Chapter-03
Basic system properties

$$\text{i/p} \rightarrow x(t) \longrightarrow \boxed{\text{sys.}} \longrightarrow y(t) \longrightarrow \text{o/p}$$

$y(1)$ $y(t)$
- $\rightarrow x(t-1) = x(0) \rightarrow$ Past
- $\rightarrow x(t) = x(1) \rightarrow$ Present
- $\rightarrow x(t+1) = x(2) \rightarrow$ Future

1) Static & dynamic sys. →

Static → If o/p of sys. depands only on present values of i/p at each & every instant of time then sys. will be static.

* These sys. are also known as memoryless system.

Dynamic → * If o/p of sys. depands on past (or) Future values of i/p at any instant of time then sys. will be dynamic.

* This sys. are also known as sys. with memory.

Q → Check static/dynamic sys.

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

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

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

(4.) $y(t) = x(t-1)$

(5.) $y(t) = \text{Even}[x(t)]$

(6.) $y(t) = \text{Real}[x(t)]$

(7.) $y(t) = \int_{-\infty}^{t} x(z)\,dz$

(8.) $y(t) = e^{-(t+1)} x(t)$

Ans → (1.) Dynamic.

(2.) Dynamic.

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

$y(-\pi) = x(0)$

$-3.14\,\text{sec} = x(0)$ Future — system is dynamic.

(4.) Dynamic

(5.) $y(t) = \dfrac{x(t) + x(-t)}{2}$

$(t=1)$

$y(1) = \dfrac{x(1) + x(-1)}{2}$ past — system is dynamic.

(6.) $y(t) = \dfrac{x(t) + x^*(t)}{2}$ system is static

(7.) ... system is dynamic

Note →

(1.) Integral & derivative sys. are dynamic sys.

(2.) In case of time scaling (or) time shifting system will be dynamic.

(2.) Causal & Non-Causal System →

* **causal →** * If o/p of sys. is independant of future values of i/p at each & every instant of time then sys. will be causal.
* This sys are practical (or) physicaly relisable sys.

Eg:- (1.) $y(t) = x(t)$

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

(3.) $y(t) = x(t) + x(t-1)$

* **Non-Causal system →** * If o/p of sys. depends on future values of i/p at any instant of time then sys. will be non-causal.

Eg:- (1.) $y(t) = \underline{x(t+1)}$

(2.) $y(t) = x(t) + \underline{x(t+1)}$

(3.) $y(t) = x(t+1) + \underline{x(t+1)}$

(4.) $y(t) = x(t) + x(t-1) + \underline{x(t+1)}$

* **Anti Causal System →** * If o/p of sys. depends only on future values of i/p then sys. will be anticausal.

Eg:- $y(t) = x(t+1)$

* All anti-causal systems are non-causal but converse of this statement is not true.

Que. → Check Causal & Non-Causal system.

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

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

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

(4.) $y(t) = \begin{cases} x(2t) \,; & t<0 \\ x(t-1) \,; & t \geq 0 \end{cases}$

(5.) $y(t) = \text{odd}[x(t)]$

(6.) $y(t) = \sin(t+2) \cdot x(t-1)$

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

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

(9.) $y(t) = \int_{-\infty}^{2t} x(\tau)\, d\tau$

Sol^n → (i.) $y(t) = x(2t)$

$(t=1)\downarrow$

$y(t) = x(2)$ (System is non-causal)

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

$(t=-1)$

$y(-1) = x(+)$ (System is Non-causal)

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

$(t=-\pi)$

$y(-\pi) = x(0)$

$-3.14 = x(0)$ (System is non-causal)

(iv) $y(t) = \begin{cases} x(2t), & t<0 \longrightarrow \text{past} \\ x(t-1), & t\geq 0 \longrightarrow \text{past} \end{cases}$

(system is causal.)

(v.) $y(t) = \text{odd}\, x(t)$

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

$(t=-1)$

$$y(-1) = \frac{x(-1) - \overset{\text{future}}{x(1)}}{2}$$ (System is non-causal)

(vi) $y(t) = \underset{\text{(Cofficient)}}{\sin(t+2)} \cdot \underset{\text{past}}{x(t-1)}$

(system is causal.)

