Sister Nivedita University

Name: Fahad Dubey Sec: B

Department: B.Tech CSE Sem: 6

Subject: Digital Signal Processing

Enrollment No.: 21112000001217

Reg No.: 210012175539

Q.1. $x(t) = 2\sin(40\pi t) - 3\sin(100\pi t) + \cos(50\pi t)$

> To determine the minimum, sampling frequency,
we need to find the highest frequency component in the analog signal, which is given by $x(t)$ signal.

Here, the highest frequency component in the signal is $f_{max} = 100Hz$ (corresponding to the term $3\sin(100\pi t)$.

> According to the Nyquist - Shannon sampling theorem,
the sampling frequency (f_s) should be atleast twice the maximum frequency component (f_{max}).

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Here, the highest frequency component in the signal is $f_{max} = 100Hz$ (corresponding to the term $3\sin(100\pi t)$.

> According to the Nyquist - Shannon sampling theorem,
the sampling frequency (f_s) should be atleast twice the maximum frequency component (f_{max}).

Therefore the minimum sampling frequency (f_s) required is:

$f_s = 2f_{max} = 2 \times 100 = 200\,Hz$

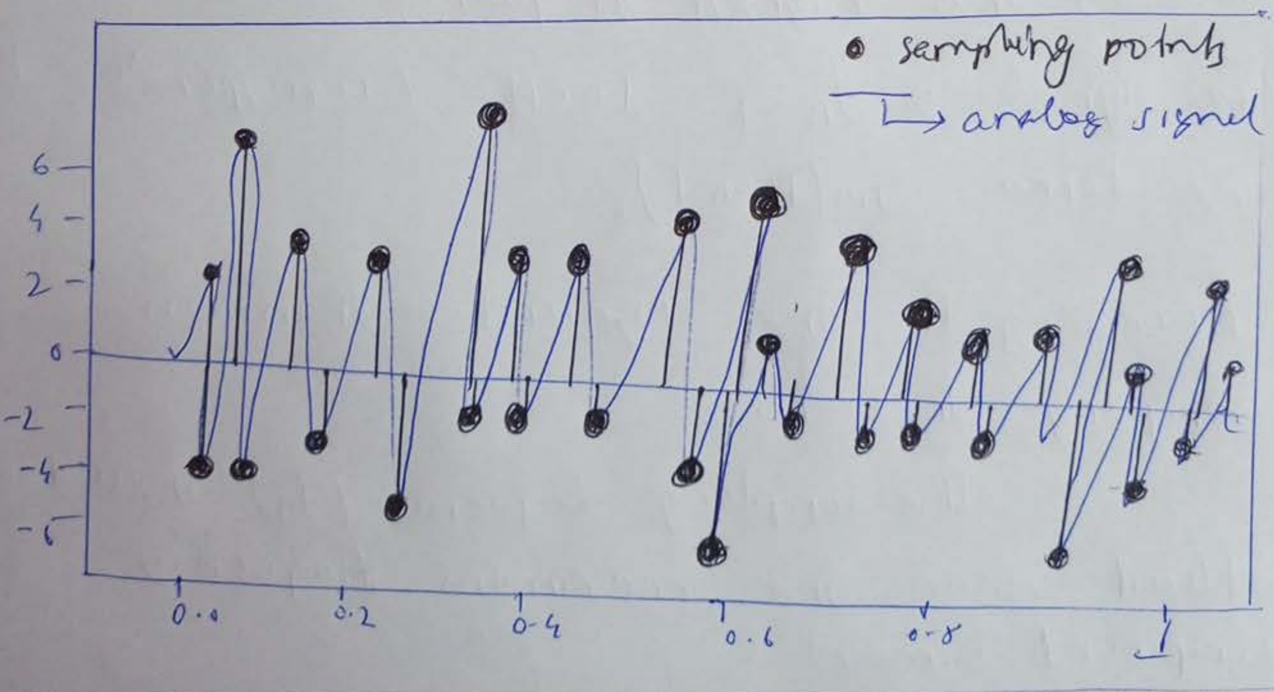
> Sampled version:

