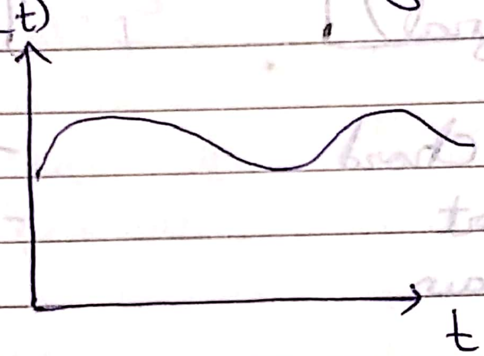
1. Discrete Time Signals (20-Marks

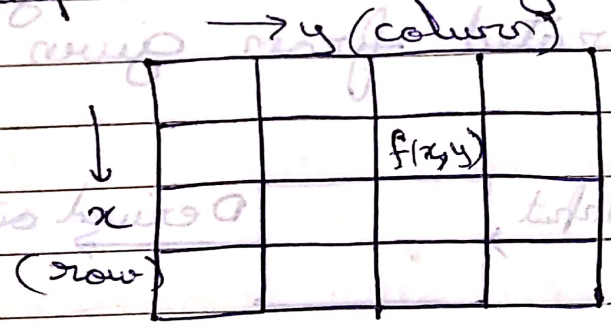
Introduction: Signal System & Signal Processing

1 Signal:- Any Physical quantity which varies with one or more independent variables.

Example:- 1D Signal



Example:- 2D Signal

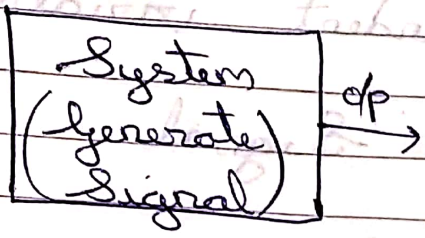


- Image (Light Intensity / Space Row-Column)

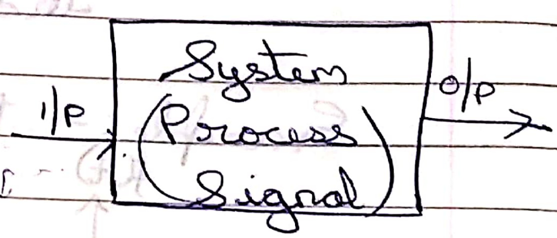
- Sound Signal (Audio / Time)
- ECG Signal (Heart Activity / Time)
- ECG Signal (Brain Activity / Time)
- Seismic Signal (Vibration) / Time)