(vii) $y(t) = \int_{-\infty}^{t} x(\tau)\,d\tau \longrightarrow x(t)$

$= \int_{-\infty}^{t} x(t)$ (System is causal)

(viii) $y(t) = \int_{-\infty}^{(t+1)} x(\tau)\,d\tau \longrightarrow x(t+1)$

(System is non-causal)

(ix) $y(t) = \int_{-\infty}^{2t} x(\tau)\,d\tau \longrightarrow x(2t)$

(System is non-causal)

(3.) Linear & Non-linear system →

linear → * A linear sys. follows the law of superposition.

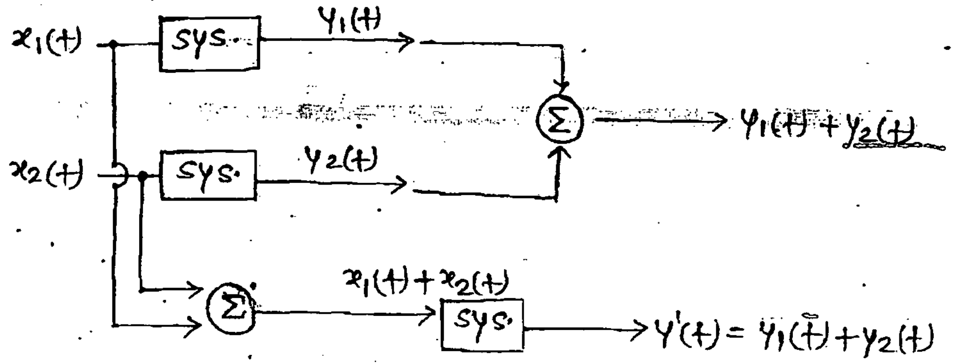
* This law is necessary & sufficient to prove linearity of system.

* It is a combination of two laws:-

(i) Law of additivity.

(ii) Law of Homogenity.

(1.) Law of additivity →



Eg:- $y(t) = x(t)+10$

$o/p = i/p + 10$

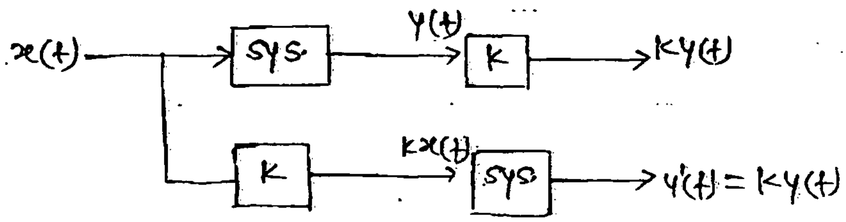
$y_1(t) = x_1(t)+10$

$y_2(t) = x_2(t)+10$ → $x_1(t)+x_2(t)+20$

$y'(t) = x_1(t)+x_2(t)+10$

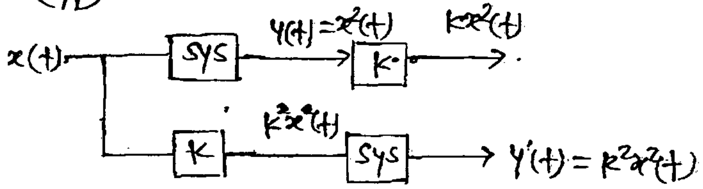
$y(t) \neq y'(t)$ [sys. is NL]

(2.) Law of Homogenity →



Eg:- $y(t) = x^2(t)$

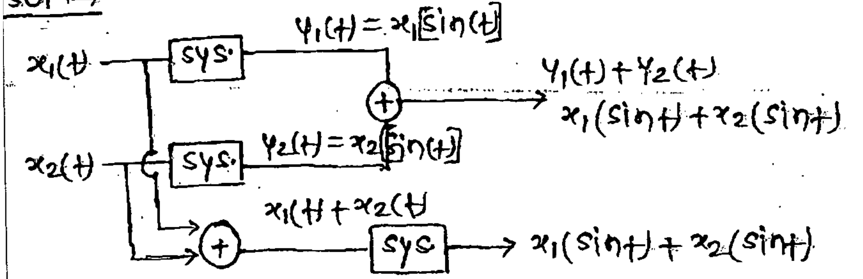
$o/p = (i/p)^2$



Que. → Check linear/Non-linear sys.