$x(t) = 2\sin 40\pi t - 3\sin 100\pi t + \cos 50\pi t$

$= 2\sin \frac{40\pi n}{200} - 3\sin \frac{100\pi n}{200} + \cos \frac{50\pi n}{200}$

$= 2\sin \frac{\pi n}{5} - 3\sin \frac{\pi n}{2} + \cos \frac{\pi n}{4}$

> Sketch of the waveform & the sampling points:



Q2. To determine whether the signal $x[n] = u(2n)$ is an energy or power signal, we need to evaluate its energy or power over all time.

The energy of discrete - time signal is given by:

$$E_x = \sum_{n=-\infty}^{\infty} |x[n]|^2$$

The power of discrete - time signal is given by:

$$P_x = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x[n]|^2$$

> now, the energy & power of the given signal $x[n] = u(2n)$ ill be evaluated, here $u(2n)$ is unit step signal, we have

$$x[n] = \begin{cases} 1 & \text{for } n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

> Now evaluating the energy,

$$E_x = \sum_{n=-\infty}^{\infty} |x[n]|^2 = \sum_{n=0}^{\infty} |1|^2 = \sum_{n=0}^{\infty} 1 = \infty$$

Since, the energy of the signal $x[n] = u(2n)$ is ∞, it is an energy signal.

> Now evaluating the power,

$$P_x = \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=-N}^{N} |x[n]|^2$$

$$= \lim_{N \to \infty} \frac{1}{2N+1} \sum_{n=0}^{N} |1|^2 =$$

$$= \lim_{N \to \infty} \frac{N+1}{2N+1} = \frac{1}{2}$$

Since, the power of the signal $x[n] = u(2n)$ is finite (equal to $\frac{1}{2}$), it's a power signal.

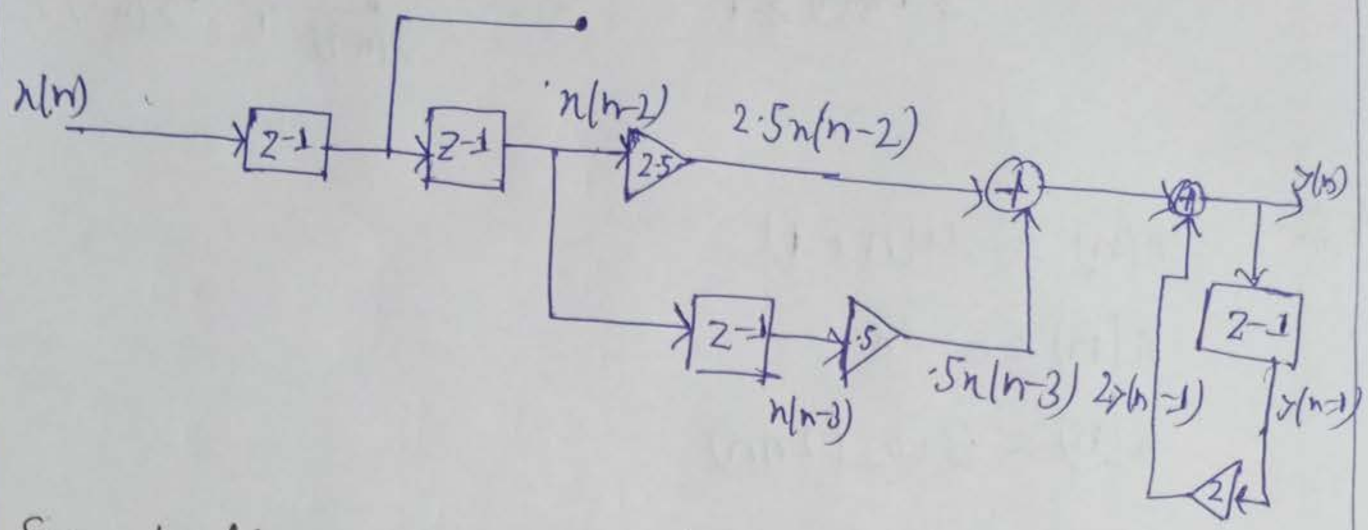
In summary:

> The signal $x[n] = u(2n)$ is an energy signal cause it's energy is ∞.

