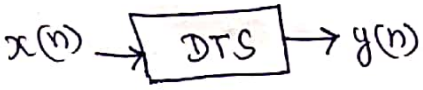
System :- A system is a set of elements or functional blocks that are connected together & produces an output in response to an input signal

(Eg) Audio Amplifier, Receiver

Continuous Time System :- If the system processes CT signal then the system is called as CT system.

$y(t) = F[x(t)]$

Discrete time system :- If the system processes DT signal then the s/m is called DT system



$y(n) = T[x(n)]$

Classification of systems :-

1) Linear and Non-Linear systems
2) Time Variant and Time Invariant systems
3) causal and Non-causal systems
4) Static and Dynamic systems
5) Stable and Unstable systems
6) Inverse system

Linear and Non-linear systems :-

A system is said to be linear, if its obeys superposition theorem

$$\underbrace{F[a_1x_1(t) + a_2x_2(t)]}_{y_3'(t)} = \underbrace{a_1y_1(t) + a_2y_2(t)}_{y_3(t)}$$

$y_3'(t) = y_3(t) \rightarrow$ linear system.

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

$y_1(t) = t\ x_1(t)$

$y_2(t) = t\ x_2(t)$

R.H.S

$y_3(t) = a_1\ t\ x_1(t) + a_2\ t\ x_2(t) \rightarrow (1)$

L.H.S

$y_3'(t) = t\left[a_1 x_1(t) + a_2 x_2(t)\right]$

$y_3'(t) = t\ a_1 x_1(t) + t\ a_2 x_2(t) \rightarrow (2)$

$y_3'(t) = y_3(t) \rightarrow$ Linear System

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

$y_1(t) = \sin x_1(t) \qquad y_2(t) = \sin x_2(t)$

R.H.S

$y_3(t) = a_1 \sin x_1(t) + a_2 \sin x_2(t) \rightarrow (1)$

L.H.S

$y_3'(t) = \sin\left[a_1 x_1(t) + a_2 x_2(t)\right]$

$= \sin a_1 x_1(t) \cos a_2 x_2(t) + \cos a_1 x_1(t) \sin a_2 x_2(t) \rightarrow (2)$

$y_3'(t) \neq y_3(t)$ – Non linear system

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

$y_1(t) = x_1^2(t) \qquad y_2(t) = x_2^2(t)$

R.H.S

$y_3(t) = a_1 x_1^2(t) + a_2 x_2^2(t)$

L.H.S

$y_3'(t) = \left[a_1 x_1(t) + a_2 x_2(t)\right]^2$

$= a_1^2 x_1^2(t) + a_2^2 x_2^2(t) + 2\left[a_1 x_1(t) - a_2 x_2(t)\right]$

$y_3'(t) \neq y_3(t) \rightarrow$ Nonlinear system

④ $y(t) = x(t) \cos 200\pi t$

$y_1(t) = x_1(t) \cos 200\pi t$

$y_2(t) = x_2(t) \cos 200\pi t$

R.H.S $\quad y_3(t) = a_1 x_1(t) \cos 200\pi t + a_2 x_2(t) \cos 200\pi t$

L.H.S $\quad y_3'(t) = \cos 200\pi t \left[a_1 x_1(t) + a_2 x_2(t) \right]$

$= a_1 x_1(t) \cos 200\pi t + a_2 x_2(t) \cos 200\pi t$

$y_3'(t) = y_3(t) \rightarrow$ Linear System.

Time Invariant & Time Variant System :- (or)

Shift Invariant & Shift Variant System :-

A system is said to be time invariant if the time shift in the input signal results in the corresponding time shift in the output

$$y(t) = F[x(t)]$$

If $x(t)$ is delayed by time t_1 then the o/p $y(t)$ also be delayed by same time

$$F[x(t-t_1)] = y(t, t_1)$$

$$y(t-t_1) = F[x(t-t_1)]$$

$$\therefore \quad y(t, t_1) = y(t-t_1) \rightarrow \text{Time Invariant}$$

① $y(t) = \sin x(t)$

$y(t, t_1) = \sin x(t-t_1)$

$y(t-t_1) = \sin x(t-t_1)$

$y(t, t_1) = y(t-t_1) \rightarrow$ Time Invariant System

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

$y(t, t_1) = x(t^2 - t_1)$

$y(t - t_1) = x(t - t_1)^2$

$y(t, t_1) \neq y(t - t_1)$ → Time Variant system

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

$y(t, t_1) = t\, x(t - t_1)$

$y(t - t_1) = (t - t_1)\, x(t - t_1)$

$y(t, t_1) \neq y(t - t_1)$ → Time Variant system

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

$y(t, t_1) = x(-t - t_1)$

$y(t - t_1) = x(-t + t_1)$

$y(t, t_1) \neq y(t - t_1)$ → Time Variant system

(5) $y(t) = 10x(t) + 5$

$y(t, t_1) = 10x(t - t_1) + 5$

$y(t - t_1) = 10x(t - t_1) + 5$

$y(t, t_1) = y(t - t_1)$ → Time Invariant system

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

$y(t, t_1) = x^2(t - t_1)$

$y(t - t_1) = x^2(t - t_1)$

$y(t, t_1) = y(t - t_1)$ → Time Invariant system