, \quad x(n/2) = x(1/2) = 0$

$n = 2 \quad x(n/2) = x(1) = -4$

$n = 3 \quad " = x(3/2) = 0$

$n = 4 \quad x(n/2) = x(2) = 2$

$n = 5 \quad x(\cancel{n}/2) = x(5/2) = 0$

$n = 6 \quad x(n/2) = x(3) = 1$

$n = 7 \quad x(n/2) = x(7/2) = 0$

$n = -1 \quad x(n/2) = x(-1/2) = 0$

$n = -2 \quad x(n/2) = x(-1) = 5$

$n = -3 \quad x(n/2) = x(-3/2) = 0$

$n = -4 \quad x(n/2) = x(-4/2) = 4$

$n = -5 \quad x(n/2) = x(-5/2) = 0$

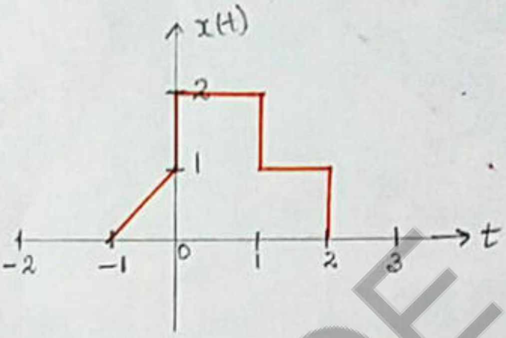
Part - B

Anna University Solved Problems

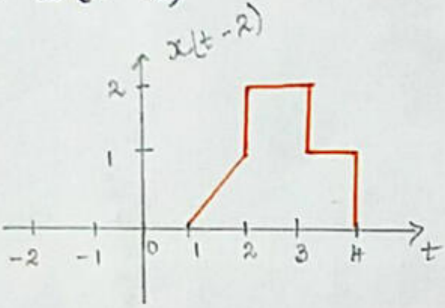
(April-May 2019
Nov - 2009)

Ⓧ A Continuous Time Signal $x(t)$ is shown in Fig below, Sketch & label each of the following signals.

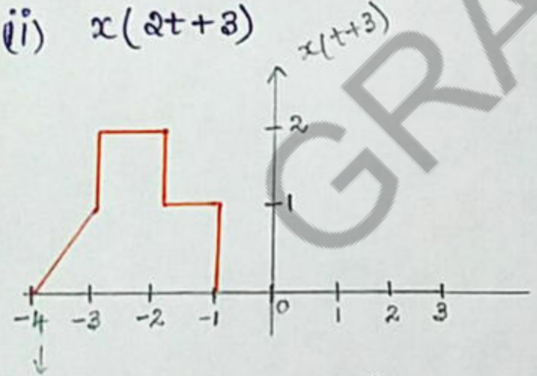
(i) $x(t-2)$
(ii) $x(2t+3)$
(iii) $x\left(\frac{3}{2}t\right)$
(iv) $x(-t+1)$

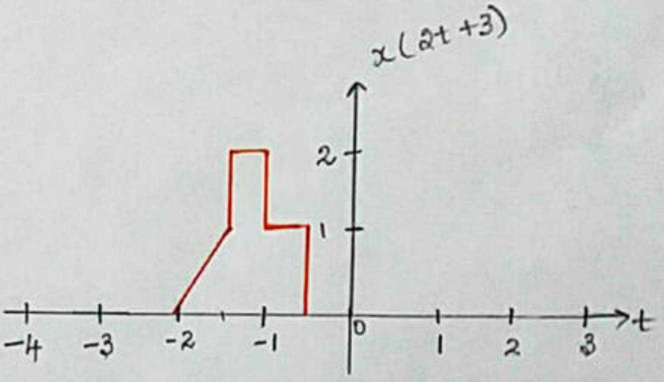


(i) $x(t-2)$

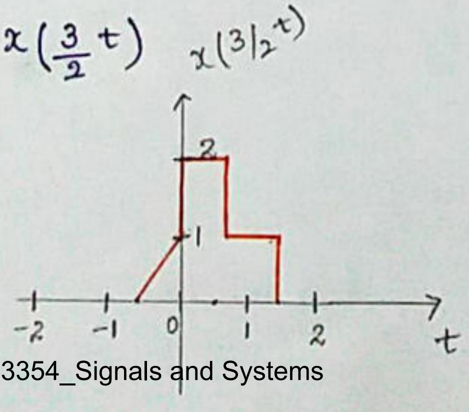


(ii) $x(2t+3)$

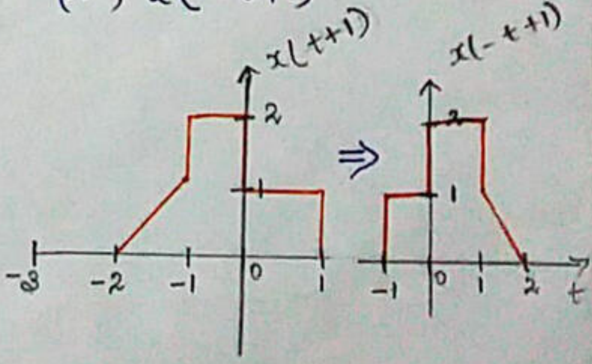




(iii) $x\left(\frac{3}{2}t\right)$



(iv) $x(-t+1)$



Anna University Solved Problem

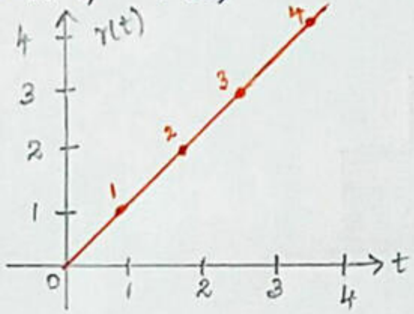
(Nov-Dec 2017
Nov-Dec 2018)

Draw the waveform for the signal

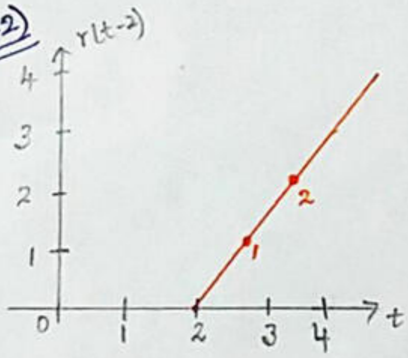
$$x(t) = r(t) - 2r(t-1) + r(t-2)$$

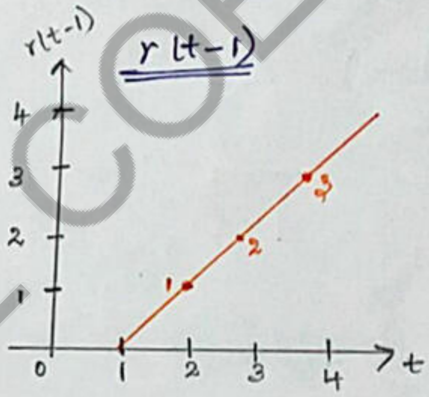
W.K.T, r(t) is a ramp signal.

r(t)

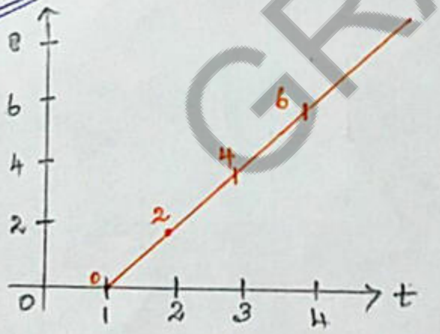


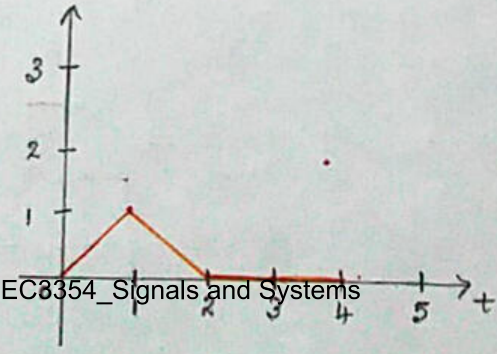
r(t-2)





2r(t-1)



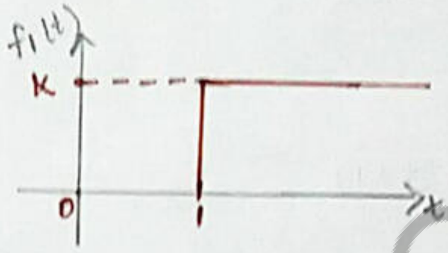


1) Draw the waveforms of the following function

(i) $f_1(t) = k \cdot u(t-1)$

Here, it represents a unit step function delayed by 1 sec, and having amplitude $\underline{k}$.

$\therefore f_1(t) = k \cdot u(t-1)$



(ii) $f_2(t) = u(2-t)$

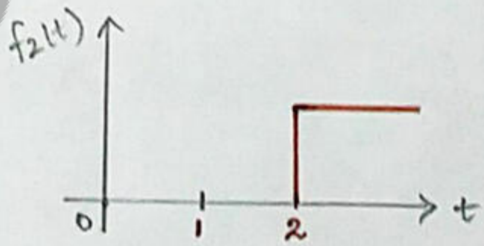
⇒ Here, the unit step function is delayed by 2 sec.