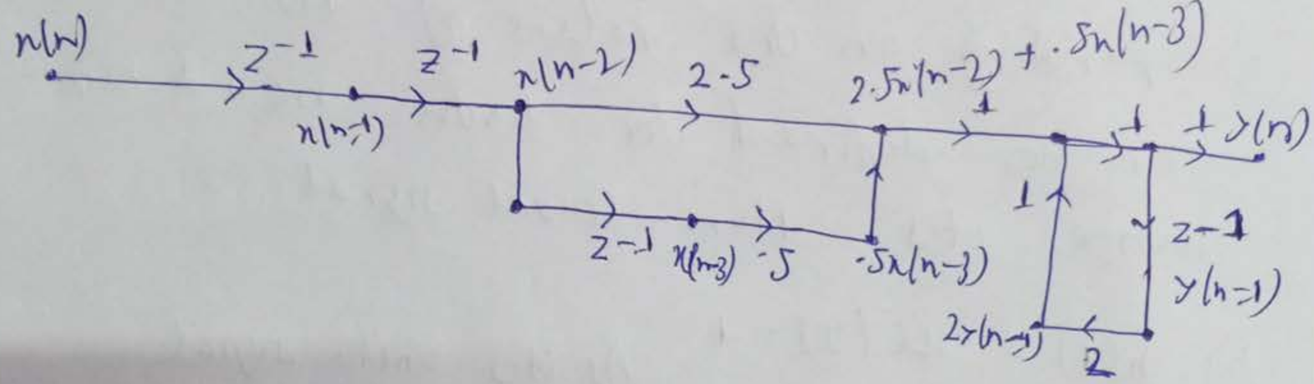
> The signal $x[n] = u(2n)$ is a power signal cause it's power is finite.

Q3. a) $y(n) = 2y(n-1) + 2.5x(n-2) + .5x(n-3)$

Block Diagram of $y(n)$:

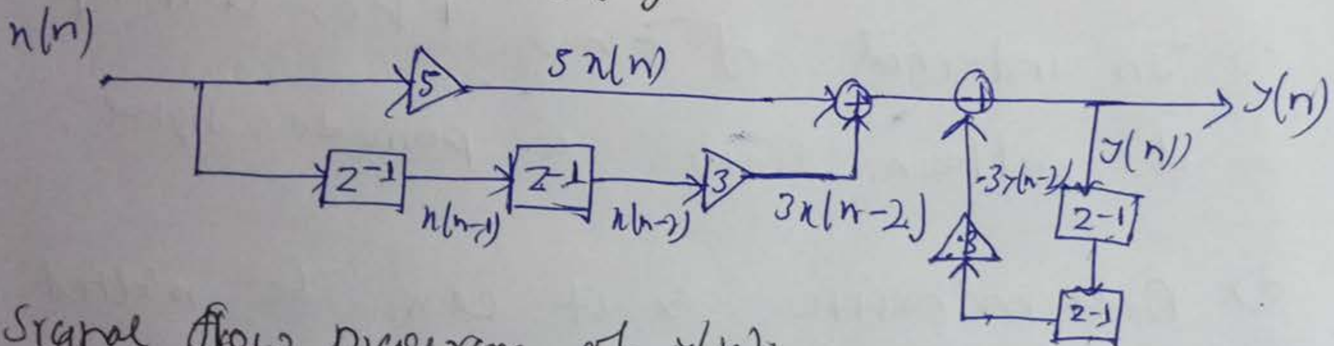


Signal flow Diagram of $y(n)$:



b) $y(n) = 3x(n-2) + 5x(n) + .3y(n-2)$

Block Diagram of $y(n)$:



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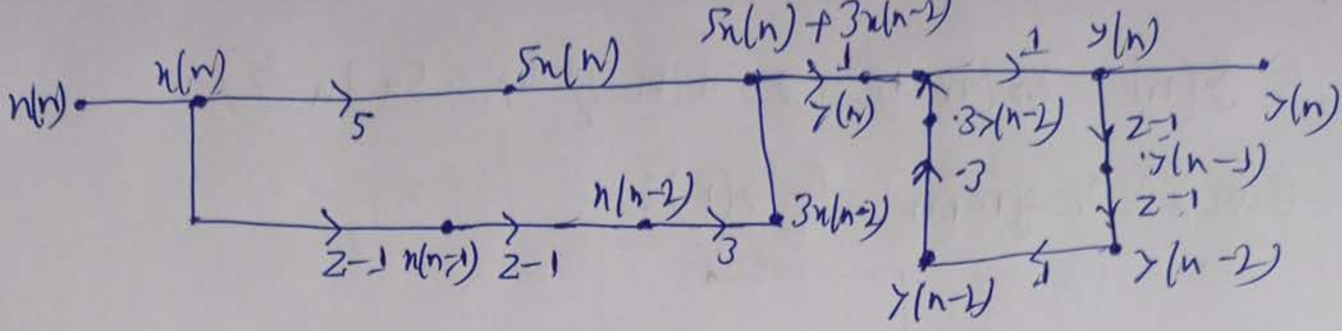


Q.4.i)

$x(n) = u(n+1)$

$x(n) = e^{-3n}$

$x(n) = 3\cos(2\pi n)$

i) $x(n) = u(n \pm 1)$

a) depending on the value of n, the system can be defined for both $n<0$ & $n \geq 0$. Hence, it is Non-Causal signal.

b) $x(1) = u(2) = 1$ As its unit signal

$x(-1) = u(0) = 1$

As $x(1) \cancel{\neq} = x(-1)$ Hence, it is ~~odd~~ even signal.

c) In interval of every 4 sec, it'll repeat its pattern, Hence a periodic signal.

d) Deterministic as it can be plotted like unit step signal.

4.ii. $x(n) = e^{-3n}$

a) ~~Causal signal if defines for only n≥0.~~

But here $-(3n)$ represents all inputs are negative.

Hence, it's anti-causal signal.

b) $x(1) = e^{-3}$

$x(-1) = e^{3}$

As $x(1) \neq x(-1)$ Hence it's a odd signal.

c) Non-periodic.

d) Deterministic

4.iii $x(n) = 3\cos(2\pi n)$

a) As n can be both +ve & -ve hence it's a Non-causal signal.