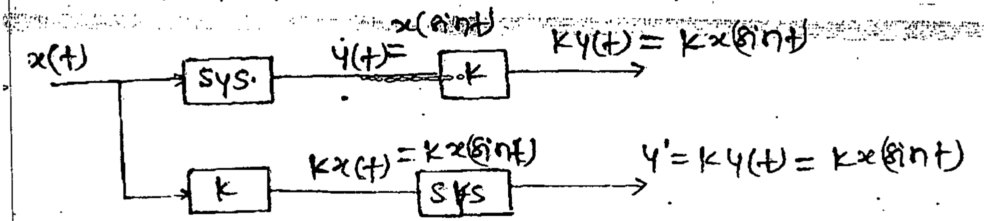
(1.) $y(t) = x(\sin t)$ (2.) $y(t) = x(\tan t)$ (3.) $y(t) = x(t^2)$

Sol^n →



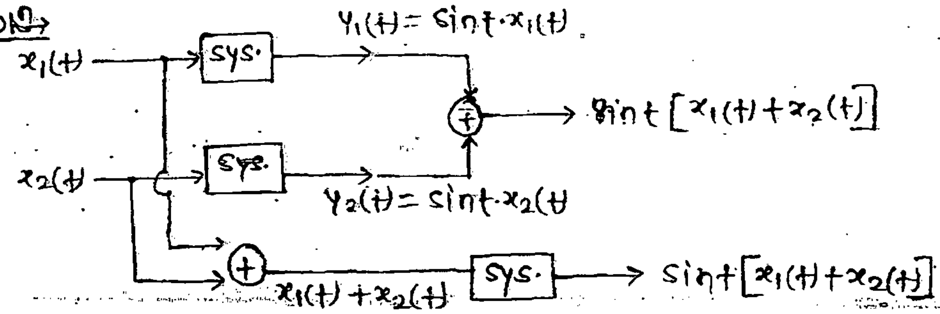
Note →

Linearity of sys. is independant of time scaling.

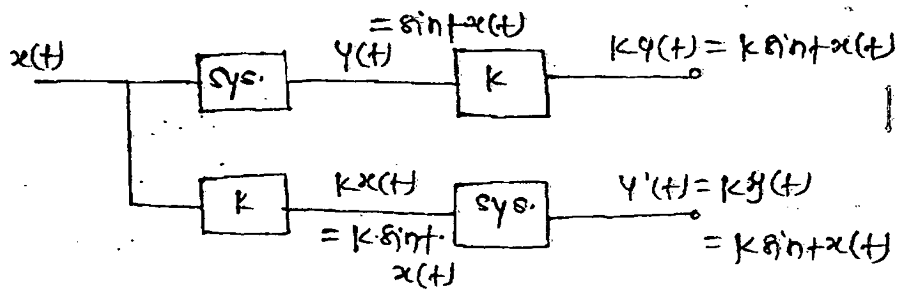


(2.) $y(t) = \sin t \cdot x(t)$ (3.) $y(t) = \log t \cdot x(t)$

Sol^n →



Note:- linearity of sys. is independant of cofficient used in sys. relationship.



2nd method →

For linearity :-

(i) O/p should be 0 for 0 i/p.

(ii) There should not be any 'NL' operation.

eg:- [sin, cos, tan, sec, cosec, cot, ...
log, exponential, modulus, sq., cubes......
.... root, ... Sa( ), sinc( ) ... sgn( ) etc
either on 'x' or 'y'.]

Q.→ Check linear/NL sys.

(i) $y(t) = x(t) + 2$ ⟶ put ($t=0$) then $y(0) \neq x(0)+2$ ⟶ NL

(ii) $y(t) = e^{x(t)}$ ⟶ Because of $e^{x(t)}$ it is NL & also both condn not satisfying.

(iii) $y(t) = x(\tan t)$ ⟶ Linear

(i) If ($t=0$), then $y(0) = x(0)$ means No i/p no o/p

(ii) above fn is not operating on 'x'; it is operating on the 't'.

(iv) $y(t) = \tan[x(t)]$

system is NL

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

i/p ⟶ $\boxed{\text{sys.}}$ ⟶ o/p = $\cancel{\text{past}}$ i/p + $\cancel{\text{future}}$ i/p

No any NL fn so this is linear

(vi) $y(t) = \text{even}[x(t)]$

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

No non-linear operator so linear

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

$$y(\cancel{t}) = \int_{-\infty}^{t} x(\cancel{0})\,d\tau$$ linear

(viii) $y(t) = \begin{cases} x(t-1), & t<0 \\ x(t+1), & t\geq 0 \end{cases} = \begin{cases} \text{past } \cancel{i/p}, & t<0 \\ \cancel{\text{future}}\ i/p, & t\geq 0 \end{cases}$ linear

Note→

(1.) Integral & derivative operators are linear.

