Signals and Systems

Systems and their classifications-II

Causal & Non-causal Systems

Linear & Nonlinear Systems

Causal & Non-causal Systems

(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. depands on future values of i/p at any instant of time then sys. will be non-causal.

Cont..

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

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

<u>Eg:-</u> $y(t) = x(t+1)$

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

Cont..

<u>Que.</u> → 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.) $y(t) = \sin(t+2) . x(t-1)$

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

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

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

Cont..

Sol^n → (i.) $y(t) = x(2t)$

$(t=1)\downarrow$

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

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

$(t=-1)$

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

Cont..

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

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

$(t = -1)$

$$y(-1) = \frac{x(-1) - x(1)}{2}$$ (system is non-causal)

future

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

(cofficient) past

(system is causal.)

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

$x(t)$

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

Cont..

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

(System is non-causal)

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

(System is non-causal)

Linear & Nonlinear Systems

(3.) Linear & Non-linear system →

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

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

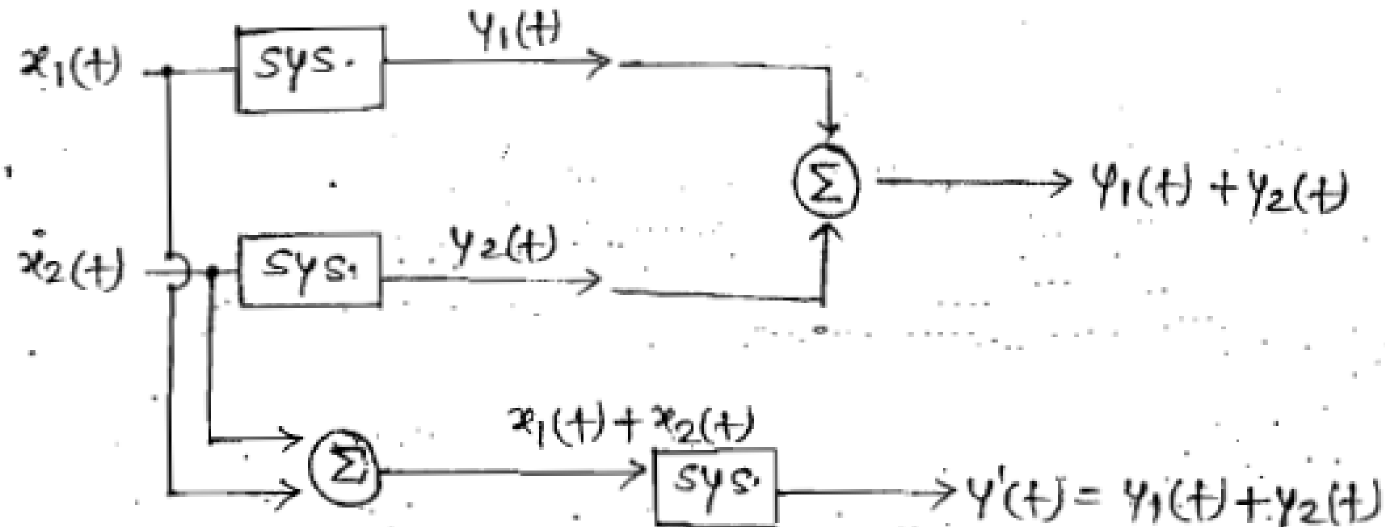
* It is a combination of two laws:-

(i) Law of additivity.

(ii) Law of Homogenity.

Cont..