2. System :- It is means by which signal is generated or processed.

Example - Generate



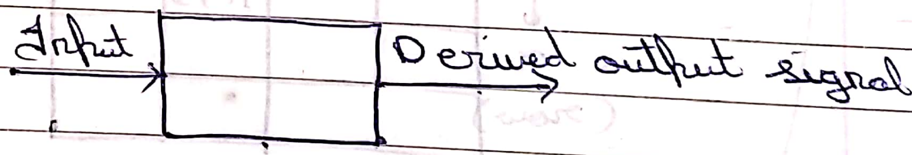
Example - Processed



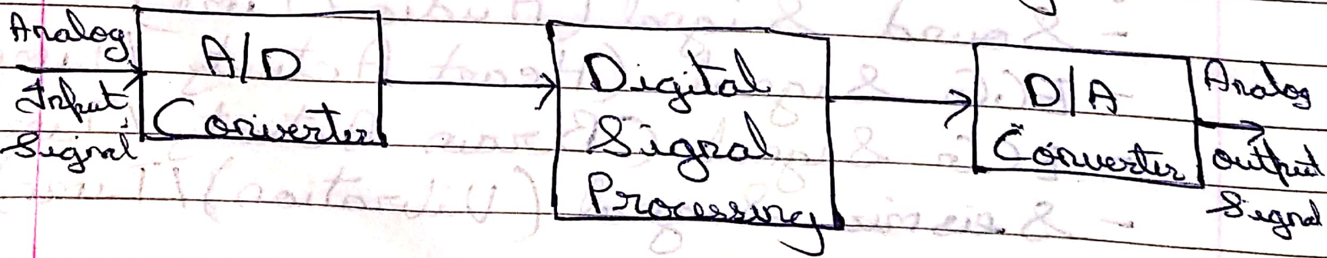
- Vocal Chord
- Heart
- Brain

- Amplifier
- Filter

3. Signal Processing :- It is a process by which desired signal is generated from given signal



→ Digital Signal Processing



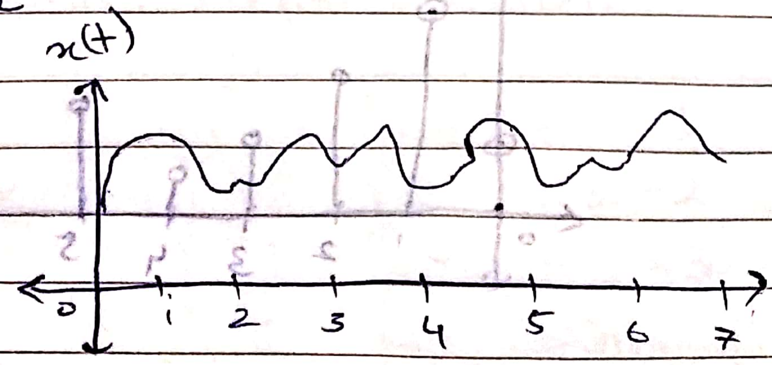
VIVA

Analog Signal Processing	Digital Signal Processing
- Uses Analog devices mostly hardware based	- Uses Digital devices mostly S/W based.
- Less Flexibility	- More Flexibility
- Less accuracy due to device tolerance	- High Accuracy
- No storage of signal possible	- Storage of signal possible
- Low Cost	- High Cost
- High Bandwidth	- Low Bandwidth

→ Classification of Signals 5-10 Marks

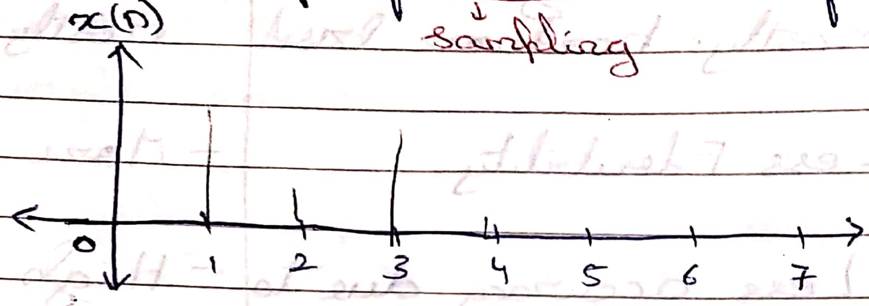
1. Continuous Time / Discrete Time Signals

- Continuous Time Signals are those which exists for all instants of time



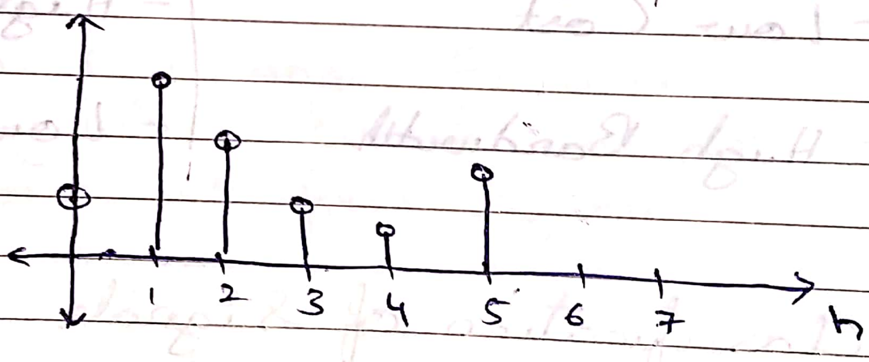
- Discrete Time Signal (DT) signal are those which exists for only certain specific instants of time