(i.e) $u(t-2)$

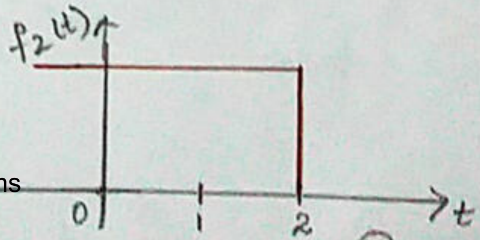
$$\downarrow$$

$$u[-(t-2)] = u(-t+2)$$
$$= u(2-t)$$

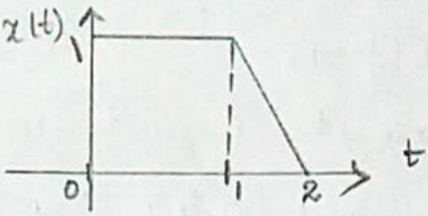
$\therefore u[-(t-2)]$, first we draw $\underline{u(t-2)}$



Now, draw $u[-(t-2)]$,



2) A time signal is given below



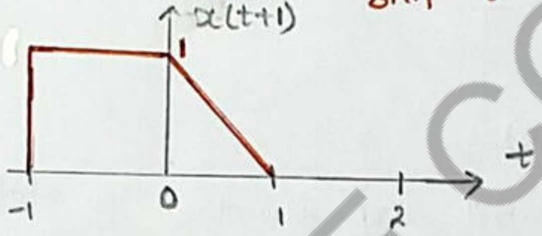
Sketch the following:

(i) $x\left(\frac{3}{2}t+1\right)$ (ii) $x\left(-\frac{3}{2}t+1\right)$

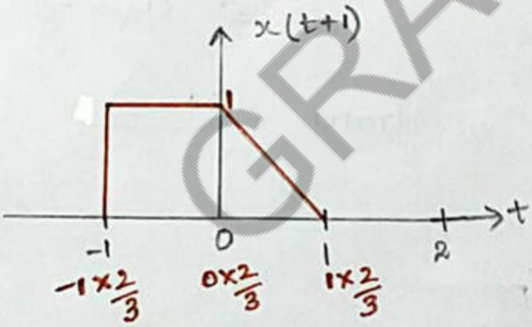
1. Time Shifting
2. Time Reversal
3. Time Scaling

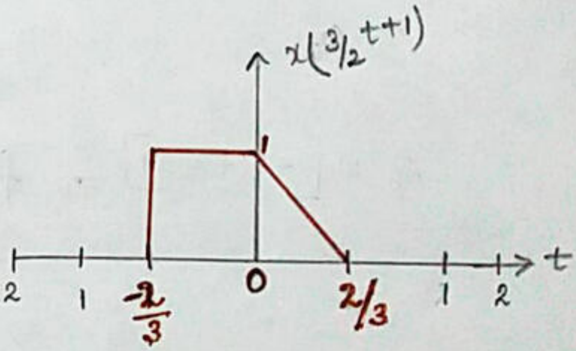
(i) $x\left(\frac{3}{2}t+1\right)$

Now take $x(t+1)$ → Time Shifting



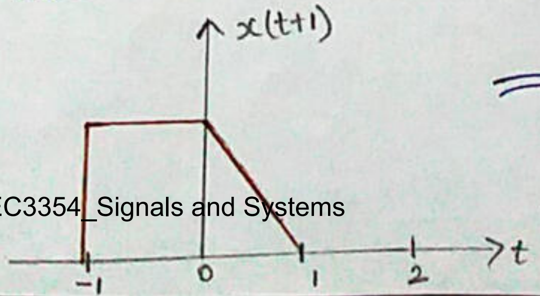
Now, take $x\left(\frac{3}{2}t+1\right)$ → Time scaling.





(ii) $x\left(-\frac{3}{2}t+1\right)$

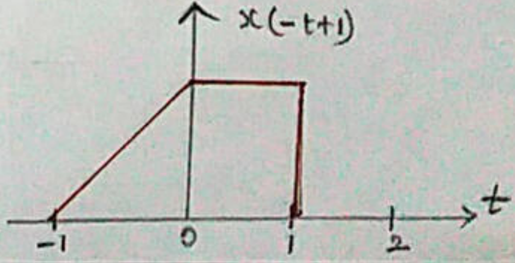
Now draw $x(t+1)$



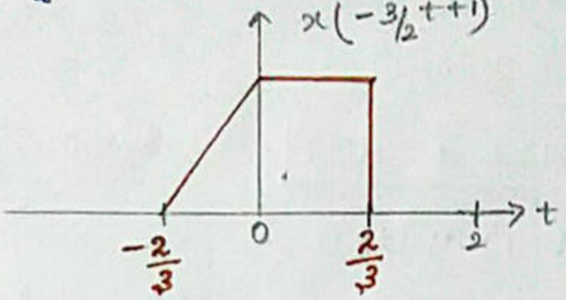
$\Longrightarrow$

Now draw $x(-t+1)$

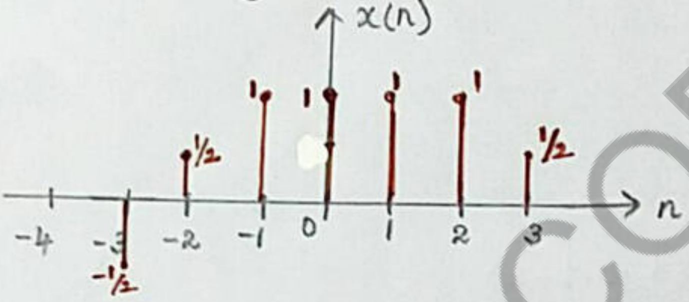
(i.e) Take Time Reversal,



Now $x(-\frac{3}{2}t+1)$, Take Time Scaling,



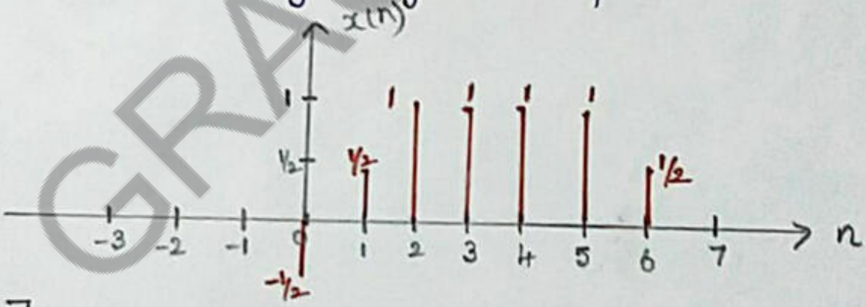
2) A discrete time signal is as shown below:



(i) $x(3-n)$ (ii) $x[(n-1)^2]$

(i) $x(3-n)$

Here x(n) is delayed by 3 samples.



(ii) $x[(n-1)^2] = y(n)$, find y(n).

$y(n) = x[(n-1)^2]$, Substitute the values of 'n' & calcula

$n=0$, $y(0) = x[(0-1)^2] = x(1)$

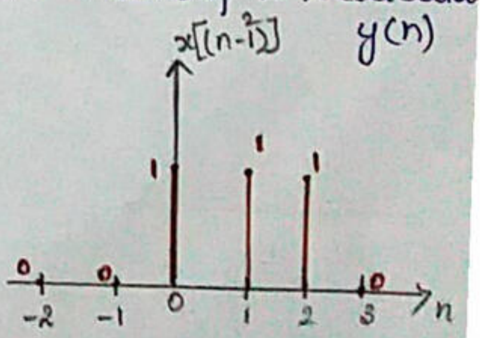
$n=1$, $y(1) = x[(1-1)^2] = x(0)$

$n=2$, $y(2) = x[(2-1)^2] = x(1)$

$n=3$, $y(3) = x[(3-1)^2] = x(4)$

$n=-1$, $y(-1) = x[(-1-1)^2] = x(4)$

$n=-2$, $y(-2) = x[(-2-1)^2] = x(9)$



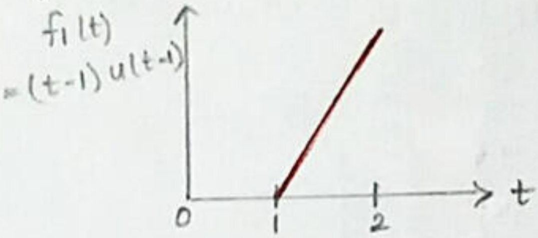
9) Trace the waveforms represented by following functions:

(i) $f_1(t) = (t-1)\,u(t-1)$

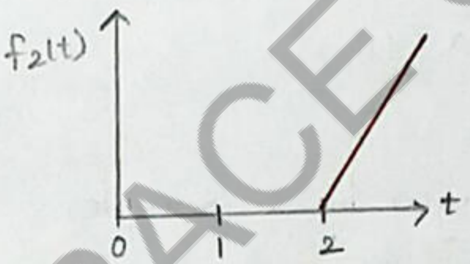
W.K.T, $\boxed{r(t) = t \cdot u(t)} \longrightarrow$ ramp signal.

$f_1(t) = (t-1)\,u(t-1)$

This represents a unit ramp delayed by 1 sec.



(ii) $f_2(t) = (t-2)\,u(t-2)$



Anna University solved Problem:

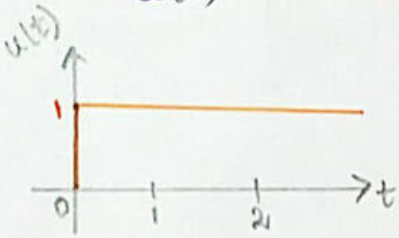
1) Draw the waveforms represented by following step functions.

(i) $f_1(t) = 2u(t-1)$ (ii) $f_2(t) = -2u(t-2)$

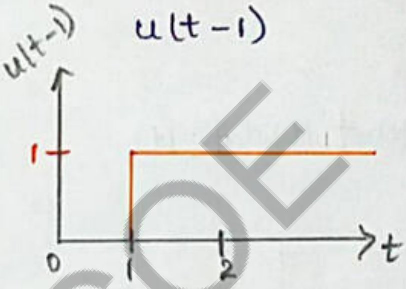
(iii) $f(t) = f_1(t) + f_2(t)$ (iv) $f(t) = f_1(t) - f_2(t)$

(i) $f_1(t) = 2u(t-1)$

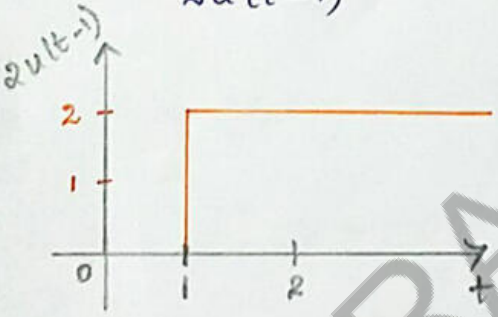
u(t)



u(t-1)



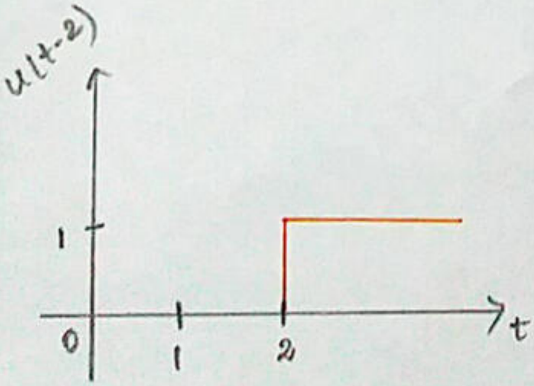
2u(t-1)