(2.) Even & odd operators are linear.

(ix) $y(t) = \int_{-\infty}^{t} x^2(\tau)\,d\tau$

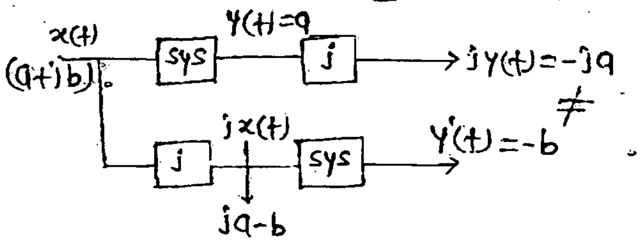
$y(t) = \int_{-\infty}^{t} x^{2}(\tau)\,d\tau$ → NL

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

$y(t)^0 = e^{t}x(t)^0$ linear

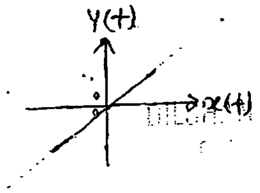
(xi) $y(t) = \text{Real}[x(t)]$

$y(t) = \dfrac{x(t)+x^{*}(t)}{2}$ → NL



Note→ Real & imaginary operators are NL.

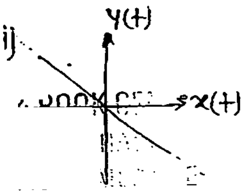
(xii)



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

system is linear

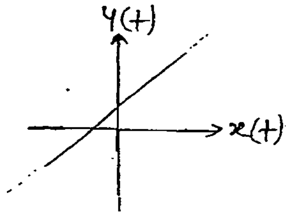
(xiii)



$y(t) = -m\,x(t)$

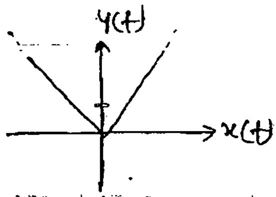
system is (L)

(xiv)



when i/p 0 then we got o/p NL

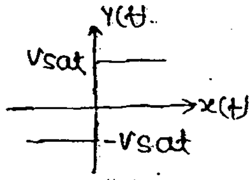
(xv)

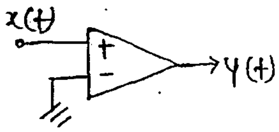


$y(t) = |x(t)|$

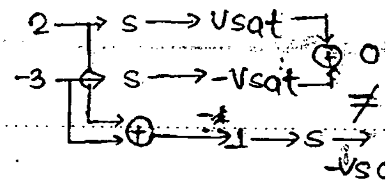
NL

(xvi)



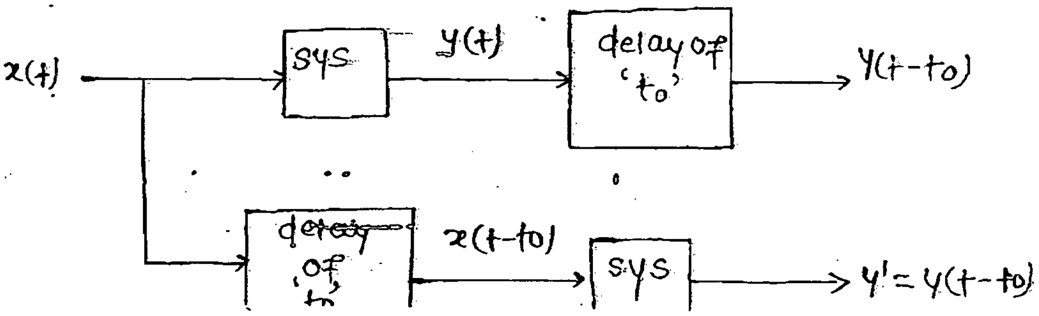


$y(t) = V_{sat}\,\text{sgn}[x(t)]$ → NL (or)



(4) Time invarient & time varient sys.→

Time invarient→



Note:- Any delay provided in i/p must be reflected in o/p for a time invariant system.

Que.→ Check time invarient/varient sys.

