What is the significance of colour red? Why is it perceived as dangerous.

Signal always contains information

Two types analysis

subjective (changes from person to person)

objective (independent of person)

We have the job of extracting information from a signal. It is called processing.

Process the signal to extract information

(x,y axis are in continuous) → continuous

① Signal → ∞ no. of points on x & y axis

② by sampling → finite

③ finite on x axis, finite on y-axis

Cannot be stored in pendrive

Continuous time signal (ct)

↓ sampling

finite values on x axis but ∞ y points. (discrete time signal) (dt)

↓ quantization

finite values on both x & y (digital signal).

↓

can be stored in USB.

Types of signals

1. ct
2. dt
3. (digital signal) → need to process this signal to extract information.

Write a paragraph infer from the lecture?

What did you infer from lecture?

→ This subject deals with extracting information from a signal. This is called as processing of a signal. There are three types of signals.

Signal always contains information.

① Continuous time –
There are infinite no. of points on both x, & y axis. This signal cannot be stored.

② discrete time –
There are infinite no. of points on the y axis but there are some finite no. of points on the x-axis. This signal cannot be stored in a storage device.
We get discrete time signal after sampling ct.

Values of → samples come from ∞ nos.

we take values at instances set resolution / set intervals

③ ~~finite~~ digital signal –
There are finite no. of pts on both x-y axes. This signal can be stored in a storage device. We get digital signal after quantising dt signal.

process of rounding off / process of setting resolution → quantising / quantization

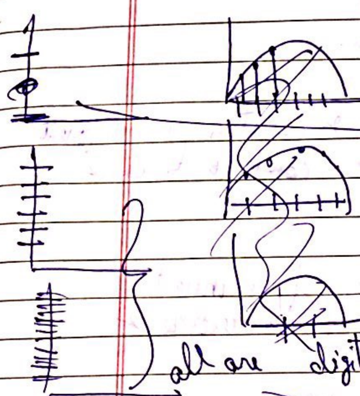
In this course we will be processing a digital signal in order to extract information from it.

All practical signals ~~are~~ are continuous in nature

Continuous & discrete time signal are collectively called as analog signals because they both cannot be processed on a digital system. | digital signals.

analog → ct, dt | digital signals.

(1) 1st FootNote - CT→DT → what you want to do with the signal.
How will you decide finite values on the ~~y~~x-axis?
Opinion
How many intervals on y-axis in the process of quantization.



→ all are digital systems but different
→ 2 levels.
binary digital signal.

all are digital signals.

~~∴ digital signal is 0 & 1~~ wrong notion.

Every binary is digital but the converse is not true.

Where do I process this ~~system~~ signal?
→ system → hardware + software

system – consists of various components.

process it in a system.

system → Hardware, Software (algorithm), Both.

A Signal is ~~but~~ not hardware or software.
A signal is a physical quantity (a f^n with some ~~phy~~ dependent & independent variable)

→ hardware fragrance → signal
$\boxed{\text{soap}}$ ~ $\boxed{\text{soap}}$ human.

NOTE: when the form of signal & system is different how do we integrate them to ~~come~~ to work together?

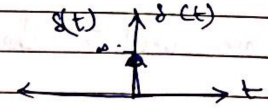
Impulse – ~~an~~ the duration of an instant
impulse response – it is a way to describe & characterize different systems.
A ~~way~~ └→ one of the ways.

Non-quantifiable
intensity of the pain – un-quantifiable (cannot be measured) tending to ∞ for an instant.

Impulse –
intensity $\to \infty$ & duration $\to 0$.

$$\boxed{\begin{array}{l} \delta(t) = \infty \\ \text{when } t = 0. \\ \& \ \delta(t) = 0 \\ \text{when } t \neq 0. \end{array}} \quad (1)$$

→ impulse at an instant pain is unbearable. Not anywhere.



over before you can measure intensity. tending to zero. tending to infinity.

if width of pulse $\xrightarrow{\text{tends to}} 0$
~~an~~ ⇒ height of pulse $\to \infty$.

if width = quantifiable. height ~~=~~ not ∞ anymore.
} width = finite, height = ∞. physically not feasible.

Let us standardise the pulses.

$$\boxed{\int_{-\infty}^{\infty} \delta(t)\, dt = 1} \quad (2)$$

← ~~to~~ width & height have constraints such as.

if (1) & (2) both satisfied it is an unit impulse system conceive perceive.

Dirac

Unit step signal

Ramp signal

These various responses are used to characterise systems.

4. What is the utility of impulse response? & physical ~~response~~ of response.

Foot notes

#1 How to decide ~~member~~ number of samples / interval of samples on x-axis for a given signal to convert to CT to DT.

#2 How many intervals to take on y-axis for quantization from DT to digital.

#3 Every binary digital but the converse is not true.

The form of a system is a hardware / software combination of both.

A signal can't be categorised in the same way its is only a physical quantity.

#4 When the form of signals and systems are different, how do we integrate them to work together

#5 What is the utility of the impulse response and physical significance of the impulse.