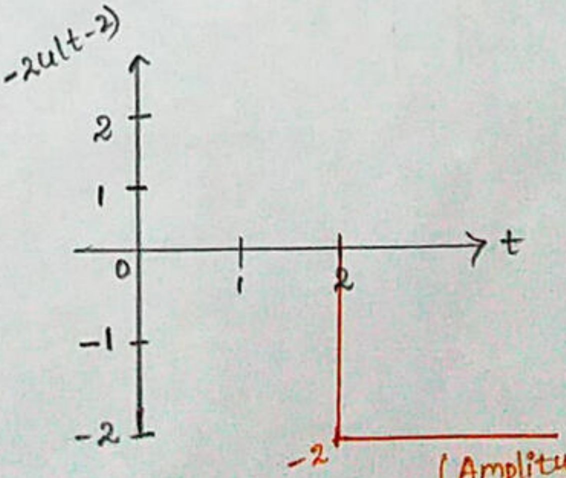
(Amplitude multiplied by 2)

(ii) $f_2(t) = -2u(t-2)$

u(t-2)

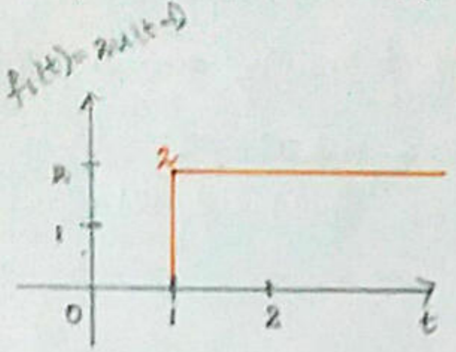


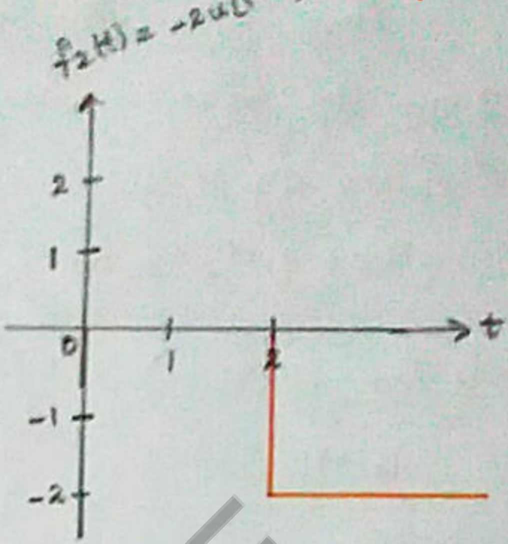
-2u(t-2)



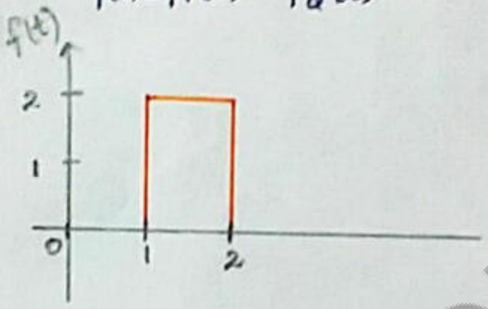
(Amplitude multiplied -2)

(iii) $f(t) = f_1(t) + f_2(t)$

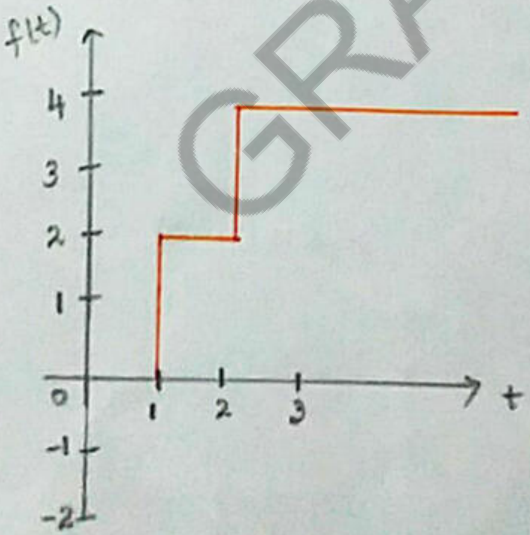




$f(t) = f_1(t) + f_2(t)$



(iv) $f(t) = f_1(t) - f_2(t)$



Classification of Signals:-

Signals can be classified into 2 parts, depending upon independent variable (time).

A) Continuous Time (CT) Signals.

B) Discrete Time (DT) Signals.

Both the CT and DT signals can be classified into following parts:

(i) Periodic and non-periodic Signals.

(ii) Even and odd signals.

(iii) Energy and power signals.

(iv) Deterministic and random signals.

i) Periodic & Non Periodic Signals:

Periodic Signal:

A signal is said to be periodic, if it repeats at regular intervals.

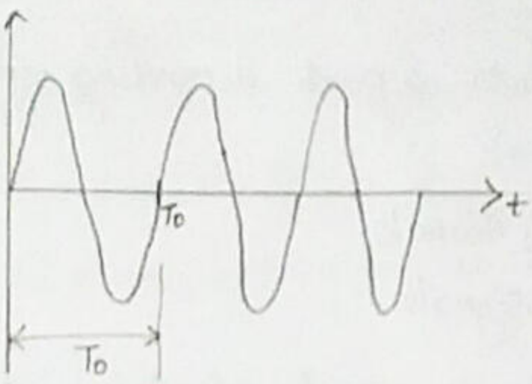
Non Periodic Signal:

Non periodic signals do not repeat at regular interval.

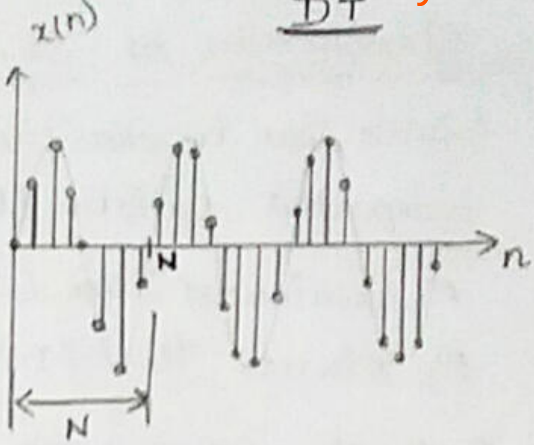
For Continuous	For Discrete
→ For CT signal, it repeats after certain period T is $x(t) = x(t+T)$	→ For Discrete, $x(n) = x(n+N)$

↳ ∴ Periodic signal must satisfy 'Time Shifting' Property

CT



DT



Condition for CT :

1) $x(t) = x(t+T)$ (or)

$x(t) = x(t+mT)$,

where $m = 1, 2, 3 \ldots$

Periodic with period $T, 2T, 3T \ldots$

$$\boxed{T = \frac{1}{f}}$$

The smallest value of T, which satifies the condition is called fundamental Time period.

2) Any signal is the form of :

→ $A \sin(\omega t+\phi) = A \sin(2\pi f t+\phi)$

→ $A \cos(\omega t+\phi)$

→ $A e^{j(\omega t+\phi)}$

are periodic signal.

3) Sum of 2 periodic signals - may or may not be periodic

→ Sum of 2 periodic signals is periodic only if $\frac{T_1}{T_2}$ is rational number.

→ Fundamental period for T_1 & T_2 = LCM (T_1, T_2).

Condition for DT :

1) $x(n) = x(n+mN)$

where $m = 1, 2, 3 \ldots$

Periodic with period $N, 2N, 3N \ldots$

2) $x(n) = \cos(2\pi f n)$

$$\boxed{f = \frac{k}{N}}$$

(i.e) ratio of two integers.

If f is rational, then signal is periodic

If f is irrational, then signal is Non-periodic

Here N → fundamental period.

3) Sum of 2 periodic signals are periodic, only if $\frac{N_1}{N_2}$ is rational number

= LCM (N_1, N_2)

Problems:

Determine whether the following signals are periodic or not? If periodic, determine fundamental period.

(i) $x(t) = \cos\left(t + \frac{\pi}{4}\right)$

$x(t) = \cos(2\pi f t + \phi)$ $\Rightarrow$ $2\pi f = 1$ $\left(f = \frac{1}{T}\right)$

↙ General form

$\frac{2\pi}{T} = 1$

$\therefore \boxed{T = 2\pi}$

Hence, this signal is non periodic with $T = 2\pi$

(ii) $x(t) = \sin\left(\frac{2\pi}{3}t\right)$

General form, $\Rightarrow \sin(2\pi f t + \phi)$

$\therefore \cancel{2\pi} f = \frac{\cancel{2\pi}}{3}$, $f = \frac{1}{3}$ $\boxed{T = 3}$

$\frac{1}{T} = \frac{1}{3}$,

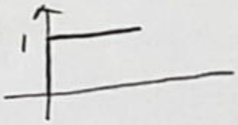
This signal is periodic with $T = 3$.

(iii) $x(t) = \sin 10\pi t \cdot u(t)$

$2\pi f = 10\pi$

$f = 5$

$\frac{1}{T} = 5$, $\therefore T = \frac{1}{5}$, But $u(t)$ is a step signa



$\therefore$ It is Non periodic signal.

(iv) $x(t) = e^{j5t}$

General form, $e^{j2\pi f t}$

$\Rightarrow 2\pi f = 5$

$\frac{2\pi}{T} = 5$, $T = \frac{2\pi}{5} = 0.4\pi$

$\therefore$ Periodic with $\boxed{T = 0.4}$

(v) $x(t) = \cos 100\pi t + \sin 50\pi t$

Compare with $\cos 2\pi f_1 t + \sin 2\pi f_2 t$

$$2\pi f_1 = 100\pi \qquad 2\pi f_2 = 50\pi$$

$$f_1 = \frac{100\pi}{2\pi} \qquad f_2 = \frac{50\pi}{2\pi}$$

$$\frac{1}{T_1} = \frac{50\cancel{\pi}}{\cancel{\pi}} \qquad \frac{1}{T_2} = 25$$

$$T_1 = \frac{\cancel{\pi}}{50} = \frac{1}{50} \qquad T_2 = \frac{1}{25}$$

Ratio of two periods $\frac{T_1}{T_2} = \frac{1/50}{1/25} = \frac{25}{50} = 1/2 \rightarrow$ rational

$LCM(T_1, T_2) = 1, 2$

$\boxed{=2}$

$\therefore$ Signal is periodic.