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

$$\begin{tikzcd} x(t) \arrow[r] \arrow[dr] & S \arrow[r, "y(2t)=y(t)"] & D \arrow[r] & y(t-t_0) = x[2(t-t_0)] \\ & D \arrow[r, "x(t-t_0)"] \arrow[d] & S \arrow[r] & y'(t) = f(2t) = x(2t-t_0) \\ & f(t) & & \end{tikzcd}$$

system is TV

(2.) $y(t) = x(\cos t)$

Sol^n→

$$\begin{tikzcd} x(t) \arrow[r] \arrow[dr] & S \arrow[r, "y(t)=x(\cos t)"] & D \arrow[r] & y(t-t_0) = x[\cos(t-t_0)] \\ & D \arrow[r, "x(t-t_0)"] \arrow[d] & S \arrow[r] & y'(t) = f(\cos t) \\ & f(t) & & = x[\cos t - t_0] \end{tikzcd}$$

System is TV

Note:- In case of time scaling sys. will be time varient.

(3.) $y(t) = \cos t \cdot x(t)$ (4.) $y(t) = \log t \cdot x(t)$

Sol^n→

$$\begin{tikzcd} x(t) \arrow[r] \arrow[dr] & S \arrow[r, "y(t)=\cos t \cdot x(t)"] & D \arrow[r] & y(t-t_0) = \cos(t-t_0)\, x(t-t_0) \\ & D \arrow[r, "x(t-t_0)"] \arrow[d] & S \arrow[r] & y'(t) = \cos t \cdot f(t) \\ & f(t) & & \cos t \cdot x(t-t_0) \end{tikzcd}$$

system is TV

Note:- If coefficient in sys. relationship is f^n of time then sys. will be time varient.

(5.) $y(t) = \text{odd}[x(t)]$

Sol^n→ $y(t) = \dfrac{x(t) - x(-t)}{2}$

Time scaling (TV)

(6.) $y(t) = CS[x(t)]$

$y(t) = \dfrac{x(t) + x^*(-t)}{2}$

Time scaling (TV)

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

Sol^n → $y(t) = x(t-1) + x(t+1)$

No scaling

coefficient are indepandant of time so TIV

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

Sol^n → $y(t) = \int_{-\infty}^{t} x(\tau)\,d\tau \rightarrow x(t)$

TIV

(ix) $y(t) = \int_{-\infty}^{3t} x(\tau)\,d\tau$

Sol^n → $y(t) = \int_{-\infty}^{3t} x(\tau)\,d\tau \rightarrow x(3t)$ (TIV)

(x) $y(t) = \int_{-\infty}^{t} \cos\tau \cdot x(\tau)\,d\tau$

Sol^n → $y(t) = \int_{-\infty}^{t} \cos\tau\, x(\tau)\,d\tau \rightarrow \cos t\, x(t)$ (TV)

(xi) $y(t) = \begin{cases} x(t-1) & , t \leq 0 \\ x(t+1) & ; t \geq 0 \end{cases}$

Sol^n → $= a(t)\, x(t-1) + b(t)\, x(t+1)$

split systems are time varient system.

(5.) Stable/Unstable sys →

Stable → Bounded i/p bounded o/p (BIBO) criteria. → Finite/bounded in amplitude

BIBO → For stable system, o/p should be bounded (or) finite for finite (or) bounded i/p at each & every instant of time.

Eg:- Bounded i/p are $u(t)$, dc-signal, $\sin t$, $\cos t$, $sgn(t)$

Que → Check stable/Unstable sys

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

$x(t)$	$y(t)$
10	12

(Stable)

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

$x(t)$	$y(t)$
10	$10t$

$\infty = \infty$

$-\infty = \infty$

(Unstable)

(3.) $y(t) = \dfrac{x(t)}{\sin t}$

$x(t)$	$y(t)$
2	$\dfrac{2}{\sin t}$ ($t = 0, \pi$)

(Unstable)

(4.) $y(t) = \sin t \cdot x(t)$

Sol^n→ $y(t) = \sin t \cdot x(t)$

$\sin t \to (-1, 1)$

$y(t) \to -x(t), x(t)$

$x(t)$	$y(t)$
2	$(-2, 2)$

(stable)

(5.) $y(t) = \sin[x(t)]$

Sol^n→ $y(t) = \sin[x(t)]$

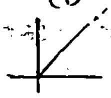
$\to (-1, 1)$

(stable)

