SIGNALS & SYSTEMS

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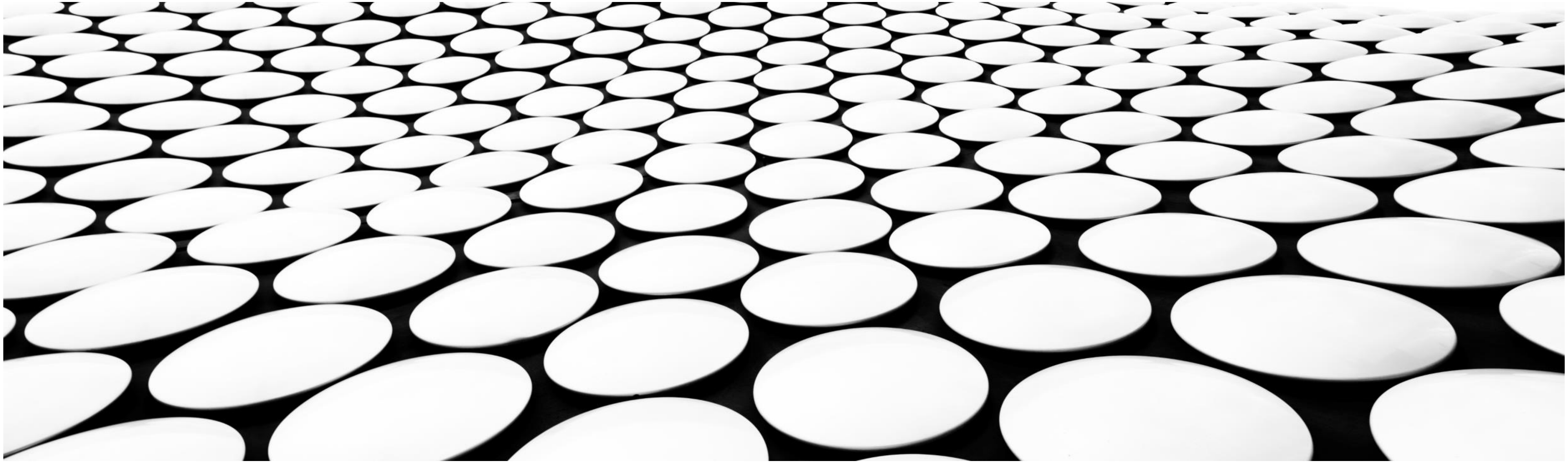


Classification of discrete Time Systems:-

1) static - dynamic
2) Time invariant - variant
3) Linear - non-linear
4) causal - non-causal
5) stable - unstable
6) FIR and IIR systems
7) Recursive and Non-recursive

Digital signal processing.

Time domain (t) $\xrightarrow{\text{Laplace transform}}$ s - domain → Differential Equation

Discrete time domain $\xrightarrow{\text{Z-transform}}$ z - domain → Difference Equation static → memoryless → present

dynamic → having memory → past | present | future.

$y(n) = a\,x(n)$

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

$n=-1$, $y(-1) = a\,x(-1)$

static

$y(n) = \sum_{m=0}^{N} x(n-m)$ → Dynamic system

finite memory elements are needed

$y(n) = \underbrace{x(n)}_{\text{present value of i/p}} + \underbrace{x(n-1) + x(n-2) + \cdots x(n-N)}_{\text{past values of the i/p}}$