A: To characterise different systems

#6 What to do with the impulse response so as extract info from ~~digits~~ our i/p ↑ signal

system representation

Types of signals –

1. impulse
2. step
3. ramp.
4. parabolic.

They are like Hi hello how are you...
They are used to characterise a signal.

System is characterised on the basis of impulse response. or we can use any of the above signals.

These signals are testing signals. i.e. to see if the system is working or not.

What to do with the impulse response

$x[n-k]$ → no. of participants at a line

↑

~~Total no. of participants~~ nth participant.

1199 1119

$\sum_k h(k) \times x[n-k]$. ???

Fashion show

Ans to #6

Processes involve :– to extract info. from signal using impulse response

1. flip / queue/line up – $x(-k)$ is
2. moving / translation / shifting — $x[n-k]$ → people in line that are coming.
3. integrating → multiplication → $h(k) \times x[n-k]$
4. adding (aggregating marks)

↳ $\sum_k h(k) \times x[n-k]$

k ← how many samples are there.

impulse : judge is sitting — participants are walking

or $x(k)$ $h(n-k)$

Ask Sir — doubt

$h(1)\ \ x(1)$

$h(2)\ \ x(1)$.

$h[k]$. $\ x[n-k]$

2   1   3.

1   1 k [$h(1)\ \ x[1]$

2   1 $h(2)\ \ x(1)$.

1   2

$n=3$ 2   2

$k=0,1,2$ 1   3

2   3.

1, 1

1   2

1   3

2   1 ✓

2   2 ✓

2   3 ✓

$x[1]$

$x[2]$

$\sum_k x[k]\, h[n-k]$,

$n=1$ $n=2$. $x[1]\, h[2]$

$n=3$

$\sum_k h[k]\, x[n-k]$ $k=1, 2$.

$h[1]\ \ x[2]$,

$h[2]\ \ x[1]$.

$$\boxed{\begin{matrix} h[1] & x[1] \\ h[2] & x[1] \end{matrix}}$$

$$\boxed{\underline{\text{eq}^n}\ \ \sum_k h[k] \times x[n-k]}$$

Real signal interacts with the system. no need of changing the signal in the form of system. We can just use impulse response, step response, etc.

$y[n] = \sum_k h[k]\, x[n-k]$. ($y[n]$: processed signal; $h[k]$: impulse response; $x[n-k]$: signal i/p)

or $y[n] = \sum_k x[k]\, h[n-k]$

Output depends on the system and the input

h represents the system & system i/p.

$x[n]$. const →

Constant	change	change
$h[k]$	$x[n]$	$y[n]$

We ~~are either sure of the information~~ in the i/p ~~signal or the system~~.

Analysis vs. synthesis

Analysing a system — i/p system given, you don't know what info is in the signal, finding out this. you just know system is capable of processing it.

diff i/p → $\boxed{\text{system}}$ → diff o/p

Synthesising or designing a system. ~~what are~~ i/p o/p pair is given, design system

knowing & cont i/p → $\boxed{\text{system}}$, favourable / desired o/p

different systems are possible (more than one) when o/p is unique

Write a comment on which part they would like to be?

⇒ synthesis & designing.

$y[n] = \sum_k h[k]\, x[n-k]$.

	J_1	J_2	J_3	
$P_3\ P_2\ P_1$				$h(1)$ $J_1 \cdot P_1$
$P_3\ P_2$	P_1			$J_1 \cdot P_2 + J_2 P_1$
$P_4\ P_3$	P_2	P_1		$J_1 P_3 + J_2 P_2 + J_3 P_1$
P_4	P_3	P_2	P_1	
	P_4	P_3	P_2	P_1

$J = h(n) = [1\ 2\ 3]$
$P = x(n) = [4\ 5\ 6\ 7]$.

why → 7654?

$x_1\ x_2\ x_3\ x_4$	h_1	h_2	h_3	
	1	2	3	$1 \times 4 =$
7 6 5 4 →				$1\times5 + 2\times4 =$
7 6 5	4			$1\times6 + 2\times5 + 3\times4 =$
7 6	5	4		$1\times7 + 2\times6 + 3\times5 =$
7	6	5	4	$2\times7 + 3\times6 =$
				$3\times7 =$

$y(n) = \sum_k h(k)\, x(n-k) = ?$

5-3. $n-k=4$. $n=5$

ed	1 2 3.	
3 4 ~~4 3 2 1~~	4×1	$h(1)\, x($

Synthesis – sol^n of synthesis ⇒ system ⇒ not unique.
unique o/p ⇒ System is not unique.
synthesis is not unique.

Analysis –
system is unique.
analysis is unique.

Make something of your own.

	h_1	h_2	h_3.
$x_1\ x_2\ x_3\ x_4$			$h(1)x(4)$

	h_1	h_2	h_3	
$x_1\ x_2\ x_3\ x_4$				$k=1$
$x_1\ x_2\ x_3$	x_4			$h(1) \times x(4)$. $n-k=4$ $= n \Rightarrow 5$
	x_3.	x_4		$h(1)\, x(3) + h(2)\, x(4)$
				$n=4$. ↳ $n=6$.