b) Even signal as it keeps repeating itself after every 2π

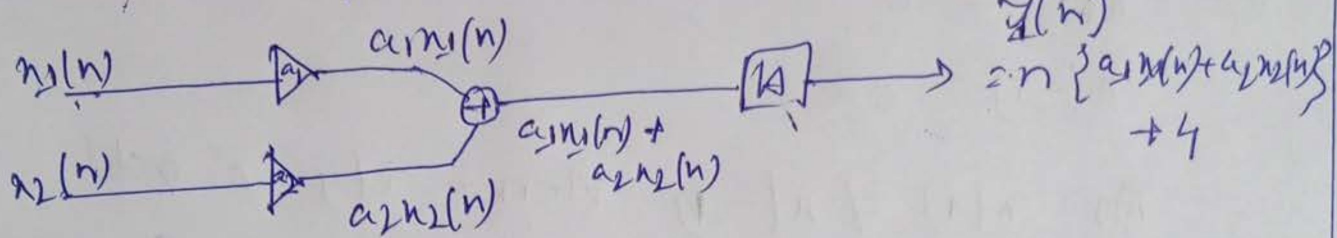
c) Periodic

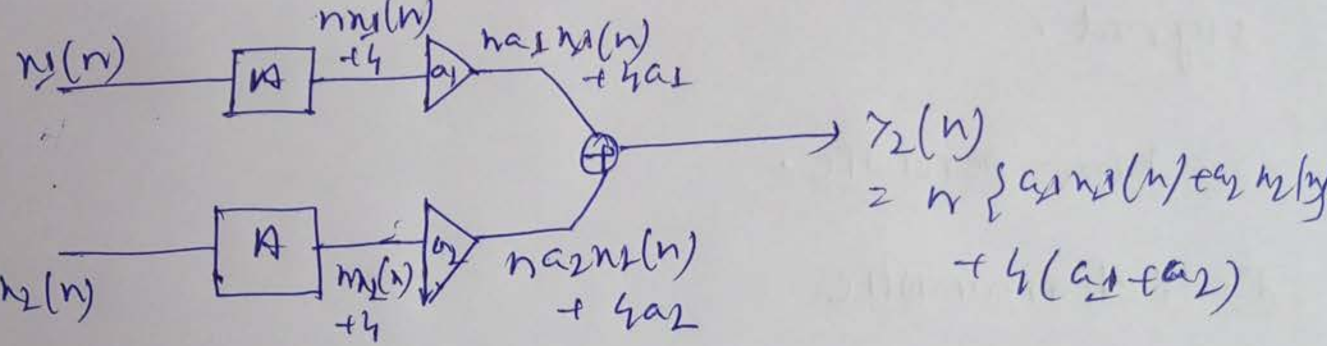
d) Deterministic

95. a) $y(n) = nx(n) + 4$

a) Checking Linearity: A system is called Linear if it follows the principle of superposition.

let, $x_1(n)$ & $x_2(n)$ are 2 components of the signal $x(n)$.





As $y_1 \neq y_2$, Hence the system is not Linear.

b) Checking Causality: system is causal if its o/p doesn't depend on future inputs or outputs.

$\forall n \geq 0$ or $\forall n \leq 0$; its input only depends on present inputs.

for, $n = -3$, $y(-3) = -3x(-3) + 4$

$n = -2$, $y(-2) = -2x(-2) + 4$

$\vdots$

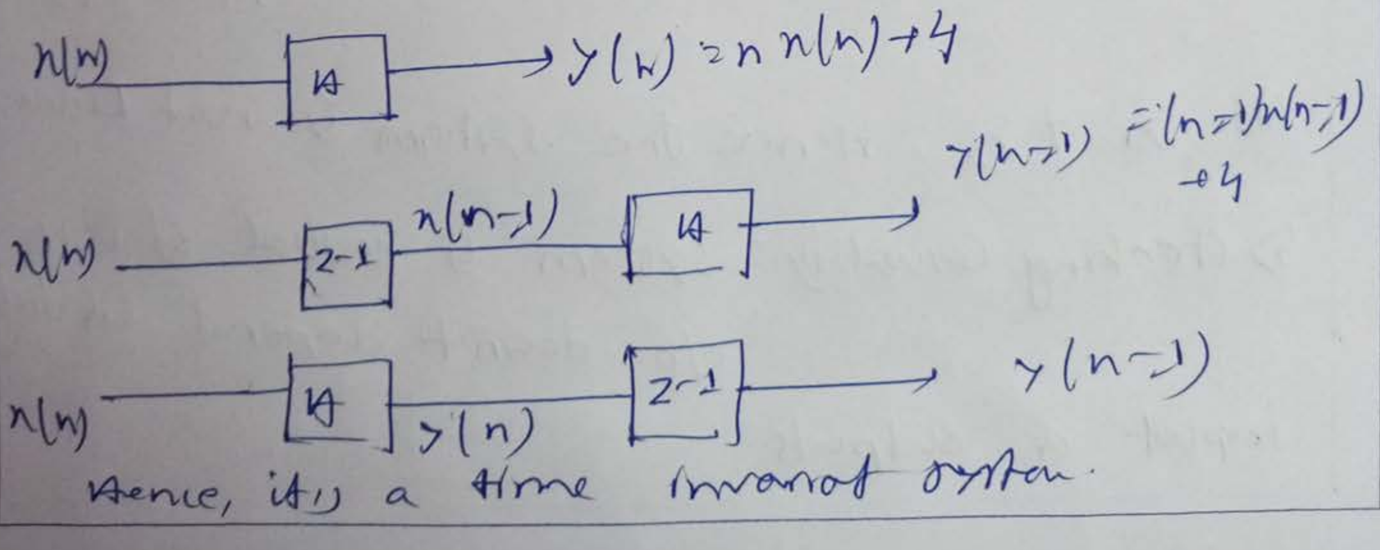
$n = 2$, $y(2) = 2x(2) + 4$

This output only depends on present input, hence the system is causal.

c) Checking if system is Dynamic: Dynamic if output depends on past or future input.