sampling

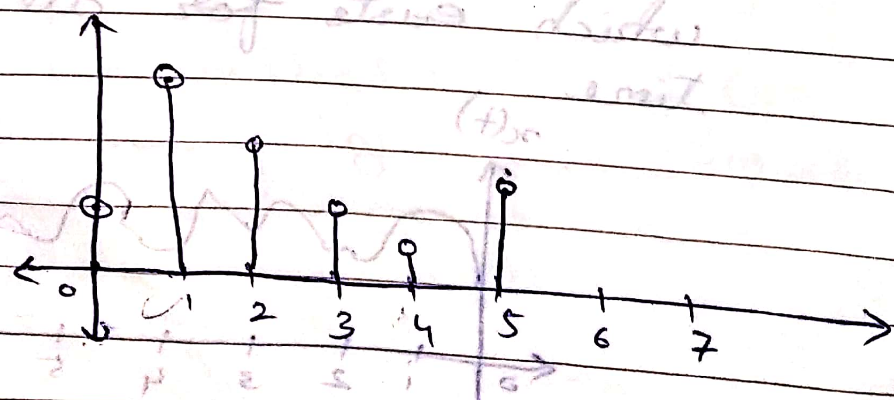


2. Continuous Valued / Discrete Valued Signal

- Continuous Valued Signals can take any value or magnitude.



- Discrete Valued Signals can take only limited set of values (Quantization Levels)



Analog Signal - Continuous Time & Continuous Values

Sampling

↓ (Discrete Time)

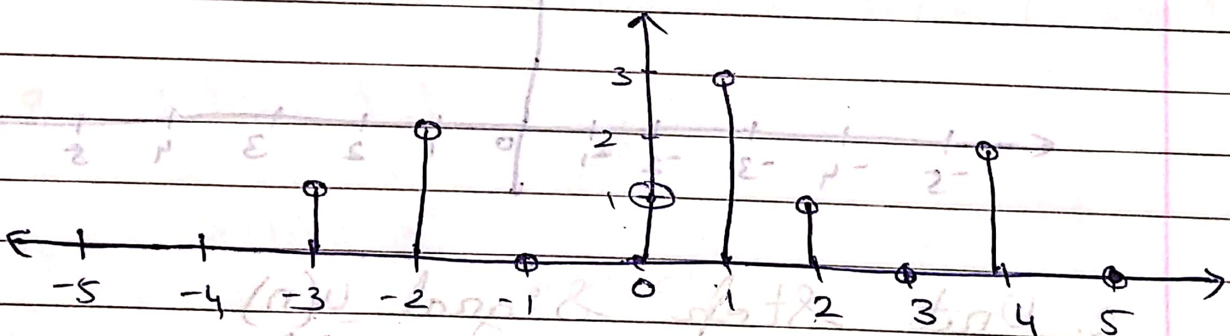
Quantization

↓ (Discrete Values)

Digital Signal - Discrete Time & Discrete Values

→ Representation of Discrete Time Signals

1. Graphical Representation



2. Functional Representation

$$x(n) = \begin{cases} 3 & \text{for } n = 1 \\ 2 & \text{for } n = -2, 4 \\ 1 & \text{for } n = -3, 0, 2 \\ 0 & \text{for otherwise} \end{cases}$$