The equation cannot be applied

The eq^n can be applied to an unbiased and where the o/p does not depend on the time which the i/p is applied.

Flip shift and multiply and add ⇒ ~~convolution~~ convolve.
↳ It is the process of convolution.

Process of convolution ~~used~~ for to extract information from the actual / i/p signal.

This process of convolution cannot be applied to a systems with biases.

i/p → $x[n]$ $x[n]$.
o/p → $y[n]$

$$y[n] = x[n] - \underbrace{2}_{\text{bias}}$$

x ~~5~~ → gives 10 y receives $\underline{\underline{8}}$
can y give back ~~$\$$~~ 10rs? No

bias → non-linear
unbiased → linear.

You cannot apply convolution to a non-linear system.

~~The time at which i/p~~ Time variant —

Convert

4 words ① The o/p varies / depends on the ~~the~~ time at which the i/p is applied.

②③ Convolution can only be applied when the system is linear and time invariant.

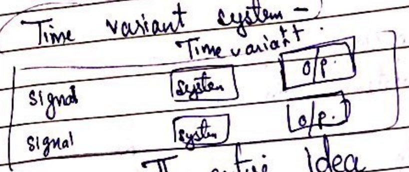
The 4 step process: LTI system — linear Time invariant system.

What is linearity? → unbaised system.

2 different cases! The o/p changes with time.

The o/p changes with time that the ~~...~~ i/p is applied.

Time variant system



The entire Idea

↳ impulse response } cannot

General question

→ How can we ~~...~~ use a biased system to extract information

---

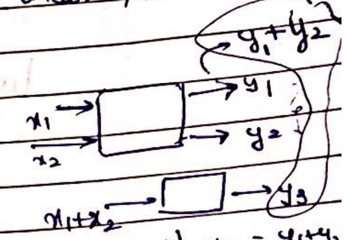
Time variant —

The o/p varies on the time at which i/p is applied.

Convolution can be applied only on LTI system linear Time invariant system.

Which process can we use to ~~ext~~ ~~on~~ with a NL TV → ~~yes~~

How do I test a system is linear, non linear or time variant time invariant



Superposition Theorem

$y_{Total} = f(x_1 + x_2) = y_1 + y_2$

if $y_3 = y_1+y_2$ linear system

Principle of homogeneity:

i/p scaled o/p is also scaled.

Such a system is called ~~non~~ linear system.

① $y[n] = 2\,x[n]$

or differential eq^n or difference eq^n → eq^n that describe a system or give the relation between the i/p & o/p

a- In discrete / digital system ⇒ difference eq^n

In Continuous domain ⇒ differential eq^n

$y[n] = \alpha x[n]$

$y[n_1] = 2x[n_1]$
$y[n_2] = 2x[n_2]$.
$y[n_1] + y[n_2] = 2(x[n_1] + x[n_2])$

$2x[n_1 + n_2] = y[n_1 + n_2]$

$y[n] = 2x[n]$
$y[n_1] = 2$

Linear system $\rightarrow$ additivity & Homogeneity
superposition
(scaling)

if $x_1(t) \rightarrow y_1(t)$
$x_2(t) \rightarrow y_2(t)$ then

$x_1(t) + x_2(t) \rightarrow y_1(t) + y_2(t)$.

$a x_1(t) \rightarrow a y_1(t)$

Linear if
$a x_1[n] + b x_2[n] \rightarrow a y_1[n] + b y_2[n]$

$y[n] = 2x[n]$
$x_1[n]$ $x_2[n]$ o/ps. $y_1[n]$ $y_2[n]$.

let third i/p $x_3[n]$

$y_1[n] = 2x_1[n]$
$y_2[n] = 2x_2[n]$
$y_3[n] = 2x_3[n]$.

$x_3[n] = x_1[n] + x_2[n]$

$\therefore y_3[n] = 2(x_1[n] + x_2[n])$

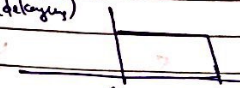
$y_1[n] + y_2[n] = 2(x_1[n] + x_2[n])$

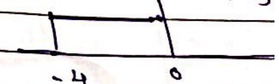
$\therefore y_3[n] = y_1[n] + y_2[n]$
Hence linear.

x(t)

-2 0 2

amplifier
1. $y[n] = 2x[n]$ Ek ka do.
2. $y[n] = x[n-1] \rightarrow$ shifted kal aana (delaying)
3. $y[n] = x[n] - 4$ (Commission)

x(t-2)

0 4

x(t+2)

-4 0

When a difference eqn consists a constant it is called non-linear.

op-amp with offset,
Op-amp, C,
inductor / capacitor with an initial charge $\rightarrow$ non-linear
current
(charged capacitor gives rise to voltage).

inductor / capacitor with no initial charge $\rightarrow$ linear

delays –
eg. buffer, delay flip flop

Can a timer circuit IC555 be eg. of delay
w

4. $y[n] = \log(x[n])$ → openly contain log non linear f^n — where have we used it?