Here, output only depends on present inputs hence it's a static system.

d) Checking if time invariant: A system is said time invariant if its input & output doesn't change with time.

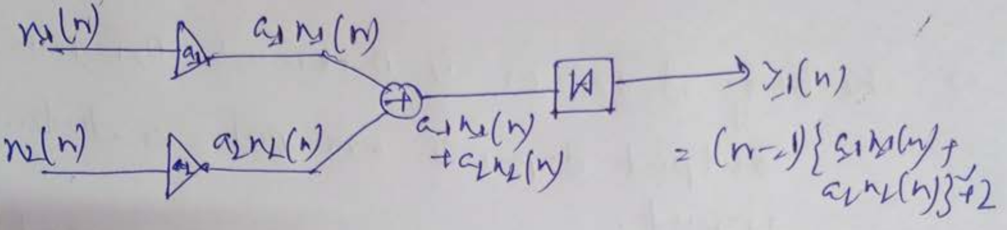


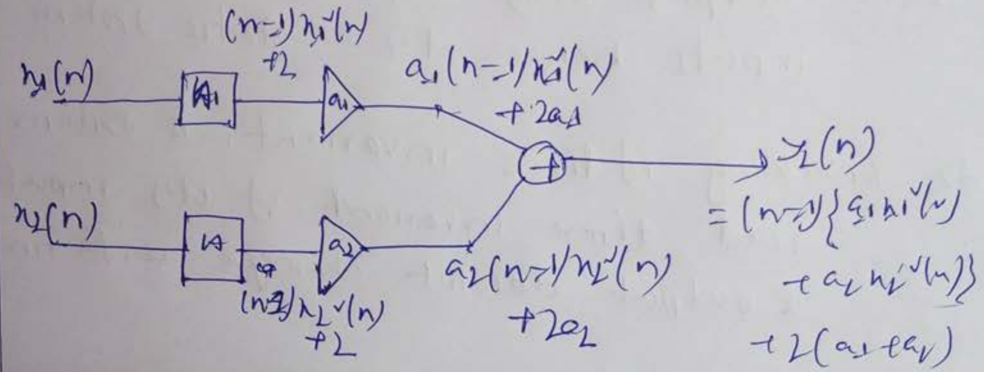
Hence, it's a time invariant system.

$y(n) = (n-1)x^2(n) + 2$

a) Checking Linearity : A system is called linear if it follows the principle of superposition.

Let, $x_1(n)$ & $x_2(n)$ are 2 components of the signal $x(n)$.





As $y_1 \neq y_2$, Hence the system is not Linear

b) Checking Causality : system is causal if it's o/p doesn't depend on future input or outputs.

$\forall n$, system only depends on present inputs.

for $y = -1$, $y(-1) = -2x^2(-1) + 2$

$y(-2) = -3x^2(-2) + 2$

$\vdots$

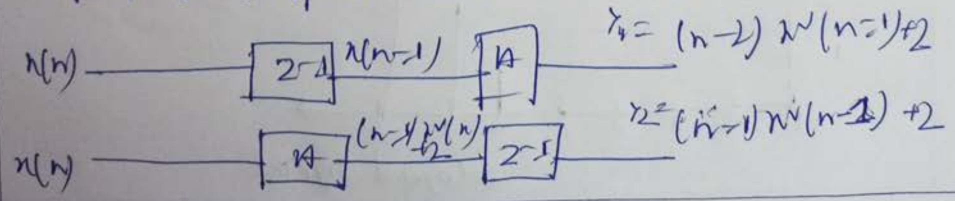
$y(2) = x^2(2) + 2$

Hence, the system is causal.