3. Tabular Representation

-4	-3	-2	-1	0	1	2	3	4	5
0	1	2	0	1	3	1	0	2	0

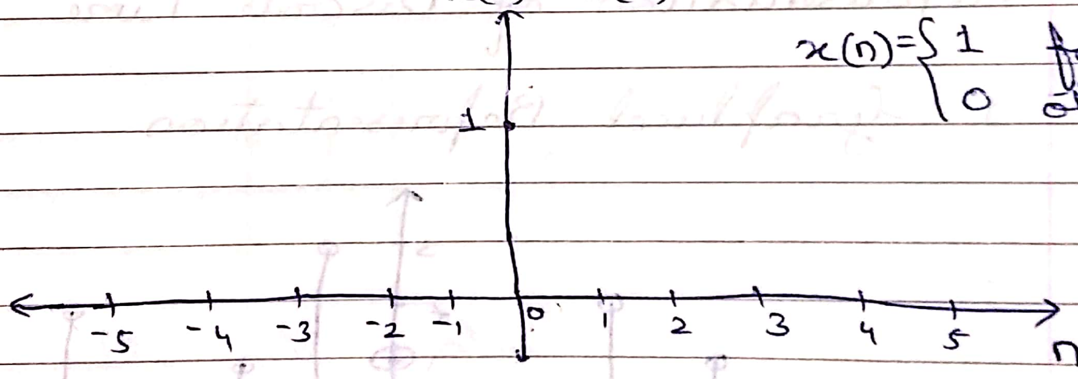
4. Sequence Representation

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

→ Standard D.T. Signals

1. Unit Impulse / Delta Signal $\delta(n)$

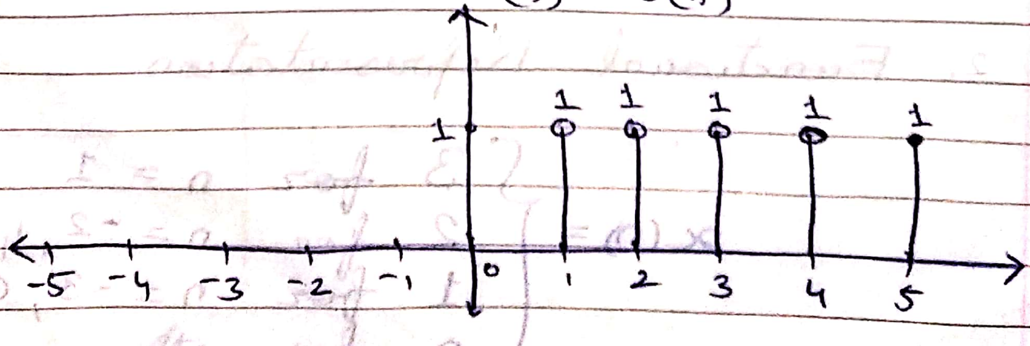
$x(n) = \delta(n)$



$$x(n) = \begin{cases} 1 & \text{for } n = 0 \\ 0 & \text{otherwise} \end{cases}$$

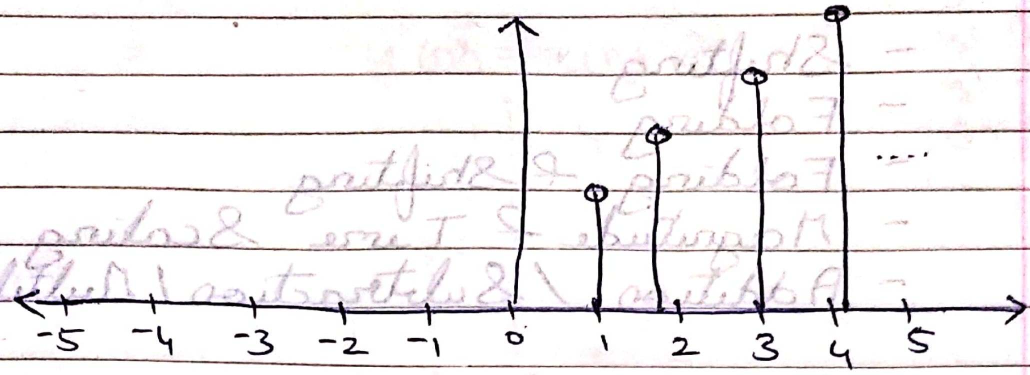
2. Unit Step Signal $u(n)$

$x(n) = u(n)$



$$x(n) = \begin{cases} 1 & \text{for } n \geq 0 \\ 0 & \text{otherwise} / n < 0 \end{cases}$$

3. Unit Ramp Signal $U_r(n)$



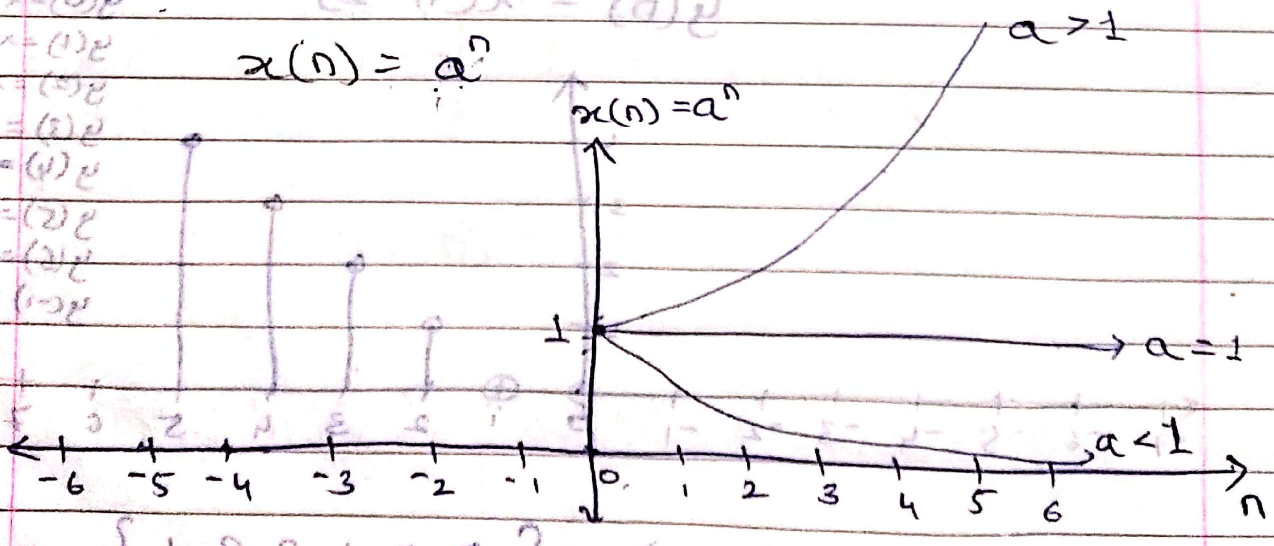
$$x(n) = \begin{cases} n & \text{for } n \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