$y_1[n] = \log(x_1[n])$
$y_2[n] = \log(x_2[n])$

$= \log(x_1[n]) + \log(x_2[n])$.

$y_3[n] = \log(x_1[n] + x_2[n])$.

$y[n] = \left.\begin{array}{l} \cos(x[n]) \\ \sin(x[n]) \\ \tan[x[n]] \end{array}\right\}$ non linear

5. $y[n] = n\,x[n]$
$y_1[n] = n\,x_1[n]$
$y_2[n] = n\,x_2[n]$
$y_1[n] + y_2[n] = n(x_1[n] + x_2[n])$

$y_3[n] = n\,x_3[n]$
$= n\,(x_1[n] + x_2[n])$

6. $y[n] = x[n]$

$y_1[n] = x_1^2[n]$.
$y_2[n] = x_2^2[n]$.
$y_1[n] + y_2[n] = x_1^2[n] + x_2^2[n]$

$y_3[n] = (x_1[n] + x_2[n]) =$

7.) $y[n] = x^2[n]$
⇒ $y[n] = x[n] \cdot x[n]$
coefficient is non linear $x[n]$ ∴ the system is non-linear.

8.) ~~if the coefficients~~
$y[n] = \sin(n) \cdot x[n]$
linear.
$y_1[n] = \sin(n)\; x_1[n]$.
$y_2[n] = \sin(n)\; x_2[n]$.
$y_3[n] = \sin[n]\; [x_1[n] + x_2[n]]$

9.) → $y[n] = x^3[n]$
non linear.

$y = x^2[n]$
$y = x^3[n]$

$y = n^2\, x[n]$.
$y = n\, x[n]$
$y = \sin(n)\, x[n]$

~~coe~~

coefficient f^n of time — coefficients are time dependent.

~~such a coef~~ implicit f^n of time — explicit f^n of time.

put n get $x[n]$. ↳ after this find $x[\,]$ value. — put n get a numerical value

non-linear — linear

Two types of coefficient —
→ implicit f^n of time
→ explicit f^n of time

→ ~~sys~~

→ ~~term is openly non-linear~~

→ ~~coeficients are const are~~

Test of linearity -

For systems to be linear - eg. $y[n] = x[n] + 3$

① → system eq^n should not have constants

② → terms should not be openly non-linear any thing that has a series expansion

③. → coefficient should not be implicit f^n of time

↳ $y[n] = x^3[n]$

1. should not contain any constant
2. should not contain any
3.

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \cdots$$

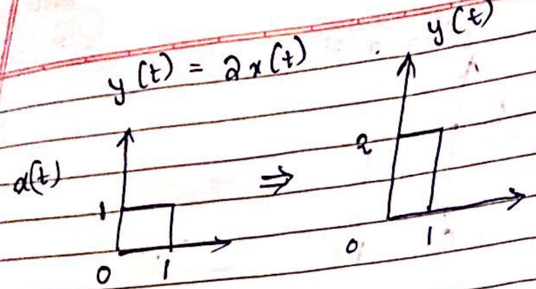
$$\cos(x) = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \cdots$$

$$\exp(x) = \frac{x^0}{0!} + \frac{x^1}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots$$

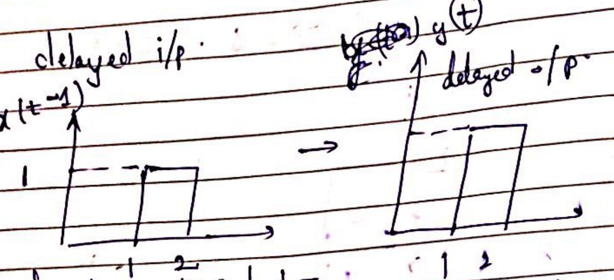
$$\log(x+1) = x - \frac{x^2}{2} + \frac{x^3}{3}$$

Scanned with CamScanner

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



delayed i/p



O/p depends on time but –
o/p does not depend at which the time at which
the i/p is applied.

$y[n] = 2x[n]$ → Time invariant system
$y[n] = n\,x[n]$ → Time variant.
↳ o/p depends at which the time at which the i/p is applied.

$y[1] = x[1]$
$y[2] = 2x[2]$
$y[3] = 3x[n]$

$y[n] = 2x[n]$ → T.I (Time invariant)
$y[n] = x[n-1]$ → T.I
$y[n] = x[n] - 4$ → T.I
$y[n] = \log(x[n])$ → T.I
$y[n] = n \cdot x[n]$ → T.V. (Time variant)

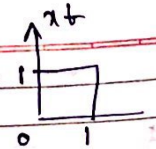
$y[n] = x^2[n]$ → T.I.
$y[n] = \sin(x[n])$ → T.I.

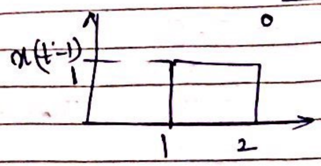
$y[n] = \sin(n)\,x[n]$ → Time variant system.
$\sin(1)\;x[1]$
$\sin(2)\;x[2]$
$\sin(3)\;x[3]$

$y[n] = 2x[n]$
coefficient → constant.