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

Sol^n→ $x(t) = u(t) \longrightarrow$ bounded

$y(t) = r(t) \longrightarrow t u(t)$



(Unstable)

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

Sol^n→ $x(t) = u(t) \longrightarrow$ bounded

$y(t) = \delta(t) \longrightarrow$ Unbounded

(Unstable)

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

Sol^n→

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

$x(t) \longrightarrow \cos t =$ bounded sig.

$$y(t) = \int_{-\infty}^{t} \cos\tau \cdot \cos\tau \, d\tau$$

$$= \int_{-\infty}^{t} \cos^2\tau \, d\tau$$

$$= \int_{-\infty}^{t} \left(\frac{1+\cos 2\tau}{2}\right) d\tau$$

$$= \frac{1}{2}\left[(\tau)_{-\infty}^{t} + \left(\frac{\sin 2\tau}{2}\right)_{-\infty}^{t} \right]$$

Finite

(Unbounded)

(Unstable)

Note:- So the integration & differentiation signals are unstable sys.

Static / Dynamic – D → I, D, TS & TS

linear / NL – L → I, D, E, O

NL → R & I

* Linear time invarient (LTI) system →

$$x(t) \longrightarrow \boxed{\text{LTI sys.}} \longrightarrow y(t)$$

$h(t) \rightarrow$ Impulse-Responce of sys.

$H(\omega)$ (or) $H(s) \longrightarrow$ TF of sys.

* Impulse Responce & TF terms are used only for LTI system.
* Impulse Responce is used for defining LTI sys in time domain & TF is used for defining LTI sys. in freq. domain.

Impulse Responce →

$$\delta(t) \longrightarrow \boxed{\text{LTI}} \longrightarrow h(t)$$

* If i/p to LTI sys. is unit impulse then o/p of sys is known as impulse Responce.

Transfer function →

* It is the ratio of laplace Xform of o/p to Laplace Xform of i/p when all initial condn are assumed to be 0.

$$H(s) = \left.\frac{Y(s)}{X(s)}\right|_{\text{zero intial cond}^n}$$

Total o/p = Zero i/p responce + zero state responce

$$\text{Total o/p} = \underbrace{ZIR}_{\text{due to initial cond}^n/\text{states}} + \underbrace{ZSR}_{\text{due to applied i/p}}$$

* for linearity of sys. initial condn are assumed to be zero, because non-zero initial condn make the sys. non-linear.

Convolution →

$$x(t) \longrightarrow \boxed{\text{LTI}}_{\,h(t)} \longrightarrow y(t) \qquad y(t) = x(t) * h(t)$$

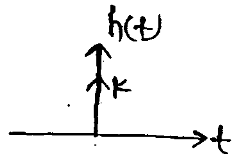
* Convolution is a linear time invarient operator & it is used only for LTI system.

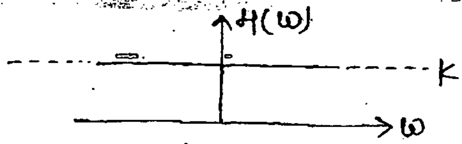
$$y(t) = x(t) * h(t)$$
$$y(t) = \int_{-\infty}^{t} h(\tau)\, x(t-\tau)\, d\tau$$

* The above relation is both linear & TIV. so it is LTI system.

Condition for LTI system to be static →

$$y(t) = k\,x(t)$$
$$h(t) \downarrow y(t) \qquad \downarrow x(t) = \delta(t)$$
$$\boxed{h(t) = k\,\delta(t)}$$
$$\boxed{H(\omega) = k}$$

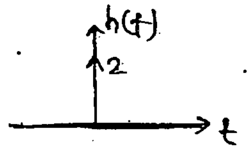




* Impulse $\delta(t)$ is the f^n whose all X_{form} is one.
* For static LTI system, impulse responce should be impulse at origin & TF should be indepandant of freq.

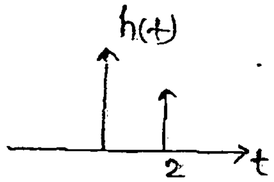
Q.→ check S/D LTI sys.

(i)



(static)

(ii)

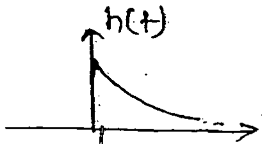


Impluse is not at ~~origin so~~ dynamic

(iii) $h(t) = u(t)$

(Dynamic)

(iv)



(dynamic)

(iv) $H(s) = 2$
static (free of freq.)