$y(n) = \sum_{m=0}^{\infty} x(n-m)$

$y(n) = x(n) + x(n-1) + \cdots\cdots + x(n-\infty)$

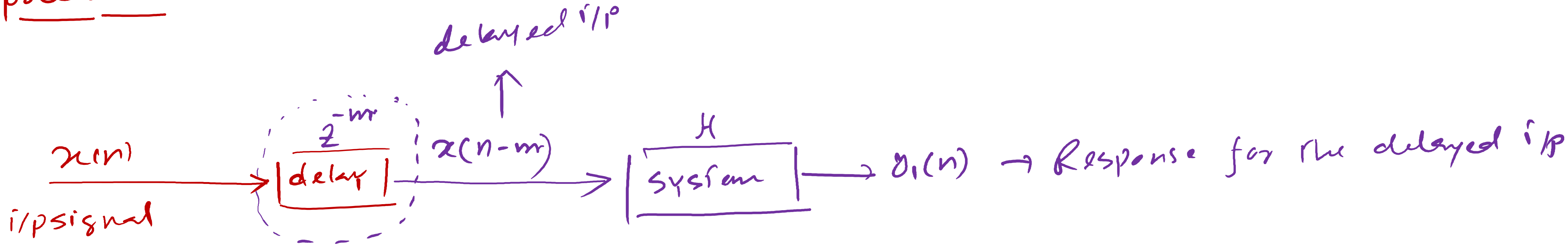
infinite memory elements.

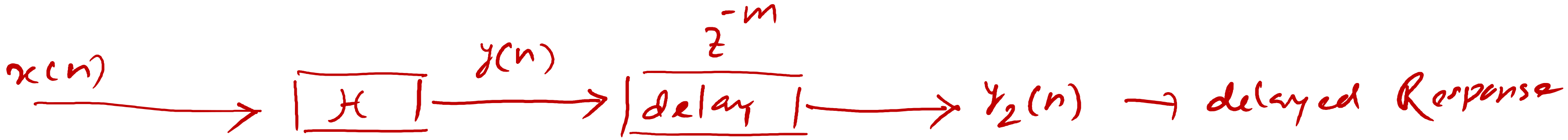
Time variant:- o/p varies in accordance with i/p. (time)

Time invariant:- o/p doesn't vary in accordance with i/p (time)

$(t-m)$

Procedure:-





If $y_1(n) = y_2(n) \Rightarrow$ Time invariant DTS

$$y(n) = x(n) - x(n-1) \rightarrow \text{check for time invariance}$$

$$x(n) \longrightarrow \boxed{z^{-m}} \longrightarrow x(n-m) \longrightarrow \boxed{H} \longrightarrow \underbrace{y_1(n) = x(n-m) - x(n-m-1)}_{\text{Response for delayed i/p}}$$

$$x(n) \longrightarrow \boxed{H} \longrightarrow y(n) \longrightarrow \boxed{z^{-m}} \longrightarrow Y_2(n) = x(n-m) - x(n-m-1)$$

$$\therefore y_1(n) = y_2(n) \Rightarrow \text{Time invariant system.}$$

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

coefficient of $x(n)$
i/p

Sol^n:-

For delayed i/p response:-

$x(n) \longrightarrow \boxed{z^{-m}} \longrightarrow x(n-m) \longrightarrow \boxed{H} \longrightarrow y_1(n) = n\,x(n-m)$

For delayed o/p:-

$x(n) \longrightarrow \boxed{H} \longrightarrow y(n) \longrightarrow \boxed{z^{-m}} \longrightarrow y_2(n) = (n-m)\,x(n-m)$

$y_1(n) \neq y_2(n)$ $\Rightarrow$ Time-variant system.

$y(n) = x(-n) \rightarrow$ ***

Check the time-variancy.

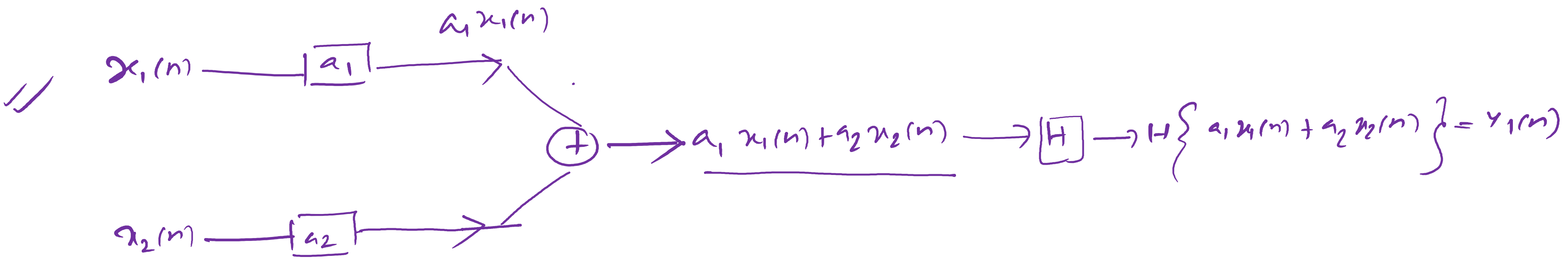
Sol^n:- $x(n) \longrightarrow$ delay $\rightarrow x(n-m) \rightarrow H \rightarrow y_1(n) = x[-(n-m)] = x(-n+m) \rightarrow y_1(n)$