- If the coefficient of system eq^n are explicit then the system is time variant.

Ex. for time invariant –
→ coefficient must be implicit f^n of time or constant.

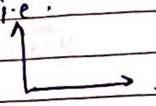




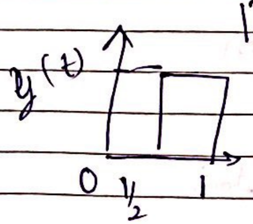
For time invariant
→ 1 unit se delay kiya
y(t) bhi 1 se delay hona chahiye.

O/p $y(t)$ → system

i.e.



$2t = 1$
$\Rightarrow \boxed{t = 1/2}$.
$2t = 2$
$\boxed{t = 1}$



System is Time variant →
→ ~~implicit~~ explicit coefficient of time
→ time scaling

Time invariant –
→ Coefficient should NOT be explicit f^n of time
→ No time scaling.

For the system to be LTI :
(1) System eq^n should not have constants
(2) Terms should not be openly Non-linear i.e. anything that has a series expansion.
(3) Coefficient should be const. or not dependent on time
(4.) No time scaling.

		L/NL	TimeV/IV
1.)	$y[n] = 2x[n]$	L	I.V.
2.)	$y[n] = x[n-1]$	L	I.V.
3.)	$y[n] = x[n] - 4$.	N.L.	I.V.
4.)			
5.)			
6.)			
7.)	$y[n] = 2x[n]$		
8.)	$y[n] = x^2[n]$	N.L.	T.I.V.
9.)	$y[n] = x[n]$		
10.)	$y[n] = n\,x^3[n]$	N.L.	V
11.)	$y[n] = n\,x[n]$	L	V.
12.)	$y[n] = \sin(x[n])$	N.L.	I.V.
13.)	$y[n] = \sin(n)\,x[n]$.	L	[illegible]
14.)	$y[n] = x[n^2]$	L	V
15.)	$y[n] = x[n^{0.5}]$	L	V.

4:30

$x[1] \rightarrow x[1]$
$x[2] \quad [x^4]$
$x[3] \quad x[9]$.