(vi) $x(t) = \cos t + \sin \sqrt{2}\, t$

$$2\pi f_1 = 1 \quad , \quad 2\pi f_2 = \sqrt{2}$$

$$\frac{2\pi}{T_1} = 1 \qquad 2\pi f_2 = \sqrt{2}$$

$$T_1 = 2\pi \qquad \frac{2\pi}{T_2} = \sqrt{2}, \quad T_2 = \frac{2\pi}{\sqrt{2}}$$

$$\Rightarrow \frac{T_1}{T_2} = \frac{2\pi}{2\pi/\sqrt{2}} = \frac{\cancel{2\pi} \times \sqrt{2}}{\cancel{2\pi}} = \sqrt{2} \longrightarrow \text{not a rational number.}$$

$\therefore$ Non periodic signal.

Discrete Time

Determine whether the following DT signals are periodic or not? If periodic, determine fundamental period.

(i) $\cos\left(\frac{n\pi}{3}\right) + \sin\left(\frac{n\pi}{4}\right)$

$2\pi f_1 = \frac{\pi}{3}$

$f_1 = \frac{\cancel{\pi}}{2\cancel{\pi}\cdot 3} = \frac{1}{6} = \frac{k_1}{N_1}$

$\therefore \boxed{N_1 = 6}$

$2\pi f_2 = \frac{\pi}{4}$

$f_2 = \frac{\pi}{4 \times 2\pi}$

$f_2 = \frac{1}{8} = \frac{k_2}{N_2}$

$\boxed{N_2 = 8}$

$\frac{N_1}{N_2} = \frac{6}{8} \longrightarrow$ rational number

$\text{LCM}(N_1 N_2) = 24$

$\therefore$ This signal is periodic.

(ii) $\cos\left(\frac{n}{4}\right)$

$2\pi f = \frac{1}{4}$

$f = \frac{1}{2\pi \times 4} = \boxed{\frac{1}{8\pi} = \frac{k}{N}} \Longrightarrow N = 8\pi$

$\hookrightarrow$ not a rational no.

$\therefore$ It is non periodic signal.

(iii) $\cos\left(\frac{n}{8}\right)\cos\left(\frac{n\pi}{8}\right) = ?$

$2\pi f_1 = \frac{1}{8}$

$f_1 = \frac{1}{16\pi} = \frac{k_1}{N_1}$

$N_1 = 16\pi$ (irrational)

$2\pi f_2 = \frac{\pi}{8}$

$f_2 = \frac{\pi}{8 \times 2\pi} = \frac{1}{16} = \frac{k_2}{N_2}$

$N_2 = 16$ (rational)

$\therefore$ product of non periodic & periodic is $\rightarrow$ non periodic

$\frac{N_1}{N_2} = \frac{16\pi}{16} = \pi$ $\hookrightarrow$ (irrational)

$\therefore$ It is non-periodic signal

Even and Odd Signals (or) Symmetric & Anti Symmetric Signals:

Even Signal:

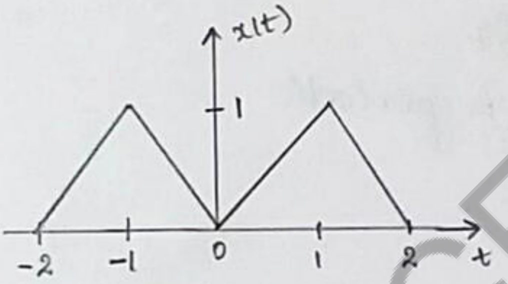
* A signal is said to be even signal if inversion of time axis does not change the amplitude

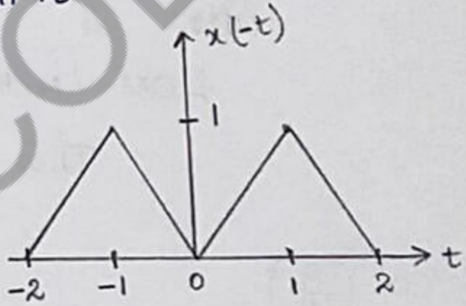
* Even signals are also called symmetric signals.

Condition for even signal:

$x(t) = x(-t)$ for all t

$x(n) = x(-n)$ for all n





Examples:

1. Cos wave is an example of even signal
2. t^2, t^4

Odd Signal (Anti Symmetric Signal)

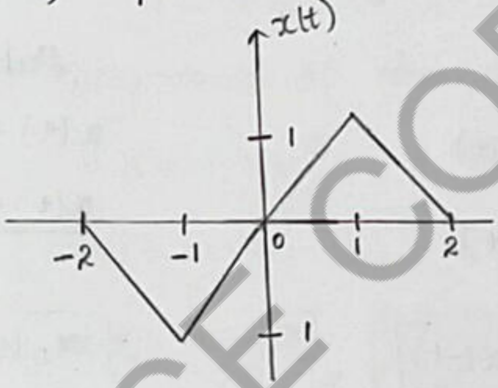
→ A signal is said to be odd signal if inversion of time axis also inverts amplitude of the signal i.e.,

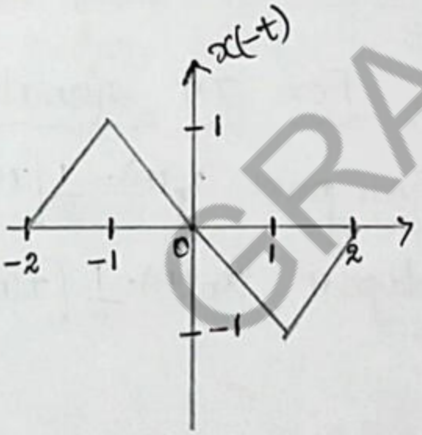
→ odd signals are also called anti symmetric signals.

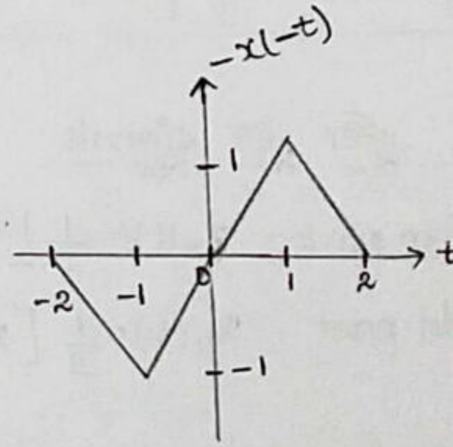
Condition for odd signal:

$x(t) = -x(-t)$ for all t

$x(n) = -x(-n)$ for all n







Representation of signal in even and odd parts:

Any signal can be expressed as sum of even and odd components,

$$x(t) = x_e(t) + x_o(t) \longrightarrow ①$$

where $x_e(t) \rightarrow$ even part of $x(t)$

$x_o(t) \rightarrow$ odd part of $x(t)$

Substitute $(-t)$ for t in eqn ①.

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

$$x(-t) = x_e(t) - x_o(t) \longrightarrow ②$$

Adding ① & ②,

$$x(t) + x(-t) = 2\,x_e(t)$$

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

$$\boxed{\therefore\ x_e(t) = \frac{1}{2}\left[x(t)+x(-t)\right]}$$

Subtracting ① & ②

$$x(t) - x(-t) = 2\,x_o(t)$$

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

$$\boxed{\therefore\ x_o(t) = \frac{1}{2}\left[x(t)-x(-t)\right]}$$

For CT signals:

Even part : $x_e(t) = \frac{1}{2}\left[x(t)+x(-t)\right]$

Odd part : $x_o(t) = \frac{1}{2}\left[x(t)-x(-t)\right]$

For DT signals:

Even part : $x_e(n) = \frac{1}{2}\left[x(n)+x(-n)\right]$

odd part : $x_o(n) = \frac{1}{2}\left[x(n)-x(-n)\right]$

Note:

1) when a signal is even, then its odd part will be zero.

2) when a signal is odd, then its even part will be zero.

3) Even + Even = Even

4) odd + odd = odd

5) Even + odd = Neither Even nor Odd

6) Even × Even = Even

7) odd × odd = [illegible]

8) Even × odd = odd

9) Product of two (or) more even signals [illegible] or product of even number of odd signals results even.

10) Product of odd number of odd signal results odd.

Problems:

1) Find even & odd components of the signal

$$x(t) = 3 + 2t + 5t^2$$

$$x_e(t) = \frac{1}{2}\left[x(t) + x(-t)\right]$$

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

Now, $x(-t) = 3 + 2(-t) + 5(-t)^2$

$$= 3 - 2t + 5t^2$$

$$x_e(t) = \frac{1}{2}\left[3 + \cancel{2t} + 5t^2 + 3 - \cancel{2t} + 5t^2\right]$$

$$= \frac{1}{2}\left[6 + 10t^2\right]$$

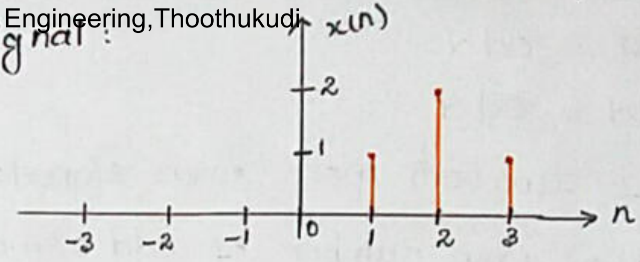
$$\boxed{x_e(t) = 3 + 5t^2}$$

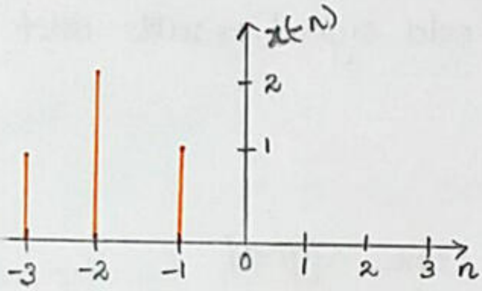
$$x_o(t) = \frac{1}{2}\left[\cancel{3} + 2t + \cancel{5t^2} - \cancel{3} + 2t - \cancel{5t^2}\right]$$

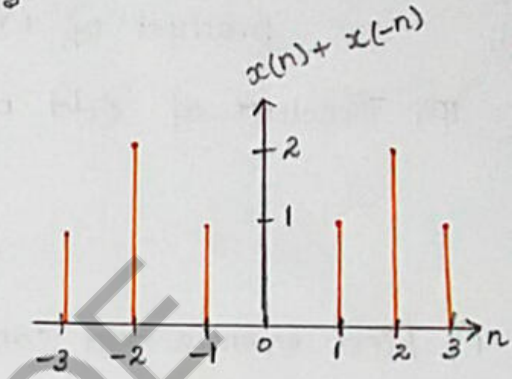
$$= \frac{1}{2}\left[4t\right]$$

$$\boxed{x_o(t) = 2t}$$

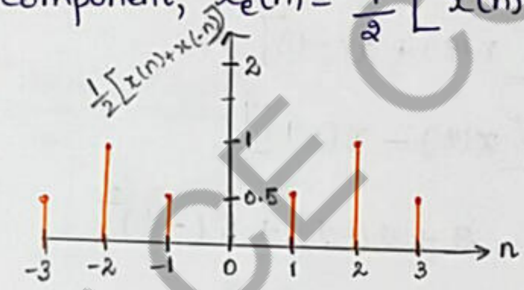
2) Find and sketch the even and odd components of the following signal:



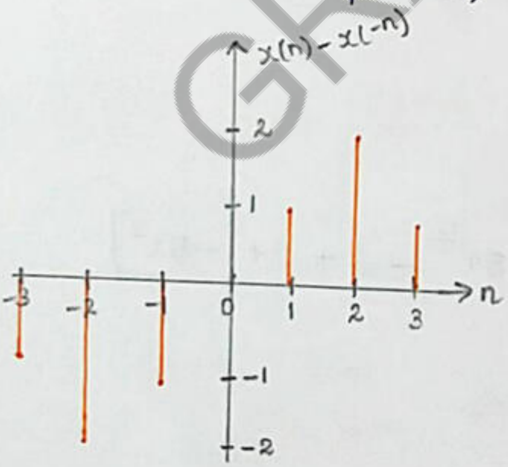


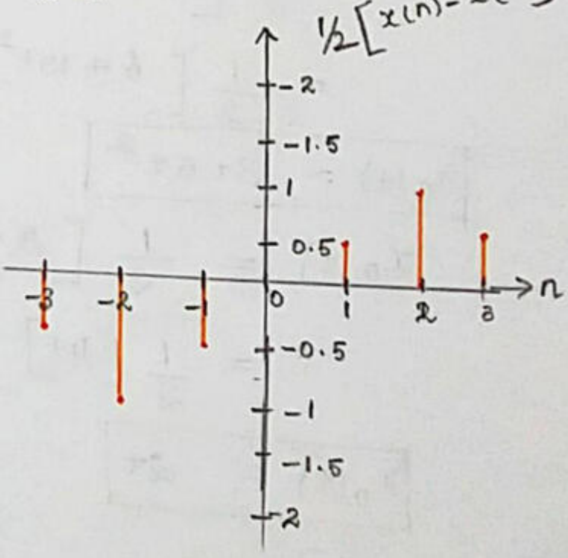


even component, $x_e(n) = \frac{1}{2}\left[x(n) + x(-n)\right]$



Odd component, $x_o(n) = \frac{1}{2}\left[x(n) - x(-n)\right]$





Energy and Power Signals:

Energy Signal:

A signal is said to be Energy signal, if its total energy is finite and non zero

(i.e) $\boxed{0 < E < \infty}$

Power Signal:

A Signal is said to be Power signal, if its normalized power is non zero and finite.

(i.e) $\boxed{0 < P < \infty}$

For Continuous Time Signal:

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

$$\text{Power, } P = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 dt$$

For Discrete Time Signal:

$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$P = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$$

Note:-

1) Suppose if a signal is $A \cos \omega t$ (or) $A \sin \omega t$, then the power signal $= \frac{A^2}{2}$

2) Square root of Power is RMS value of the signal.

3) For an energy signal, $P=0$. (i.e) power of energy signal is zero

4) For a power signal, $E=\infty$.
(i.e) Energy of power signal is infinite.

5) A signal can be an Energy signal or power signal (or) neither Energy nor power signal.

6) A signal cannot be both energy & power signal.

Important Tips:

Step 1: Observe the signal carefully. If it is periodic & infinite duration then it can be power signal. Hence calculate its power directly.

Step 2: If the signal is periodic, but of finite durati
then it can be energy signal.
Hence calculate its energy directly.

Step 3:
If the signal is not periodic, then it can be energy signal. Hence calculate the energy directly.

Energy & Power Signals

1) $x(n) = u(n)$

$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2$$

$$= \sum_{n=0}^{\infty} u(n) = 1+1+1 --- \infty$$

$$= \infty$$

$\therefore$ $E = \infty$

$$\text{Power } P = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2$$

$$= \mathrm{lm}_{N\to\infty} \frac{1}{2N+1} \sum_{n=0}^{N} (1+1++ ----1)$$

$$= \mathrm{lm}_{N\to 0} \frac{1}{2N+1} (N+1)$$

$$= \mathrm{lm}_{N\to\infty} \frac{N\left(1+\frac{1}{N}\right)}{N\left(2+\frac{1}{N}\right)} \Rightarrow \frac{1+\frac{1}{\infty}}{2+\frac{1}{\infty}} \Rightarrow \frac{1+0}{2+0}$$

$$\boxed{P = \frac{1}{2}}$$

2) $x(n) = \left(\frac{1}{3}\right)^n u(n)$

$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2 \Rightarrow \sum_{n=0}^{\infty} \left[\left(\frac{1}{3}\right)^n\right]^2$$

$$\Rightarrow \sum_{n=0}^{\infty} \left(\frac{1}{9}\right)^n$$

Infinite Geometric Series sum formula (i) $\boxed{\sum_{n=0}^{\infty} c^n = \frac{1}{1-C}}$, $C<1$

$$\Rightarrow \frac{1}{1-1/9} \Rightarrow \frac{1}{9-1/9} = \frac{1}{8/9}$$

$$= \frac{9}{8}$$

(ii) $\boxed{\sum_{n=0}^{\infty} c^n = \frac{1}{C-1},}$ $C>1$

$$\text{Power} = \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x(n)|^2 \longrightarrow \left|\left(\frac{1}{3}\right)^n\right|$$

$$\Rightarrow \lim_{N\to\infty} \frac{1}{2N+1} \sum_{n=0}^{\infty} \left(\frac{1}{9}\right)^n$$

Finite Geometric Series Sum formula

$$\sum_{n=0}^{N} c^n = \frac{1-c^{N+1}}{1-c}, \quad c<1$$

$$\sum_{n=0}^{N} c^n = \frac{c^{N+1}-1}{c-1}, \quad c>1$$

$$\Rightarrow \lim_{N\to\infty} \frac{1}{2N+1} \; \frac{1-\left(\frac{1}{9}\right)^{N+1}}{1-\frac{1}{9}}$$

$$\Rightarrow \frac{1}{\infty} \cdot 0$$

$\boxed{P = 0}$ ∴ Given Signal is Energy Signal.

Power & RMS Value

1) $x(t) = 5\cos\left(50t + \frac{\pi}{3}\right)$

General form, $A\cos(\omega t + \theta)$

$$P = \frac{A^2}{2} = \frac{5^2}{2} = \frac{25}{2} = 12.5$$

$$\text{R.M.S value} = \sqrt{P}$$

$$= \sqrt{12.5}$$

2) $x(t) = 10 \sin\left(50t + \frac{\pi}{4}\right) + 16 \cos\left(100t + \frac{\pi}{3}\right)$

$$P = \frac{A^2}{2} \Rightarrow \frac{10^2}{2} + \frac{16^2}{2} \Rightarrow \frac{100}{2} + \frac{256}{2}$$

$$= 50 + 128$$

$$P = 178$$

$$R.M.S = \sqrt{P} = \sqrt{178}.$$

$$= 13.341$$

3) $x(t) = 15\, e^{j\omega t}$

General form $= A.\, e^{j\omega t}$

Power $= A^2 = 15^2 = 225$

4) $x(t) = e^{-at}\, u(t)$

$$x(t) = e^{-at}\, u(t)$$

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

$$= \int_{0}^{\infty} \left(e^{-at}\right)^2 dt$$

$$= \int_{0}^{\infty} e^{-2at}\, dt$$

$$= \left[\frac{e^{-2at}}{-2a}\right]_0^{\infty}$$

$$= \frac{e^{-\infty} - e^{0}}{-2a} = \frac{1}{2a}$$

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

(Energy sig

$$\text{power} = \lim_{T\to\infty} = \frac{1}{T}\int_{-T/2}^{T/2} |x(t)|^2 dt$$

$$= \frac{1}{T}\int_{0}^{T/2} |x(t)|^2 dt$$

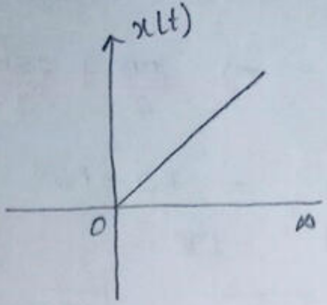
$$\lim_{T\to\infty} \frac{1}{T}\left(\frac{1}{2a}\right)_0^{\infty} \Rightarrow \frac{E}{\infty}$$

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

$$= 0$$

power $= 0$.

5) $x(t) = t \cdot u(t)$ (W.K.T, $t \cdot u(t) \rightarrow$ ramp signal)



$$E = \int_0^\infty t \cdot dt = \left(\frac{t^2}{2}\right)_0^\infty$$

$$\boxed{E = \infty}$$

$$\text{Power } P = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} t \cdot dt$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} \int_0^\infty t \cdot dt$$

$$\Rightarrow \lim_{T\to\infty} \frac{1}{T} (\infty)$$

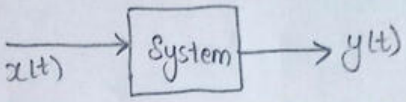
$$\Rightarrow \boxed{P = \infty}$$

Here, $E=\infty$, $P=\infty$

So, it is neither Energy signal nor power signal.

Properties of System :-

1. Static and Dynamic
2. Causal and non causal
3. Linear and non-linear
4. Time invariant and Time variant
5. Invertible & non invertible
6. Stable & ~~non~~ unstable system.