(vi) $H(s) = \frac{1}{s+1}$
(dynamic)

* Filters are dynamic system because there TF depends on fm.

*** Cond^n for LTI system to be causal →**

$$y(t) = x(t) * h(t) \rightarrow \text{Future i/p} \neq 0$$

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

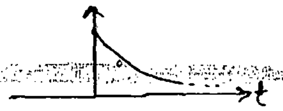
$$h(\tau) = 0;\ \tau < 0$$

$$\downarrow \tau = t$$

$$\boxed{h(t) = 0.\ t<0}$$

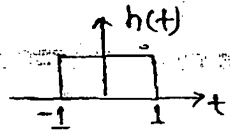
Que → Check C/NC LTI system.

(1.) $h(t) = e^{-2t}u(t)$



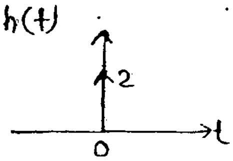
(Causal)

(2.) $h(t) = u(t+1) - u(t-1)$



(Non-causal)

(3.) $h(t)$

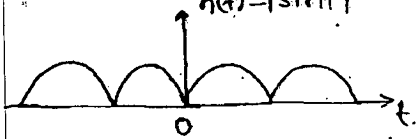


(causal)

(4.) $h(t) = e^{-(t+1)}u(t)$

(causal)

(5.) $h(t) = |\sin t|$



(Non-causal)

*** Cond^n for LTI sys. to be stable →** * If impulse Responce of LTI sys. is absolutely integrable then sys. will be stable. i.e.

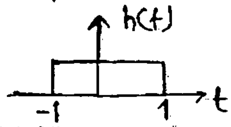
$$\boxed{\int_{-\infty}^{\infty} |h(t)|\, dt < \infty}$$

* ~~A sign~~ If impulse responce of LTI sys. is represented by energy signal (or) unit impulse f^n then sys. will be stable.

i.e. $h(t) \rightarrow$ Energy/ $\delta(t) \longrightarrow$ Stable

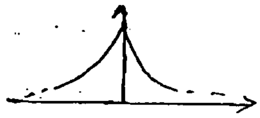
Que→ Check s/us system.

(1) $h(t) = u(t+1) - u(t-1)$



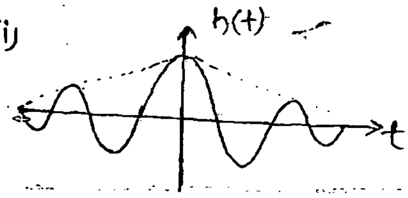
(Stable)

(2) $h(t) = e^{-2|t|}$



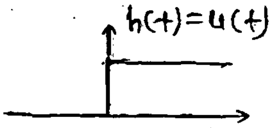
(Stable)

(iii)



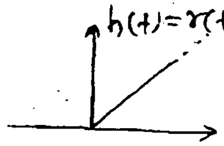
(Stable)

(iv) $h(t) = u(t)$



(Unstable)

(v) $h(t) = r(t)$



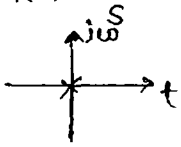
(Unstable)

(vi) $H(s) = \frac{1}{s^2+1}$

Poles $= s = \pm j$

* Because of imaginary axis lying so it is marginary stable
* $h(t) = \sin t\, u(t)$ ↓ (Unstable)

(vii) $H(s) = \frac{1}{s}$



Pole → $s = 0$

* marginaly stable
* $h(t) = u(t)$ → power sig. (Unstable)

$H(s) = \frac{1}{s} = \frac{Y(s)}{X(s)}$

$Y(s) = \frac{X(s)}{s}$

Inverse LT.

$y(t) = \left.\int_{-\infty}^{t} x(t)\,dt\right]$ Integrator

According to BIBO criteria:—

$x(t) = u(t) =$ bounded i/p

$y(t) = \int_{-\infty}^{t} u(t)\,dt = r(t)$

$r(t) =$ Unbounded sig.

So it is Unstable.

Note →

* All marginaly stable LTI sys. are BIBO Unstable.

* Distortions in LTI systems →

Types:- (i) magnitude/Amplitude distortion

(ii) Delay/phase distortion.