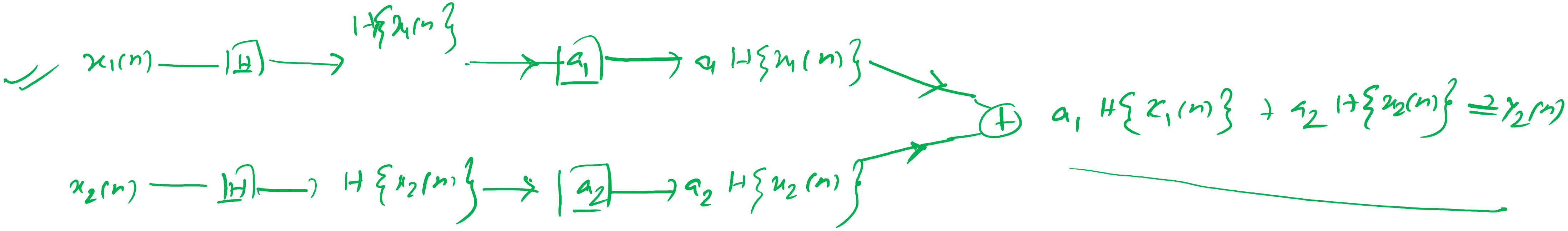
$x(n) \rightarrow H \rightarrow y(n) \rightarrow$ delay $\rightarrow y_2(n) = x[-n-m]$

$y_1(n) \neq y_2(n)$ → Time variant

Linear and Non-Linear:-

Principal of superposition
1) Additivity
2) Homogeneity.





$y(n) = n x(n)$

Sol^n:- Let us consider two i/ps $x_1(n)$ and $x_2(n)$

$x_1(n) \rightarrow y_1(n)$, $x_2(n) \rightarrow y_2(n)$

$\underbrace{a_1 x_1(n) + a_2 x_2(n)}_{\text{i/p}} \rightarrow \boxed{H} \rightarrow y_3(n) = ?$

$y_1(n) = n x_1(n)$

$y_2(n) = n x_2(n)$

$a_1 y_1(n) + a_2 y_2(n) = a_1 n x_1(n) + a_2 n x_2(n)$ — (1)

$y_3(n) = n[a_1 x_1(n) + a_2 x_2(n)]$

$\Rightarrow y_3(n) = n a_1 x_1(n) + a_2 n x_2(n)$ — (2)

From (1) and (2) $\Rightarrow$ $y(n) = n x(n)$ is linear.

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

Sol^n:-

$x_1(n) \rightarrow y_1(n)$

$x_2(n) \rightarrow y_2(n)$

$\therefore y_1(n) = n x_1^2(n)$

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

$\therefore a_1 y_1(n) + a_2 y_2(n) = a_1 n x_1^2(n) + a_2 n x_2^2(n)$ — (i)

$\underbrace{a_1 x_1(n) + a_2 x_2(n)}_{i/p \rightarrow y_3(n)} \longrightarrow \boxed{\text{system}} \longrightarrow y_3(n) = n[a_1 x_1(n) + a_2 x_2(n)]^2$

$\Rightarrow y_3(n) = n a_1^2 x_1^2(n) + n a_2^2 x_2^2(n) + 2 a_1 a_2 n\, x_1(n) \cdot x_2(n)$ — (2)

$\therefore$ (1) $\neq$ (2) $\Rightarrow$ Non-linear.