4. Sinusoidal Signal

$$x(n) = A \sin(\omega n + \phi) = A \sin(2\pi f n + \phi)$$
$$x(n) = A \cos(\omega n + \phi) = A \cos(2\pi f n + \phi)$$

5. Exponential Signal

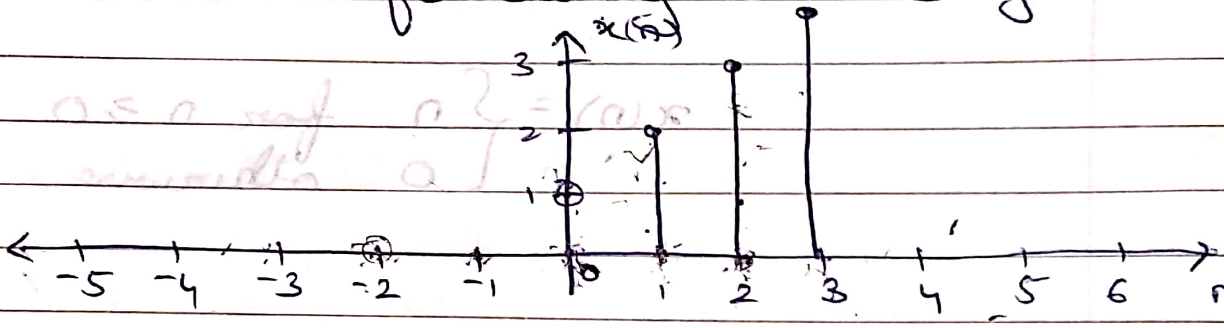
$$x(n) = a^n$$



→ Signal Manipulation 10 Marks

- Shifting
- Folding
- Folding & Shifting
- Magnitude & Time Scaling
- Addition / Subtraction / Multiplication

- Consider following D.T. Signal



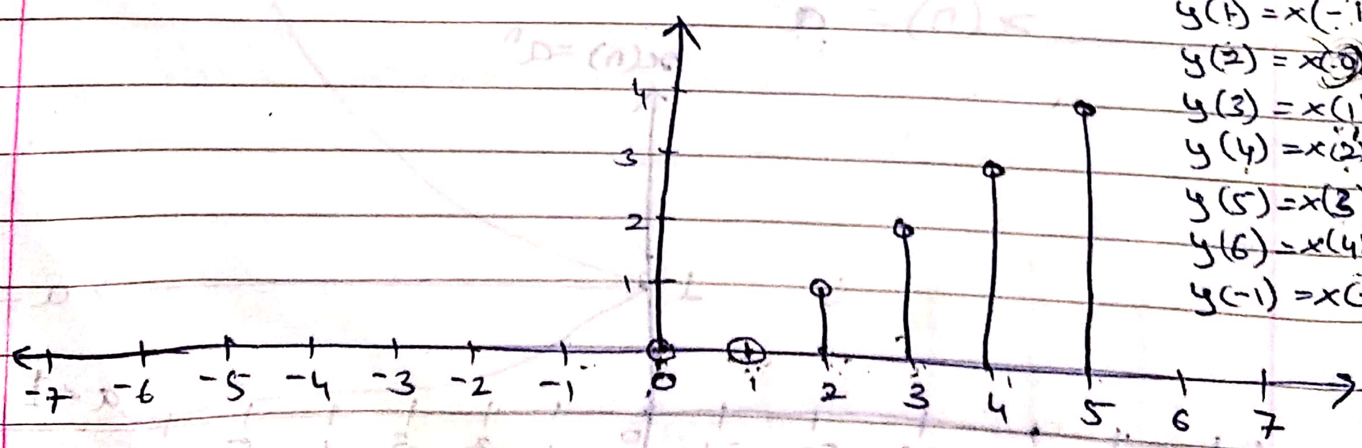
A. Shifting Operation - (Right / Left Shift)