1. Static & Dynamic System:

Static: A system is said to be static if the output of the system depends only on present input. It is also called as memoryless system (or) system without memory.

ex: $y(t) = x(t)$, $y(t) = \underbrace{e^{-(t+1)}}_{\text{constant}} \cdot x(t)$

$y(t) = 2\,x(t)$

Dynamic:

A system is said to be dynamic, if the output of the system depends on past & future values of inputs. It is also called as memory system (or) system with memory.

ex: (i) Electric circuit having inductors (or) capacitors

$$\boxed{\begin{aligned} V(t) &= \frac{1}{C}\int i(t)\,dt \\ V(t) &= L\cdot\frac{di(t)}{dt} \end{aligned}}$$

(ii) $y(t) = x(t-2)$

(iii) $y(t) = \frac{d\,x(t)}{dt} + x(t)$

(iv) $y(n) = x(n) + x(n+1)$

3. Causal and non Causal System :

Causal:

* A system is said to be causal if the output at any time 't' depends only on the present & past values of the input but not on future inputs. ((i.e) independent of future system)

* These systems are also known as non-anticipative systems.

ex: $y(t) = t \cdot \overset{\text{present values}}{x(t)}$

$y(n) = x(n) - \underbrace{x(n-1)}_{\text{past}}$

$y(0) = \underbrace{x(0)}_{\text{present}}$

$y(0) = \underbrace{x(-1)}_{\text{past}}$

$y(0) = \underbrace{x(1)}_{\text{future}}$

Non Causal :

A system is said to be non-causal, if the output at any time 't' depends on future inputs. ((i.e) both present & future) These systems are also known as anticipative systems.

ex: $y(t) = x(t+5)$

$y(t) = \underbrace{x(t)}_{\text{present}} + \underbrace{x(t+3)}_{\text{future}}$

Anti Causal System: (dependent on future only)

A system which depends $\boxed{\text{only on future inputs}}$ is called Anti Causal system.

ex: $y(t) = x(t+5)$, $y(n) = x(n+2)$

Note:

* All anticausal systems are non-causal systems.

* All non-causal systems are not anti-causal systems.

Problems

1) $y(t) = x \cdot e^{t}$

now substitute $t=0$,

$$y(0) = x \cdot e^{0} = x \cdot 1 = x(1)$$

$\therefore y(0) = x(1) \longrightarrow$ It is a non-causal

But y(0) depends only on future, so it is a anti-causal system.

2) $y(n) = x(n^2)$

$n=-1, \quad y(-1) = x(-1)^2 = x(1)$

$n=0, \quad y(0) = x(0) = x(0)$

$n=1, \quad y(1) = x(1^2) = x(1)$

$n=2, \quad y(2) = x(2^2) = x(4)$

For all values of n, the output y, depends on present & future values of input.

$\therefore$ It is a non-causal system.

3) $y(t) = \sin[x(t)]$

$t=-1, \quad y(-1) = \sin[x(-1)]$

$t=0, \quad y(0) = \sin[x(0)]$

$t=1, \quad y(1) = \sin[x(1)]$

For all values of t, the o/p depends on present values of input. Therefore the system is Causal.

4) $y(n) = x(n) + \frac{1}{x(n-2)}$

$n=-1, \quad y(-1) = x(-1) + 1/x(-3)$

$n=0, \quad y(0) = x(0) + \frac{1}{x(0-2)} = x(0) + \frac{1}{x(-2)}$

$n=1, \quad y(1) = x(1) + \frac{1}{x(-1)}$

$n=2, \quad y(2) = x(2) + \frac{1}{x(0)}$

$\therefore$ For all values, o/p depends on present & past values.

$\therefore$ System is Causal.

5). $\frac{dy(t)}{dt} + 10\,y(t) + 5 = x(t)$

$t=-1, \quad \frac{dy(-1)}{dt} + 10\,y(-1) + 5 = x(-1)$

$t=0, \quad \frac{dy(0)}{dt} + 10\,y(0) + 5 = x(0)$

$t=1, \quad \frac{dy(1)}{dt} + 10\,y(1) + 5 = x(1)$

$\therefore$ For all values, o/p depends on present values of i/p

$\therefore$ System is Causal.

Linear and Non-Linear Systems:

Linear System:

A system that satisfies the superposition principle, then it is said to be a linear system.

Non-Linear system:

A system which does not satisfies the superposition principle, then it is said to be a non-linear system.

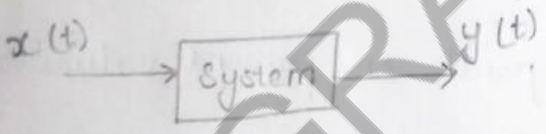
Principle of Superposition:

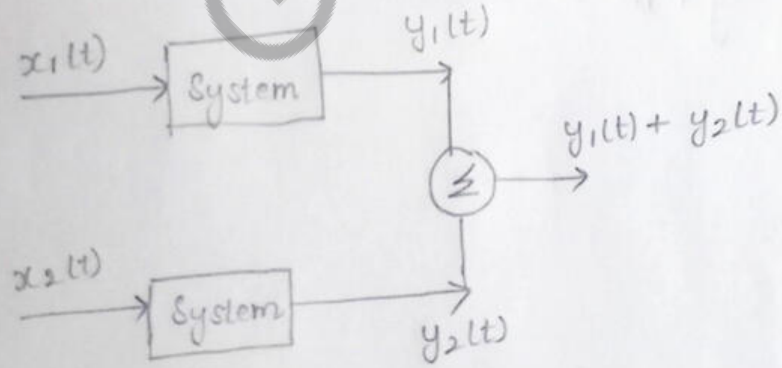
The superposition principle consists of two properties.

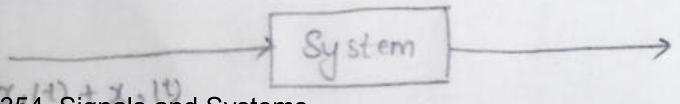
(i) Additive property.

(ii) Scaling (or) Homogeneity property.

(i) Additive property:



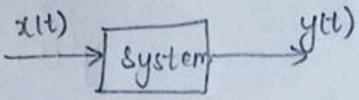


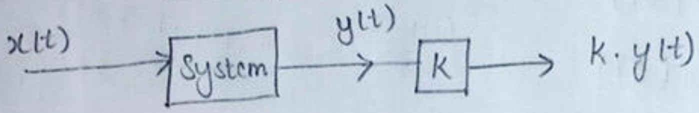


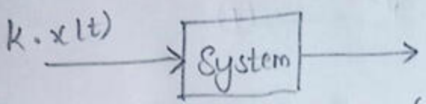
$y'(t) = y_1(t) + y_2(t)$ → follows additive property

may be, $y'(t) \neq y_1(t) + y_2(t)$ ↙ not follow additive property

(ii) Scaling Property (or) Law of Homogeneity :







$y'(t) = k \cdot y(t)$ → follows homogeneity principle

(or) $\neq k \cdot y(t)$ → does not follow

Now, combine both additive property & Homogeneity property

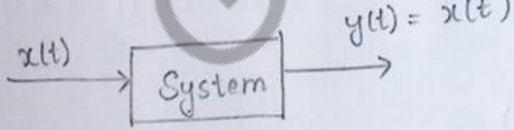
$$y'(t) = a \cdot y_1(t) + b \cdot y_2(t)$$

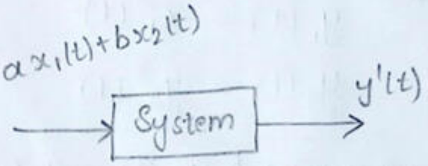
ⓧ $\therefore \boxed{y'(t) = a \cdot y_1(t) + b \cdot y_2(t)}$ → This is the condition for linearity.

Problems:

Check whether the following system is linear (or) not.

1) $y(t) = x(t^2)$.





$y'(t) = a \cdot y_1(t) + b \cdot y_2(t)$

$y_1(t) = x_1(t^2)$

$y_2(t) = x_2(t^2)$

$a y_1(t) + b y_2(t) = a \cdot x_1(t^2) + b \cdot x_2(t^2) \rightarrow ①$

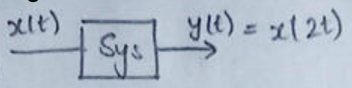
$y'(t) = a \cdot x_1(t^2) + b \cdot x_2(t^2) \rightarrow ②$

eqn ① = eqn ②

Hence system is linear.

2) $y(t) = x(2t)$ check whether the system is linear or not.

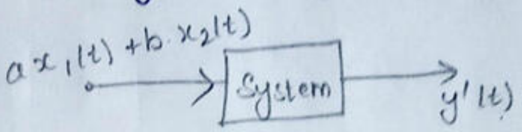
$y(t) = x(2t)$



L.H.S R.H.S
$y'(t) = a\cdot y_1(t) + b\cdot y_2(t)$

R.H.S, $y_1(t) = x_1(2t)$

$y_2(t) = x_2(2t)$



$$a\cdot y_1(t) + b\cdot y_2(t) = a\, x_1(2t) + b\cdot x_2(2t) \longrightarrow ①$$

L.H.S,

$$y'(t) = a\, x_1(2t) + b\, x_2(2t) \longrightarrow ②$$

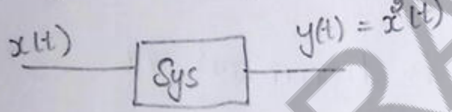
$$① = ②$$

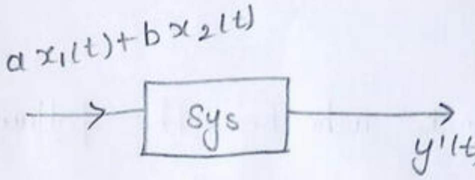
∴ The system is linear.

Important Note:

Linearity is independent of time Scaling ⓧ

3) $y(t) = x^2(t)$





R.H.S $y_1(t) = x_1^2(t)$

$y_2(t) = y_2^2(t)$

L.H.S R.H.S
$y'(t) = a y_1(t) + b y_2(t)$

$$a y_1(t) + b\cdot y_2(t) = a\, x_1^2(t) + b\cdot x_1^2(t) \longrightarrow ①$$

L.H.S

$$y'(t) = [a\cdot x_1(t) + b\cdot x_2(t)]^2 \longrightarrow ②$$

$$\therefore ① \neq ②$$

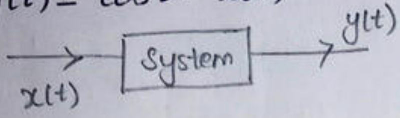
∴ The system is non-linear.