(1.) Law of additivity →



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

$o/p = i/p + 10$

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

$y_2(t) = x_2(t) + 10$

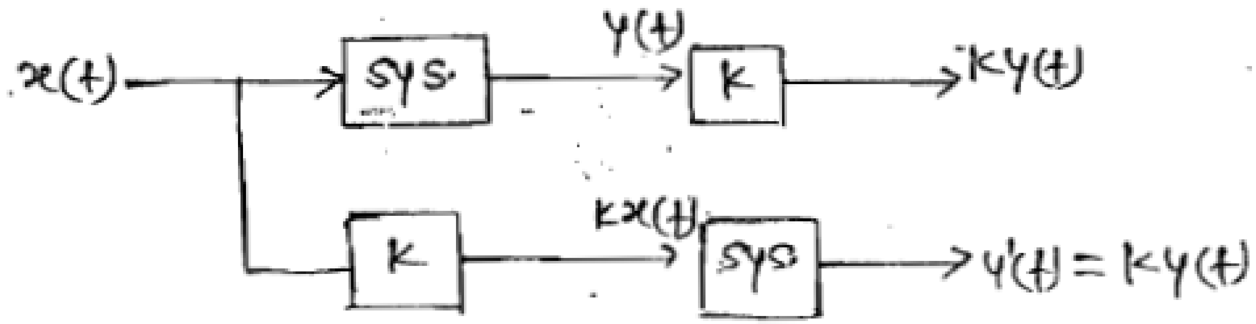
$\rightarrow x_1(t) + x_2(t) + 20$

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

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

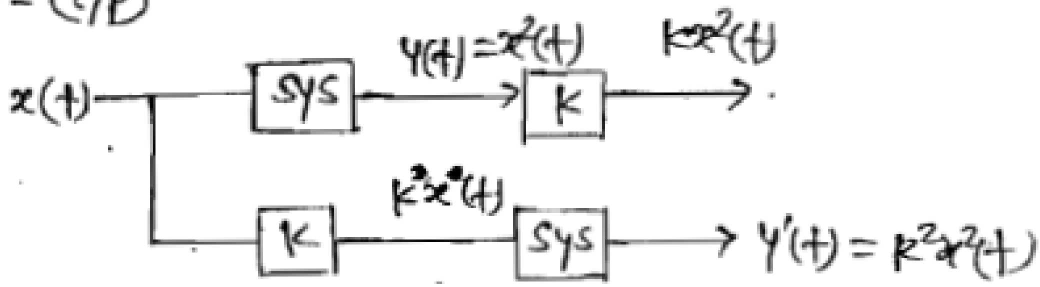
Cont..

(2.) Law of Homogenity →



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

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

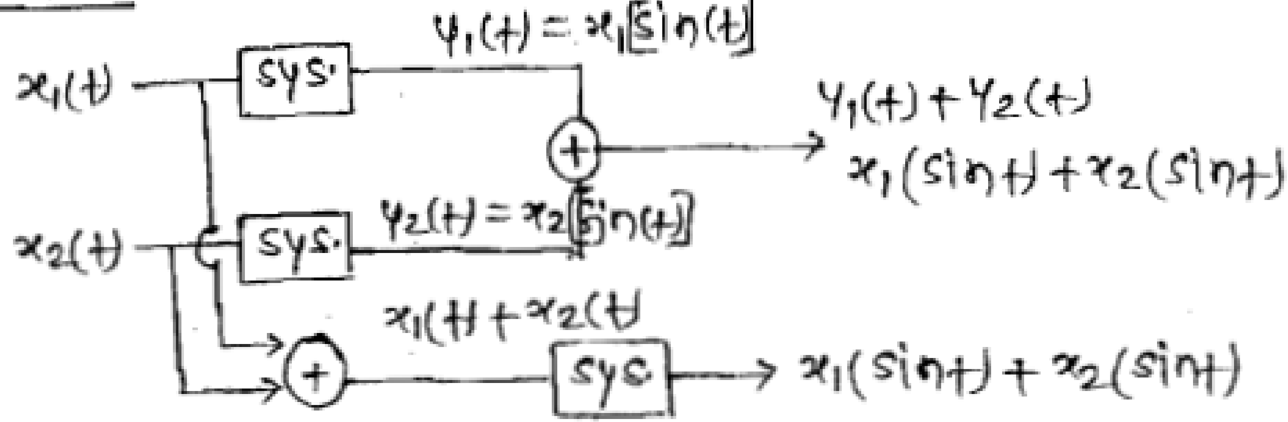


Cont..

Que. → Check linear/Non-linear sys.

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

soln →



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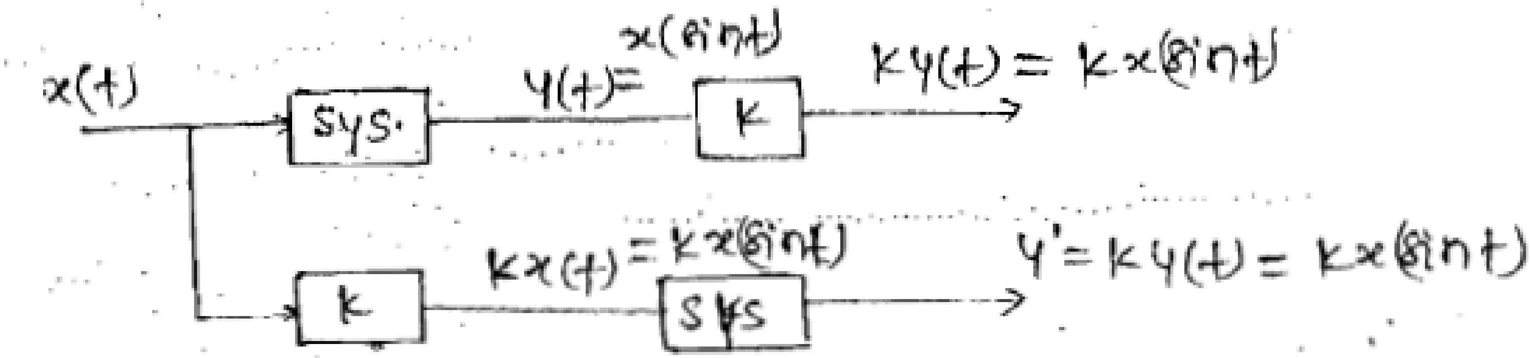
Note→