Note:-

(1) $x(t) \longrightarrow \boxed{\text{NL sys.}} \longrightarrow y(t) = x(t) + x^2(t)$

If $x(t) = \sin\omega_0 t$ then $y(t) = \sin\omega_0 t + \sin^2\omega_0 t$

$= \sin\omega_0 t + \frac{1-\cos 2\omega_0 t}{2}$

ω_0 $\qquad$ $\omega_0, 2\omega_0$

(2) $x(t) \longrightarrow \boxed{\text{TV sys}} \longrightarrow y(t) = x(t) + x(2t)$

$x(t) = \sin\omega_0 t$ $\qquad$ $y(t) = \sin\omega_0 t + \sin 2\omega_0 t$

ω_0 $\qquad$ $\omega_0, 2\omega_0$

** For production of harmonics, nature of sys should be either NL (or) T.V.

(1) Magnitude/Amplitude distortion → If sys provides unequal amount of amplification (or) attneuation two ~~to~~ diff freq. componants present in i/p sys, then sys is having magnitude distortion.

$x(t) = \sin\omega_1 t + \sin\omega_2 t \longrightarrow \boxed{\text{LTI sys.}} \longrightarrow y(t) = A_1\sin\omega_1 t + A_2\sin\omega_2 t$

$\omega_1 \neq \omega_2$ $\qquad$ $A_1 \neq A_2$

(2) Delay (or) phase distortion → If sys provides unequal amount of time delays to diff freq. componants present in i/p signal then sys is having delay (or) phase distortion.

$x(t) = \sin\omega_1 t + \sin\omega_2 t \; (\omega_1 \neq \omega_2) \longrightarrow \boxed{\text{LTI sys.}} \longrightarrow y(t) = \sin[\omega_1(t-t_1)] + \sin[\omega_2(t-t_2)] \; (t_1 \neq t_2)$

* Cond^n for LTI sys. to be distortionless →

$x(t) = \sin\omega_1 + \sin\omega_2 \longrightarrow \boxed{\text{LTI sys.}} \longrightarrow y(t) = k\,x(t-t_0) = k\sin[\omega_1(t-t_0)] + k\sin[\omega_2(t-t_0)]$

$$\boxed{y(t) = k\,x(t-t_0)}$$

So laplace transform of above eq^n

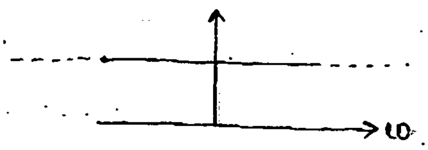
$$Y(s) = k \times X(s)\, e^{-st_0}$$

$$H(s) = \frac{Y(s)}{X(s)} = k e^{-st_0}$$

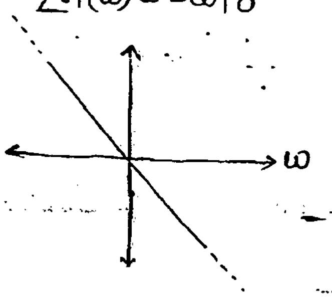
$(s = j\omega)$

$$H(j\omega) = k e^{-j\omega t_0}$$

$|H(\omega)| = k$



$\angle H(\omega) = -\omega t_0$



*** For distortionless LTI sys., magnitude of TF should be independant of freq. & phase of TF should be linear.

* Differential eq^n for LTI sys. →

$$a_n \frac{d^n y(t)}{dt^n} + a_{n-1}\frac{d^{n-1}y(t)}{dt^{n-1}} + \cdots + a_0 y(t) = b_m \frac{d^m x(t)}{dt^m} + b_{m-1}\frac{d^{m-1}x(t)}{dt^{m-1}} + \cdots + b_0 x(t)$$

For linearity →

All initial condⁿ should be zero.

Time-invariance →

Coefficients $a_n, a_{n-1}, \cdots a_0, b_m, b_{m-1} \cdots, b_0$ should be independant of time.

Que. → Check time invariance & linearity of sys. (initial condⁿ are zero).

(1.) $\frac{2d^2y(t)}{dt^2} + \frac{3dy(t)}{dt} + y(t) = x(t)$

(2.) $\frac{2d^2y(t)}{dt^2} + 3t\frac{dy(t)}{dt} + y(t) = x(t)$

(3.) $2\left[\frac{dy(t)}{dt}\right]^2 + \frac{3dy(t)}{dt} + y(t) = x(t)$

Ans. → (1.) L, TIV

(2.) L, TV

(3.) NL, TIV