Type - II

4) Check the system whether it is linear or not :

(i) $y(t) = \cos t \cdot x(t)$ (ii) $y(t) = e^{t} \cdot x(t)$

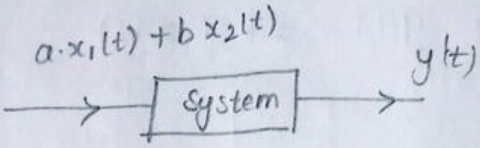
(i) $y(t) = \cos t \cdot x(t)$



$$y'(t) = a \cdot y_1(t) + b \cdot y_2(t)$$

R.H.S

$$y_1(t) = \cos t \cdot x_1(t)$$
$$y_2(t) = \cos t \cdot x_2(t)$$
$$a \cdot y_1(t) + b \cdot y_2(t) = a \cdot \cos t\, x_1(t) + b \cdot \cos t\, x_2(t) \longrightarrow ①$$



$$y'(t) = a \cdot y_1(t) + b \cdot y_2(t)$$

L.H.S

$$y'(t) = \cos t \left[a x_1(t) + b x_2(t)\right] \longrightarrow ②$$

$$① = ②$$

∴ The system is linear

(ii) $y(t) = e^{t} x(t)$

Condition for linearity $\Rightarrow y'(t) = a \cdot y_1(t) + b \cdot y_2(t)$

R.H.S

$$y_1(t) = e^{t} \cdot x_1(t)$$
$$y_2(t) = e^{t} \cdot x_2(t)$$
$$a \cdot y_1(t) + b \cdot y_2(t) = a \cdot e^{t} x_1(t) + b \cdot e^{t} x_2(t) \longrightarrow ①$$

L.H.S

$$y' = e^{t}\left[a \cdot x_1(t) + b \cdot x_2(t)\right] \longrightarrow ②$$

$$① = ②.$$

System is linear

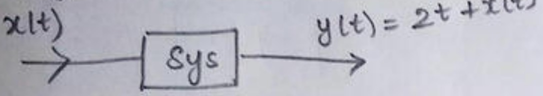
Important note:

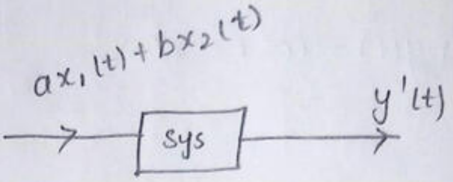
* Linearity is independent of co-efficient used in system input & o/p relationship.

Type - III

check whether the system is linear or not

(i) $y(t) = 2t + x(t)$





$y'(t) = a \cdot y_1(t) + b \cdot y_1(t)$

$y'(t) = ay_1(t) + by_2(t)$

R.H.S

$y_1(t) = 2t + x_1(t)$

$y_2(t) = 2t + x_2(t)$

$a \cdot y_1(t) + b \cdot y_2(t) = a \cdot 2t + x_1(t) + b \cdot 2t + x_2(t) \rightarrow ①$

$y'(t) = 2t + [a \cdot x_1(t) + b \cdot x_2(t)]$

$= 2t + (ax_1(t) + bx_2(t)) \rightarrow ②$

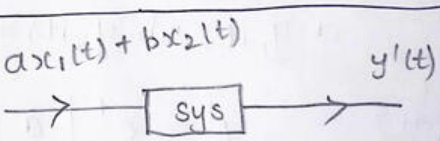
$1 \neq 2$

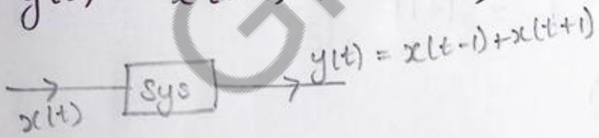
∴ The system is non linear.

Important note:

* If anything is added (or) subtracted with input, then the system is non-linear

(ii) $y(t) = x(t-1) + x(t+1)$





$y_1(t) = x_1(t-1) + x_1(t+1)$

$y_2(t) = x_2(t-1) + x_2(t-1)$

$ay_1(t) + by_2(t) = a_1[x_1(t-1) + x_1(t+1)] + b[x_2(t-1) + x_2(t-1)] \rightarrow ①$

$y'(t) = a[x_1(t-1) + x_1(t+1)] + b[x_2(t-1) + x_2(t-1)] \rightarrow ②$

① = ②

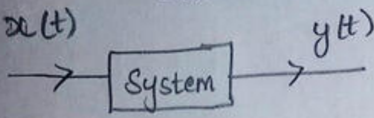
∴ The system is linear.

Note: * Linearity is independent of Time shifting.

Type - IV

Integrator or Differentiator

1. $y(t) = \int_{-\infty}^{t} x(\tau)d\tau$.

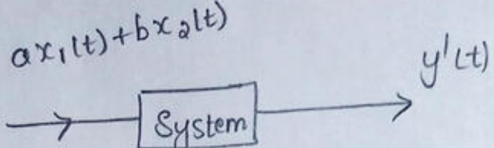


$y'(t) = a\cdot y_1(t) + b\, y_2(t)$

$y_1(t) = \int_{-\infty}^{t} x_1(\tau)d\tau$

$y_2(t) = \int_{-\infty}^{t} x_2(\tau)d\tau$

$a\cdot y_1(t)+b\cdot y_2(t) = a\cdot\int_{-\infty}^{t} x_1(\tau)d\tau + b\int_{-\infty}^{t} x_2(\tau)d\tau \rightarrow ①$



$y'(t) = a y_1(t) + b y_2(t)$

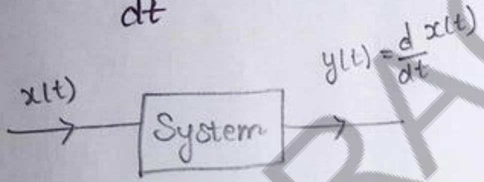
$y'(t) = \int_{-\infty}^{t} a\cdot x_1(\tau) + b\cdot x_2(\tau)d\tau$

$\Rightarrow a\int_{-\infty}^{t} x_1(\tau)d\tau + b\int_{-\infty}^{t} x_2(\tau)d\tau \rightarrow ②$

$① = ②$

∴ The system is linear.

② $y(t) = \frac{d}{dt}\, x(t)$

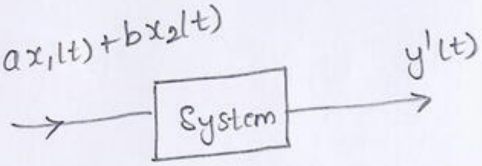


$y'(t) = a\cdot y_1(t) + b\cdot y_2(t)$

$y_1(t) = \frac{d}{dt}\, x_1(t)$

$y_2(t) = \frac{d}{dt}\, x_2(t)$

$ay_1(t)+by_2(t) = a\cdot\frac{dx_1(t)}{dt} + b\cdot\frac{dy_1(t)}{dt} \rightarrow ①$



$y'(t) = \frac{d}{dt}\left[a x_1(t) + b x_2(t)\right]$

$= a\cdot\frac{dx_1(t)}{dt} + b\cdot\frac{dx_2(t)}{dt} \rightarrow ②$

$① = ②$

∴ The system is linear.

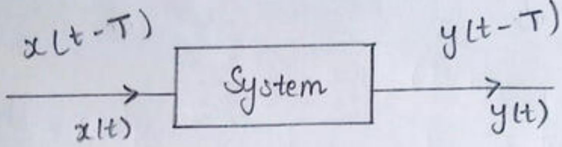
Important Note :-

- ✱ Integration & Differentiation operations are linear
- ✱ Even & odd operators are linear
- ✱ Real & conjugate operators are non-linear.

Time Variant & Time invariant Systems :-

Time invariant system :

- A system is said to be time invariant, if its input output characteristics does not change with time.
- Time invariant system is also called fixed system.



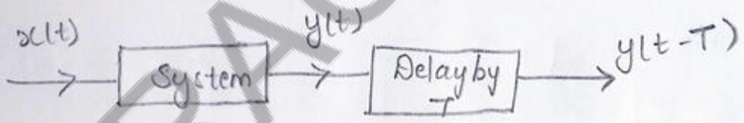
- If a time shift in the input results in a corresponding time shift in the output.

Time Variant System :-

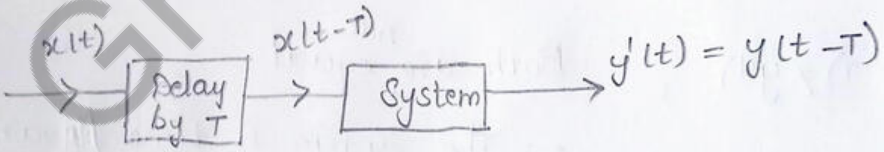
- If the output due to input $x(t-T)$ is not equal to $y(t-T)$ then the system is Time Variant System

Ex:

Step 1:



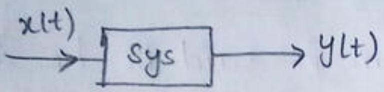
Step 2:



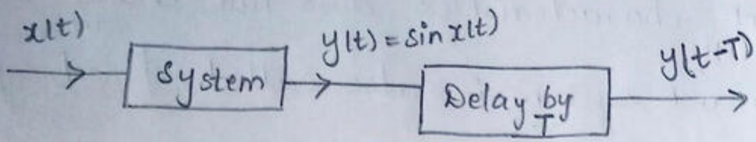
Problems :

1) Check whether the system is Time invariant (or) not.

$y(t) = \sin x(t)$

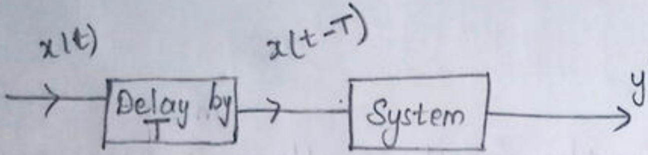


Step1:



$y(t-T) = \sin x(t-T)$

Step2:

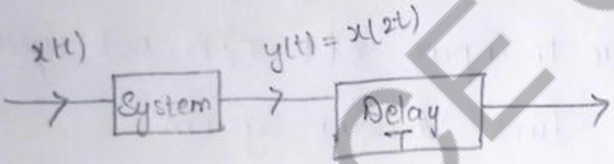


$y'(t) = \sin x(t-T)$

∴ The system is time invariant.

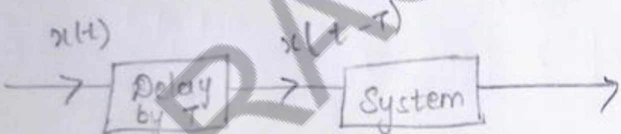
2) $y(t) = x(2t)$ (Time Scaling)

Step1:



$y(t-T) = x(2(t-T))$
$= x(2t-2T)$

Step2:



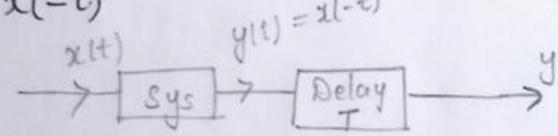
$y'(t) = x(2t-T)$

$\therefore y(t-T) \neq y(t)$, Both are not equal

∴ The system is time variant.