$x(n-k)$ Right Shift $x(n+k)$ Left Shift

- Perform $x(n-2)$

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

$y(0) = x(-2)$
$y(1) = x(-1)$
$y(2) = x(0)$
$y(3) = x(1)$
$y(4) = x(2)$
$y(5) = x(3)$
$y(6) = x(4)$
$y(-1) = x(-3)$

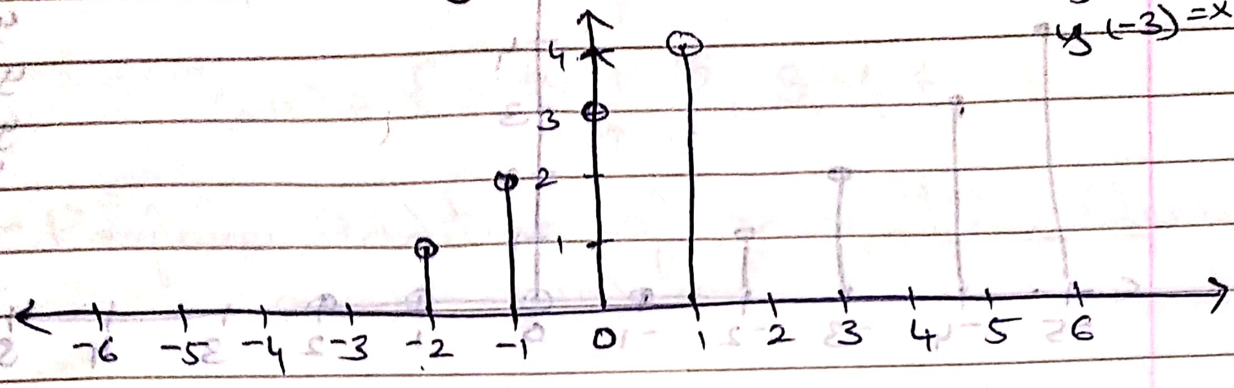


$$x(n-2) = \{\underset{\uparrow}{0}, 0, 1, 2, 3, 4\}$$

- Perform $x(n+2)$

$y(0) = x(2)$
$y(1) = x(3)$
$y(2) = x(4)$
$y(-1) = x(1)$
$y(-2) = x(0)$
$y(-3) = x(-1)$

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

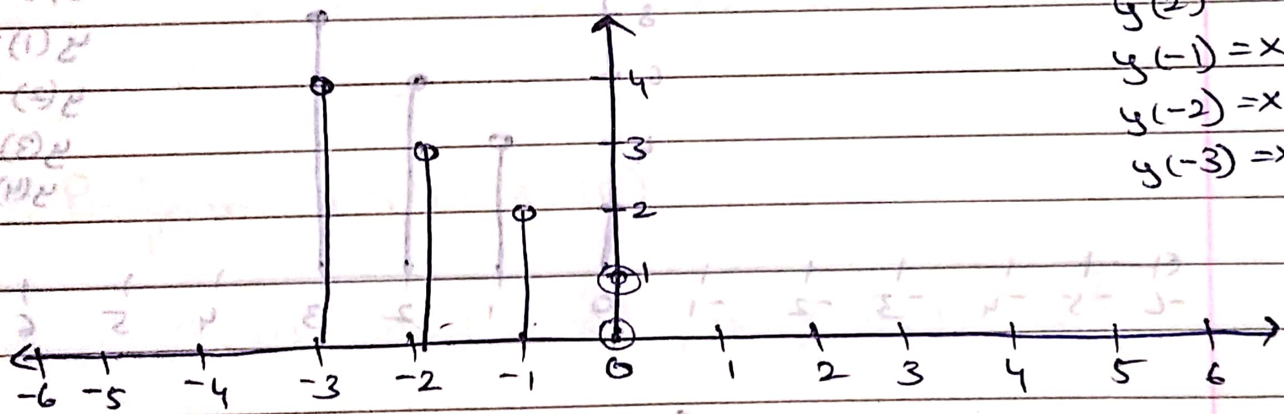


$$x(n+2) = \{1, 2, \underset{\uparrow}{3}, 4\}$$

B. Folding Operation $x(-n)$

- Perform $x(-n)$

$y(0) = x(0)$
$y(1) = x(-1)$
$y(2) = x(-2)$
$y(-1) = x(1)$
$y(-2) = x(2)$
$y(-3) = x(3)$