$\omega = 2\pi f$

Complex Exponentials

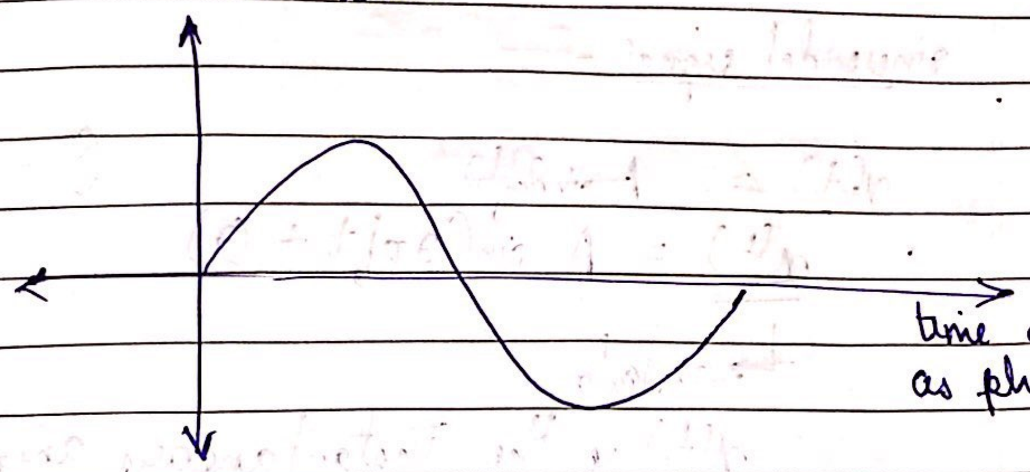
$$A \sin(\omega t)$$

max amplitude $= A$

phase $= \omega t$

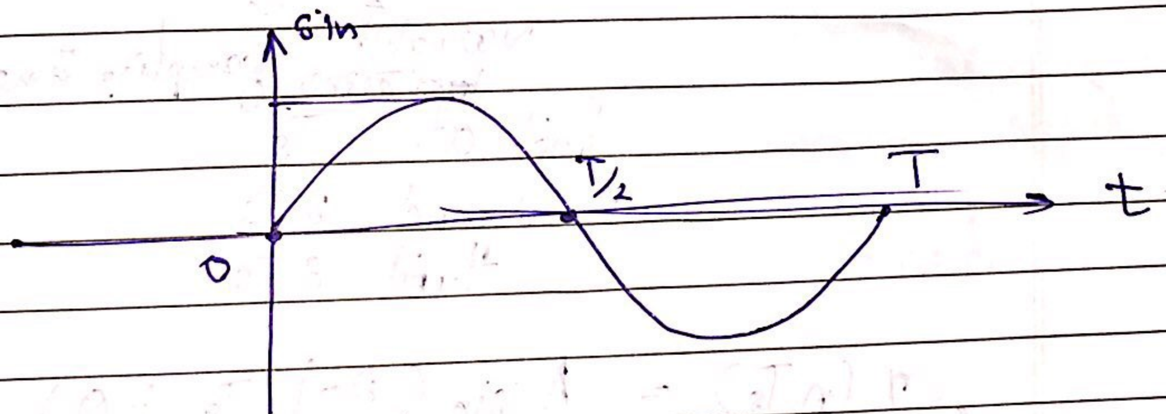
- instantaneous phase

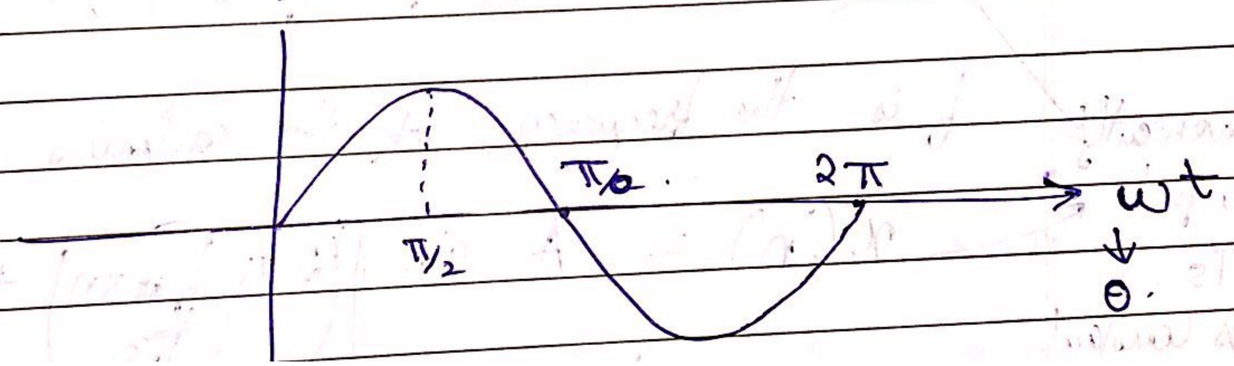
sine wave



Assumed that ω is constant because frequency is const

$\therefore$ whether you plot ωt or t both





frequency -

instantaneous amplitude
instantaneous frequency

sinusoidal signal -

$\cancel{x(t) = A \sin 2\pi f t ?}$

$x(t) = A \sin(2\pi f t + \theta)$ θ = phase const.

↳ instantaneous

$x(t)$ is the instantaneous amplitude.

Sample it → $t = n T_s$
variable ~~horizontal~~ 0. sampling time
first at T_s
Second $2 T_s$
third $3 T_s$.

$x(nT_s) = A \sin(2\pi f n T_s + \theta)$

f is the frequency of the continuous signal.

Conveniently drop T_s is constant

$x'(n) = A \sin\left[\left(2\pi \frac{f}{f_s} \times n\right) + \theta\right]$.

but in the right hand side you cannot drop 'T_s' because 'nT_s' together determines what value of sin at that moment.

$\omega = 2\pi f$
radial freq. ↳ linear freq.

sinusoidal signal

[Nyquist Theorem - (next session)] ?.

$F = \frac{f}{f_s}$

$x(n) = A \sin(2\pi F n + \theta)$
↳ instantaneous amplitude of the sampled signal.

A = max amplitude of sine signal.

t ~~f~~ n are
$x(t) = A \sin(2\pi f t + \theta)$
$x(n) = A \sin(2\pi F n + \theta)$

?

n & t are independent variable with [same unit]?
unit → (Hz)

f → frequency of the continuous sinusoidal signal.

F → frequency of the sampled sinusoidal signal.
↳ does not have a unit!
Not all frequencies ~~are~~ have units.

$F = \frac{f}{f_s}$

$f_{s_{max}} \to \infty$.
$\therefore F = 0$

$f_{s_{min}} = 2f$ → Nyquist.
$F = 0.5$ → lowest be 0.

$\therefore$ ~~$0 \le |F| \le 0.5$~~ $-0.5 \le F \le 0.5$

~~for~~ $|F|$ because F can take -ve and +ve values.

$F_{min} = 0, \quad F_{max} = \pm 1/2$

$0 \leq |F| \leq 1/2$

Now $\omega = 2\pi f$

if we multiply 2π by F.

$\therefore \Omega = 2\pi F$

① For $c(t)$ –

$-\infty < F < \infty$

$f_{min} = 0 \quad f_{max} = \pm\infty$

unit → Hz

$\omega_{min} = 0 \quad \omega_{max} = \pm\infty$

② For $d(t)$ ↔ digital?

$F_{min} = 0, \; F_{max} = \pm 1/2$

unitless.

$\Omega_{min} = 0 \quad \Omega_{max} = \pm\pi$

harmonic signal – dealing with frequency. all sine, cosine

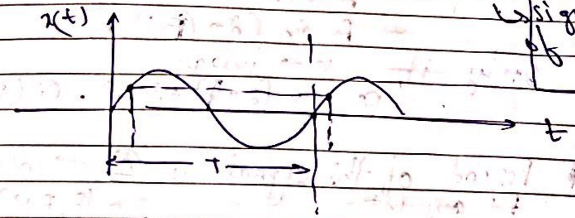
A continuous harmonic signal is always periodic.