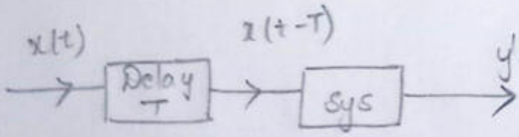
3) $y(t) = x(-t)$

Step1:



$y(t-T) = x(-t-T)$

Step2:



$y(t) = x(-(t-T))$
$= x(-t+T)$

$y(t-T) \# y'(t)$

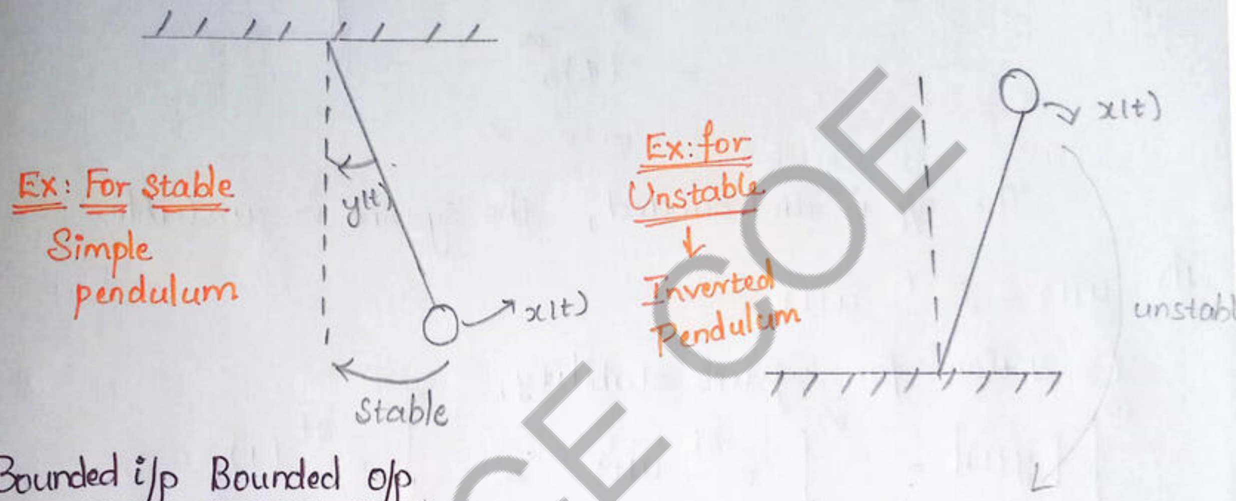
∴ The system is time Variant.

Stable and Unstable

Stable System :

A system is said to be BIBO (Bounded Input Bounded Output) stable if and only if every bounded input produces a bounded output. (or)

For a system to be stable, output should be bounded for bounded input at every instant of time.



Bounded i/p Bounded o/p

Let the input signal x(t) be finite (bounded)

(i.e) $-\infty \; |x(t)| < \infty \quad \Rightarrow \int_{-\infty}^{\infty} |x(t)|$

Then the output signal y(t) is also finite (bounded)

(i.e) $-\infty \; |y(t)| < \infty \quad \Rightarrow \int_{-\infty}^{\infty} |y(t)|$

∴ The system gives bounded output for bounded input is called stable system.

Un Stable System :

A system gives unbounded output for bounded input is called unstable system.

Problems:

1. Check whether the following systems are stable or not.

(i) $y(t) = u(t)$ (ii) $y(t) = e^{-2t} \cdot (u(t))$

Bounded Signals

1. DC signal.
2. $u(t)$ – step function
3. $\sin t$, $\cos t$

(i) $y(t) = u(t)$

Condition for the system stability,

$$\int_{-\infty}^{\infty} |y(t)| = \int_{-\infty}^{\infty} u(t) \cdot dt = \int_{0}^{\infty} 1 \cdot dt$$

$$= (t)_0^{\infty}$$

$$= \infty - 0 = \infty$$

∴ The o/p is unbounded, the system is unstable.

(ii) $y(t) = e^{-2t} \cdot u(t)$

Condition for system stability,

$$\int_{-\infty}^{\infty} | y(t) | = \int_{-\infty}^{\infty} e^{-2t} \cdot u(t) = \int_{0}^{\infty} e^{-2t} (1)$$

$$= \left(\frac{e^{-2t}}{-2} \right)_0^{\infty} = \frac{1}{2} \left(e^{-2t} \right)_0^{\infty}$$

$$= -\frac{1}{2} \left(e^{-\infty} - e^{0} \right) = -\frac{1}{2} (0 - 1)$$

$$= \frac{1}{2} < \infty$$

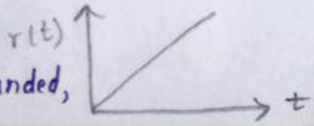
∴ The o/p is bounded, System is stable.

(iii) $y(t) = t \cdot x(t)$

For this, we give the i/p of $x(t)$ as bounded i/p (i.e) $u(t)$

∴ Take $x(t) = u(t) \rightarrow$ unit step function.

$y(t) = t \cdot u(t)$ (w.k.T, $t \cdot u(t)$ = ramp function)



$t = 2$, $r(t) = 2$

$t = \infty$, $r(t) = \infty$, So, o/p is unbounded,

System is unstable.

2) A discrete time System is given as $y(n) = 2y(n-1) + x(n)$. A bounded input of $x(n) = 2\delta(n)$ is applied to the system. Assume that the system is initially relaxed. Check whether the system is stable or not.

Given:- $y(n) = 2y(n-1) + x(n)$

$x(n) = 2\delta(n)$.

If the system is stable, bounded i/p is equal to bounded o/p.

So, $x(n) = 2\delta(n)$

For $n=0$, $x(0) = 2 \cdot \delta(0) = 2(1) = 2$

For $n=1$, $x(1) = 2 \cdot \delta(1) = 0$

For $n=2$, $x(2) = 2 \cdot \delta(2) = 0$

∴ Any values of i/p, o/p is bounded.

$y(n) = 2y(n-1) + 2\delta(n)$

For $n=0$, $y = 0, = 2y(-1) + 2\delta(0)$

$y = 0 \Rightarrow 2y(-1) + 2$

Here o/p is bounded. ∴ System is stable.

3) $y(n) = \left(\frac{1}{2}\right)^n \cdot u(n)$

$n = -1,$ $\sum_{n=-\infty}^{\infty} |y(n)| = \sum_{n=-\infty}^{\infty} \left(\frac{1}{2}\right)^n \cdot u(n)$

$= \sum_{n=-\infty}^{\infty} \left(\frac{1}{2}\right)^n \cdot 1$

$= \sum_{n=-\infty}^{\infty} \left(\frac{1}{2}\right)^n \nearrow$

w.k.T,

$a^n = \frac{1}{1-a}$

$$= \sum_{n=-\infty}^{\infty} \left(\frac{1}{2}\right)^n$$

$$a^n = \frac{1}{1-a}$$

If $|a|<1$

$$= \frac{1}{1-1/2} = 2$$

$$= 2 < \infty$$

o/p is bounded. The system is stable.

Signals and Systems

Unit I: Classification of Signals and Systems

Classification of Signals and Systems | Classification of Continuous and Discrete Time Signals | Energy and Power Signals | Operations on Signals | Systems | Problems Based on Static (or) Dynamic System | Examples Based on Time Variant and Time Invariant System | Examples on Linear (or) Non Linear System | Examples on Causal and Non Causal System | Examples on Stable and Unstable System | Important 2 mark Questions with Answers |

Unit II: Analysis of Continuous Time Signals

Introduction of Continuous Time Signals | Continuous Time Fourier Series | Properties of Fourier Series | Continuous Time Fourier Transform | Problems Based on Fourier Transform | Laplace Transform | Properties of Laplace Transforms | Initial Value Theorem and Final Value Theorem | Inverse Laplace Transform | Important 2 marks Questions with Answers |

Unit III: Linear Time Invariant Continuous Time Systems

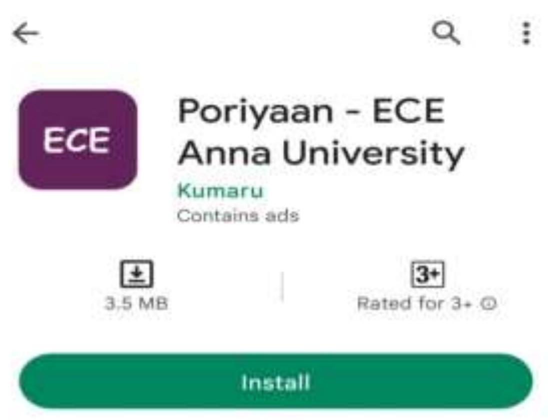
Introduction of Linear Time Invariant - Continuous Time Systems | Block Diagram Representation | Realization of Systems in Direct Form | Impulse Response | Convolution | Fourier Transform Analysis of CT Systems | Laplace Transform Analysis of CT System | Problems Based on Laplace Transform Analysis of CT System | Important 2 marks Questions with Answers of Linear Time Invariant-Continuous Time Systems |

Unit IV: Analysis of Discrete Time Signals

Introduction of Analysis of Discrete Time Signals | Discrete Time Fourier Transform (DTFT) | Problems Based on Properties of DIFT | Inverse Discrete-Time Fourier Transform | Z Transform | Problems Based on z Transform | Inverse Z Transform | Relationship between Z Transform and DIFT | Important 2 marks Questions with Answers Analysis of Discrete Time Signals |

Unit V: Linear Time Invariant-Discrete Systems

Difference Equations | Impulse Response Properties | Block Diagram Representation | Cascade Form Structure for IIR Systems | Discrete Time Fourier Transform Analysis of DT Systems | Z Transform Analysis of DT Systems | Example Problems Based on z Transform Analysis of Discrete Time Systems | Convolution Sum | Problems Based on Convolution Sum | Properties of Convolution and System Interconnections | Two Mark Questions with Answers of Linear Time Invariant-Discrete Time Systems |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- Physics for Electronics Engineering
- Electrical and Instrumentation Engineering
- Circuit Analysis

3rd Semester

- Random Process & Linear Algebra
- C Programming & Data Structures
- Signals and Systems
- Electronic Devices and Circuits
- Control Systems
- Digital Systems Designs

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- Electromagnetic Fields
- Networks & Security
- Linear Integrated Circuits
- Digital Signal Processing
- Communication Systems
- Environmental Sciences & Sustainability

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- Wireless Communication
- VLSI and Chip Design
- Transmission Lines & RF Systems
- Professional Elective I
- Professional Elective II
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- Embedded System & IOT Design
- Artificial Intelligence & Machine Learning
- Open Elective I
- Professional Course III
- Professional Course IV
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