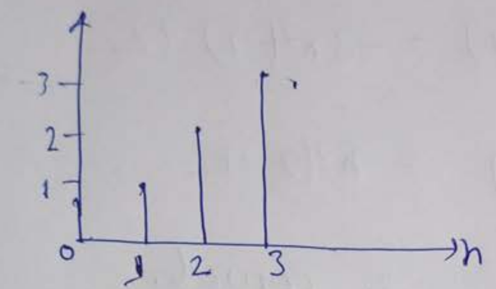
c) checking if system is dynamic: system is dynamic if output depends on ~~present~~ past or future input.

Here output, only depends on present input hence it is a static system.

d) Checking of time invariant: A system is said time invariant if it's input & output doesn't change with time.



As $y_1 \neq y_2$, hence it's a time variant system.



original signal.

$x(n) = \{\underset{\uparrow}{0}, 1, 2, 3\}$

c) let, $x_1(n) = x(n-3)$

$\therefore x_1(0) =$
$x_1(1)$

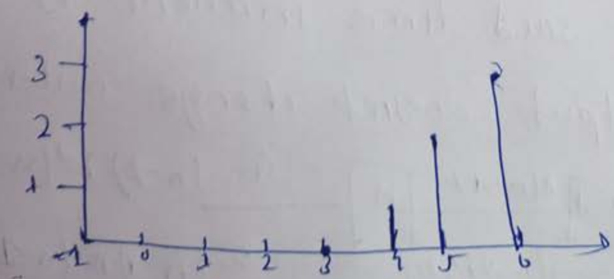
Hence, here the signal is delayed by 3 units.

When $n = 3;\ x_1(3) = x(0) = 0$

$n = 4;\ x_1(4) = x(1) = 1$

$n = 5;\ x_1(5) = x(2) = 2$

$n = 6;\ x_1(6) = x(3) = 3$



Delayed signal

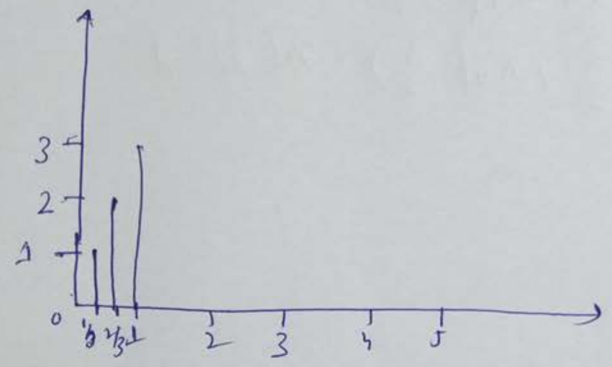
5.c. Let $x_2(n) = x(3n)$

When, $n=0$, $x_2(0) = x(0) = 0$

$n=1$, $x_2(1) = x(3) = 3$

$n=\frac{2}{3}$, $x_2\left(\frac{2}{3}\right) = x(2) = 2$

$n=\frac{1}{3}$, $x_2(.33) = x(1) = 1$



Here, signal has been downsampled.

b. Let $x_3(n) = x(n/4)$

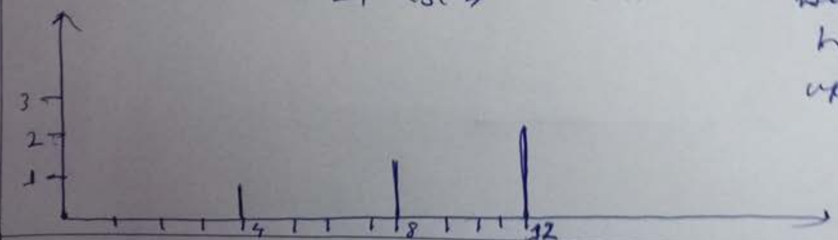
When, $n=0$, $x_3(0) = x(0) = 0$

$n=4$, $x_3(4) = x(1) = 1$

$n=8$, $x_3(8) = x(2) = 2$

$n=12$, $x_3(12) = x(3) = 3$

Here signal has been upsampled.