Linearity of sys is independant of time scaling.



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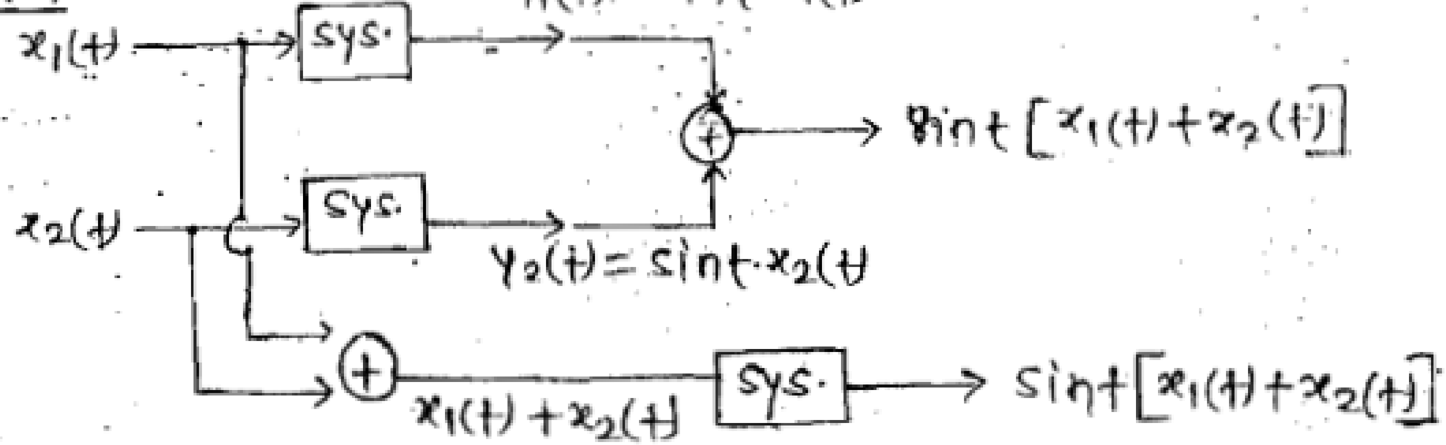
(2.) $y(t) = \sin t \cdot x(t)$ (3.) $y(t) = \log t \cdot x(t)$

Soln →



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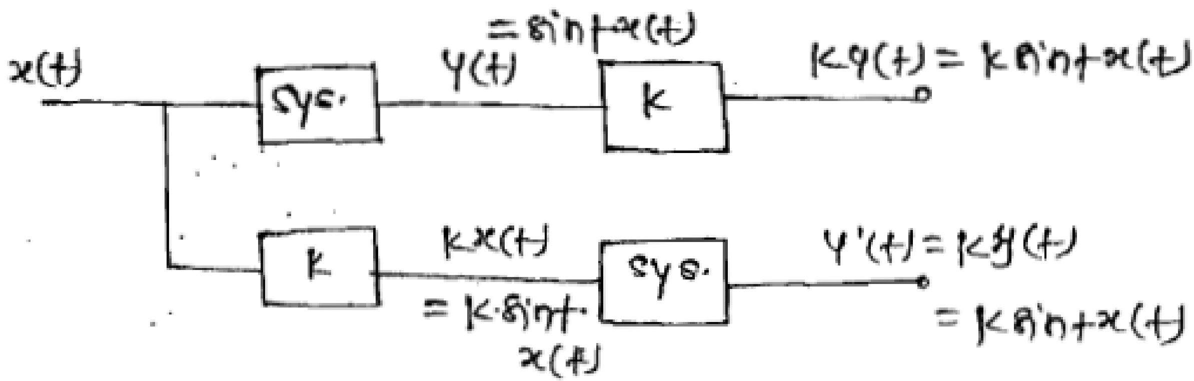
Note:- linearity of sys. is independant of cofficient used in sys. relationship.