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

$x(t+T) = A \sin(2\pi f (t+T))$
$= x(t)$

T can be any realty number.

def: if two amplitudes at two different times are the same at a given frequency then signals are periodic in time.



signal is a fn of time at a frequency.

$x(n) = A \sin(2\pi F n)$

if $x(n+N) = x(n)$???

$N \Rightarrow$ integer always.

$x(n+N) = A \sin(2\pi F (n+N))$
$= A \sin(2\pi F n + 2\pi F N)$

$\sin(A+B)$
$\sin A \sin B + \cos A \cos B$

$= A \sin(2\pi F n)$

if and only if (iff) $FN = k$ integer

i.e. $x(n) = x(n+N)$ in time!

iff $F = \frac{k}{N}$

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

if you want the digital signal to be periodic.

$\therefore$ F should be a $\boxed{\text{ratio of two integers}}$

signal as f^n of frequency at a time

let $x(n) = A\sin(2\pi F n)$

Consider $(F+1) = F_2$

$x(n) = A\sin(2\pi F_2 n)$
$= A\sin(2\pi (F+1) n)$
$= A\sin(2\pi F n + 2\pi n)$

$x(n) = A\sin(2\pi F n)$
$= A\sin(2\pi (F+1) n)$

Only if $n \to$ integer

$\therefore \sin(2\pi F n + 2\pi n) = \sin(2\pi F n)$

Period of this signal is (1) $\to 2\pi$

$(F, F+1)$

F+ any int

(n) Amplitudes are same at two diff frequencies at a given time

These signals are periodic in frequency! ↳ basic variable is diff!

F+ any int ⇒ same in frequency

$x(n) = A\sin(2\pi (F+m) n)$

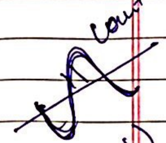
$x(n) = A\sin(2\pi F n + 2\pi m n)$

c(t)	d(t)
$f \to$ unit (Hz)	$F \to$ unitless
$-\infty < f < \infty$ min = 0	$-0.5 < F < 0.5$ min = 0 or $-\pi < F < \pi$

c(t) are always periodic in time with period $T = \frac{1}{f}$

d(t) for d(t) to be periodic in $F = \frac{k}{N}$

frequency if should be a ratio of integers


cont.
(F+1)

c(t)	d(t)
$f \to$ unit (Hz)	$F \to$ unitless
$-\infty < f < \infty$ min = 0	$-0.5 < F < 0.5$ min = 0 or $-\pi < F < \pi$
	For d(t) to be periodic in $F = \frac{k}{N}$

d(t)

sind → frequence two signals

d(t) want to be $F = 1$

d(t) → Time Condition $(F = k/N)$

d(t) → frequency (always)

c(t) → Time (always) $1/F$

$f = 0.3$

$f = \frac{1.3}{3.3}$

frequency are diff but not diff

$\rightarrow x(t) = \cancel{A\sin}\ 2\sin\left(2\pi\, 50\, t\right)$, $2\pi f t$

digital version

$f_s = 100\ Hz$.

$\rightarrow$ digit $x_1(n) = 2\sin\left(2\pi \frac{50}{100} n\right)$

$= 2\sin\left(2\pi\, 0.5\, n\right)$ ①.

$\rightarrow x(t) = \sin\left(2\pi\, 300\, t\right)$.

$f_s = 600\ Hz$.

$x_2(n) = \sin\left(2\pi \frac{300}{600} n\right)$

$= \sin\left(2\pi\, 0.5\, n\right)$, $0.5 = F$

reconstruction is impossible

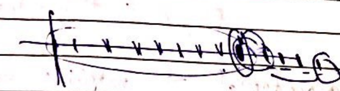
So we will not use this for d(t) reconstruction.

sampling depends on the nature of the signal.

convolution -

o/p signal = i/p signal + impulse response - 1

$h[1] = 1$ $h[2] = -0.5$ $h[3] = -0.1$ $h[4] = 0$.



c(t) (harmonic)	d(t) (harmonic)
$f \rightarrow$ unit (Hz)	$F \rightarrow$ unitless
$-\infty < f < \infty$ with $f_{min} = 0$	$-0.5 < F < 0.5$ $F_{min} = 0$ or $-\pi < F < \pi$
c(t) are periodic in time with period $T = 1/f$	They are not always periodic in time. d(t) are periodic in time iff F $\left(F = \frac{k}{N}\right)$ is a ratio of two integers.
c(t) are always periodic in time.	d(t) are always periodic in frequency with a period of 2 i.e. 2π.

different and distinct.

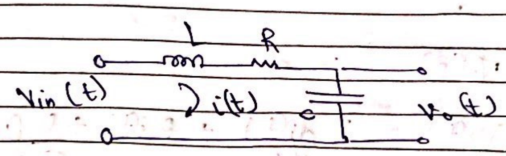
In ~~dt~~ c(t), two frequencies are always different & distinct.