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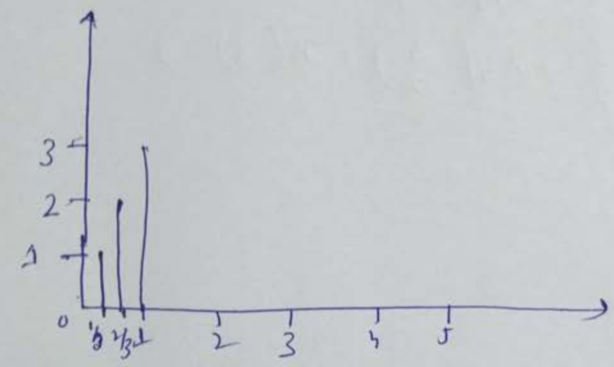

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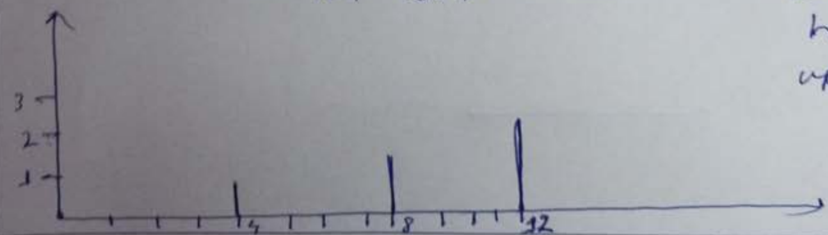


Here signal has been upsampled.

d. $x(-2n)$

↳ here the signal is folded & scaled too.

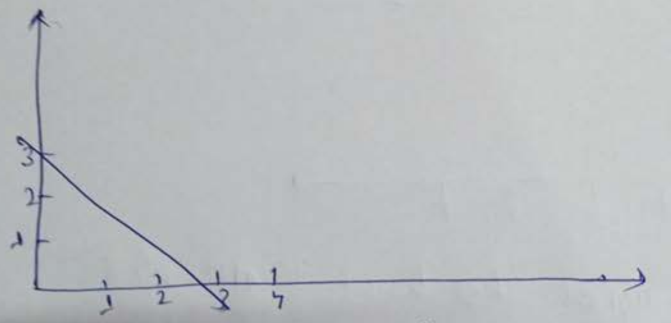
let $x_4(n) = x(-2n)$

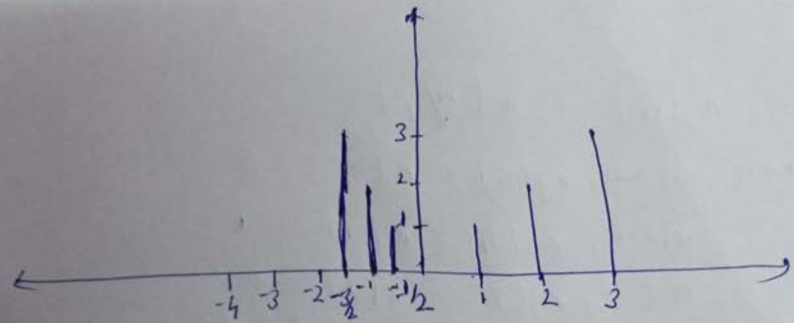
when, $n=0$, $x_4(0) = x(0) = 0$

$n = -1/2$, $x_4(-\frac{1}{2}) = x(1) = 1$

$n = -1$, $x_4(-1) = x(2) = 2$

$n = -\frac{3}{2}$, $x_4(-\frac{3}{2}) = x(3) = 3$





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When, $n = 0$, $x_4(0) = x(0) = 0$

$n = -1/2$, $x_4(-\frac{1}{2}) = x(1) = 1$

$n = -1$, $x_4(-1) = x(2) = 2$

$n = \frac{-3}{2}$, $x_4(-\frac{3}{2}) = x(3) = 3$