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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., cube. ......
.... root, ... sq( ), sinc( ) ... sgn( ) etc
either on 'x' or 'y'.]

Cont..

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 cond^n 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 f^n 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 = past i/p + future i/p

No any NL f^n so this is linear

Cont..

Note →

(1.) Integral & derivative operators are linear.

(2.) Even & odd operators are linear.

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

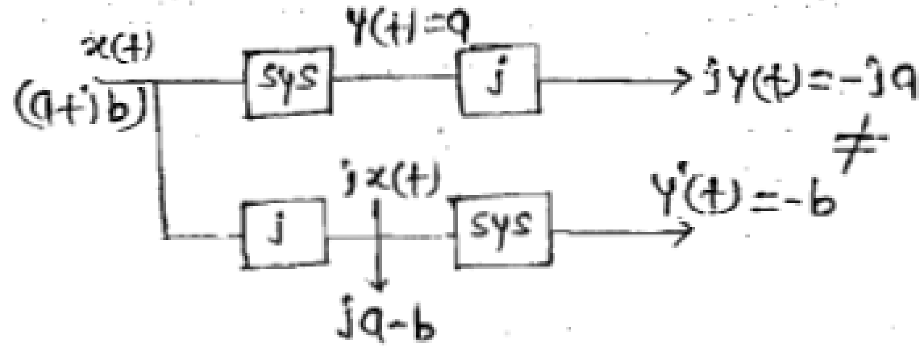
$y(t) = \int_{-\infty}^{t} x^{2}(\tau)\,d\tau$ NL

(x.) $y(t) = e^t x(t)$

$y(t) = 0 = e^t x(t) = 0$. linear

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

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



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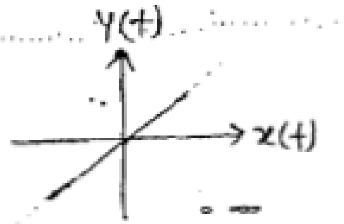
Note → Real & imaginary operators are NL.

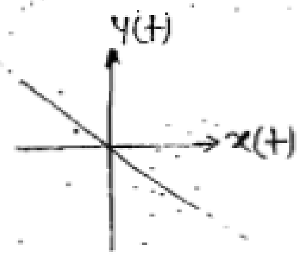
(xii)



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

system is linear

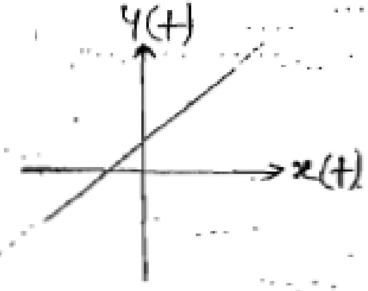
(xiii)



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

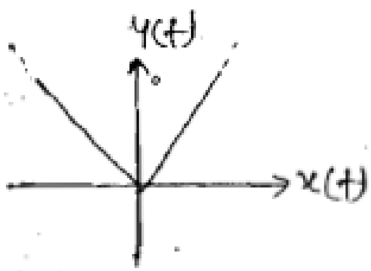
system is L

(xiv)



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

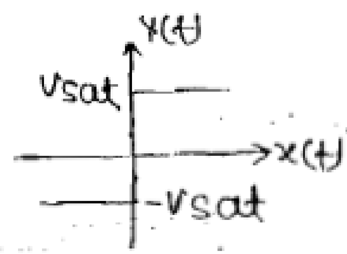
(xv)

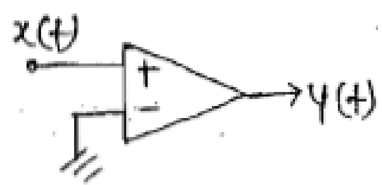


$y(t) = |x(t)|$

NL

(xvi)

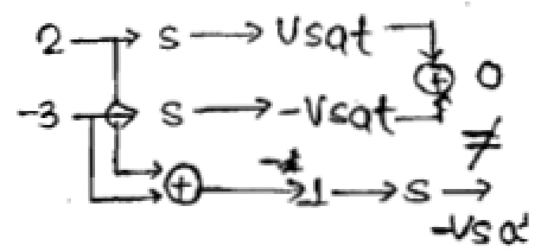




$y(t) = V_{sat}\,\mathrm{sgn}[x(t)]$

NL

(or)



Thank You