In d(t), two frequencies are ~~not~~ always different but not distinct.

Sets – simultaneous
quadratic polynomial.
transcedental
polynomial differential

In transcedental → infinite number of terms.
polynomial → finite no. of terms.

$$a_0 x^n + a_1 x^{n-1} + a_2 x^{n-2} + \cdots + a_{n-1} x = 0.$$



$$V_{in}(t) = A \sin(2\pi f t)$$

$$V_{in}(t) = L\frac{di(t)}{dt} + R\,i(t) + \frac{1}{C}\int i(t)\,dt.$$

$$V_o(t) = \frac{1}{C}\int i(t)\,dt$$

$$\frac{d\,V_{in}(t)}{dt} = L\frac{d^2 i(t)}{dt} + R\frac{di(t)}{dt} + \frac{1}{C}\,i(t).$$

$$\frac{d^2 i(t)}{dt} + \frac{R}{L}\frac{di(t)}{dt} + \frac{1}{LC}\,i(t) = \frac{dV_{in}(t)}{dt}.$$

$$\frac{-b \pm \sqrt{b^2 - ac}}{2a}.$$

$$i^2 + \frac{R}{L}i + \frac{1}{LC} = 0.$$

$$\cancel{\frac{-\frac{R}{L} \pm \sqrt{\frac{R^2}{L^2} - 1 \times \frac{1}{LC}}}{2}}$$

$$\cancel{-\frac{R}{2L} \pm \frac{1}{2}\sqrt{\frac{R^2}{L^2} - \frac{1}{LC}} = 0.}$$

$$\frac{di}{dt} = -\frac{R}{2L} \pm \frac{1}{2}\sqrt{\frac{R^2}{L^2} - \frac{1}{LC}}.$$

$$y = C_1 e^{ax} + C_2 e^{-bx}.$$

$$\frac{d\,V_1(t)}{dt} = L\frac{d^2 i(t)}{dt^2} + R\frac{di(t)}{dt} + \frac{1}{C}\int i(t)\,dt$$

$$V_2(s) = s$$

$$V_i(t) = L\frac{di(t)}{dt} + R\,i(t) + \frac{1}{C}\int i(t)\,dt \quad \text{—(1)}$$

We want to convert a differential eq^n to a set simultaneous eq^n

$$V_o(t) = \frac{1}{C}\int i(t)\,dt \quad \text{—(2)}$$

$$\frac{d}{dt}V_o(t) = \frac{1}{C}\, i(t)$$

$$\frac{dV_i(t)}{dt} = L\frac{d^2 i(t)}{dt^2} + R\frac{di(t)}{dt} + \frac{1}{C}\int i(t)$$

$$V_2(s) = s\,L\,I(s) + R\,I(s) + \frac{1}{Cs}$$

$$V_o(s) = \frac{1}{Cs}$$

What is the utility of Laplace transform?
→ to convert a differential eq^n into a set of simultaneous eq^n

For discrete
(1) Compare and contrast process for continuous time case. Illustrate difference with eg.

For dis

→ A capacitor integrates
→ an inductor differentiates
→ resistor scales

an inductor can be used to differentiate or integrate depending on which f^n, admittance or impedance.

What is differentiation?

first principle $f'(x) = \lim_{h\to 0} \frac{f(x+h) - f(x)}{h}$

$$f(x) = 4x$$

physical problem: How much the dependent variable changes when the independent variable changes.

mathematical → $f'(x) = \lim_{h\to 0} \frac{f(x+h) - f(x)}{h}$ or $\lim_{h\to 0} \frac{f(x) - f(x-h)}{h}$

$h \to 0$ because x is in continuous domain. The two ~~continuous~~ consecutive numbers are '$x, x+h$' or $x-h, x$ where $\lim_{h\to 0}$.

For discrete time,

$$y[k] = \sum_{k} x[k]\, h[k-k]$$

For continuous time,

$$y(t) = \sum_{\tau} x$$

In discrete time,

The consecutive nos. are x & $x+h$ where $h=1$

derivation of $f(x)$ in digital domain –

$$f'(x) = f(x+1) - f(x)$$

or $f(x) - f(x-1)$

$$f'(x) = f(x) - f(x-1)$$

present – what ever you had earlier

$$f''(x) = [f(x) - f(x-1)] - [f(x-1) - f(x-2)]$$

$$f''(x) = f(x) - 2f(x-1) + f(x-2)$$

What is $f'(x) = f(x) - f(x-1)$ & $f'(x) = f(x+1) - f(x)$?

→ They are taking the derivative.

Are they same?

numerically they might be different.

What should we take? which eq^n?

future – what you have.

→ $\boxed{\begin{array}{l} \text{Forward difference} \rightarrow f'(x) = f(x+1) - f(x) \\ \text{\& Backward difference} \rightarrow f'(x) = f(x) - f(x-1) \end{array}}$

what – past you have.