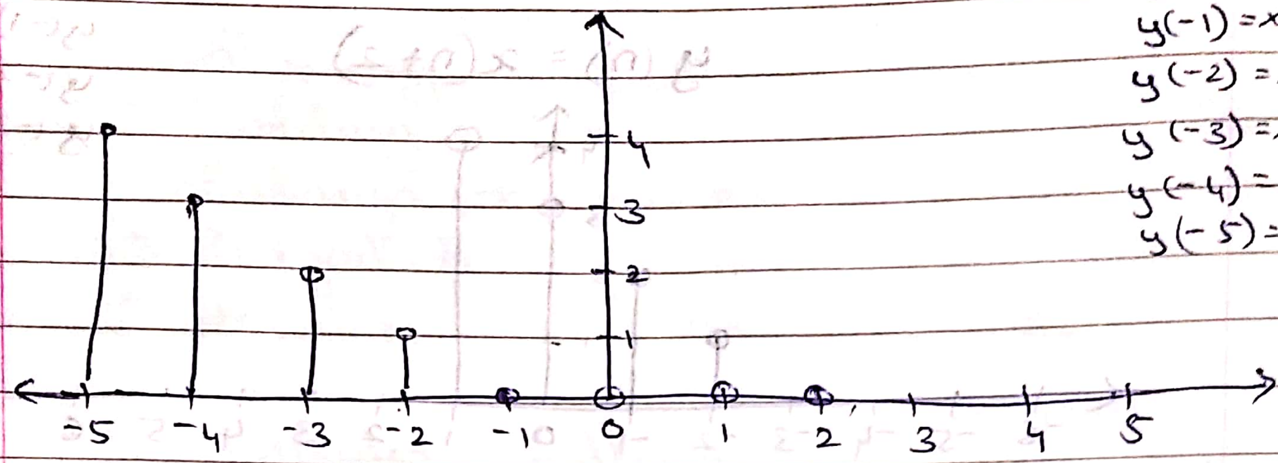


$x(-n) =$

C. Folding & Shifting (Needed for Convolution)

- Perform $x(-n-2)$

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

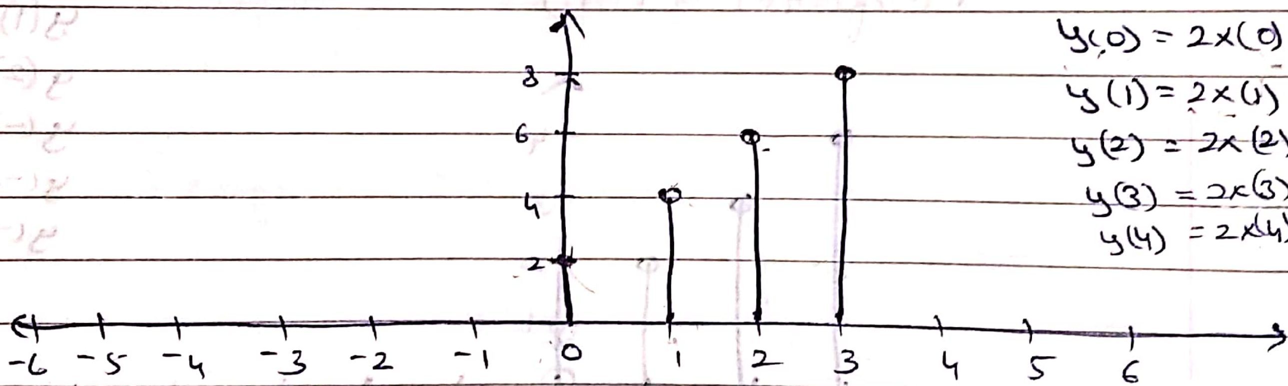


$y(0) = x(-2)$
$y(1) = x(-3)$
$y(2) = x(-4)$
$y(-1) = x(-1)$
$y(-2) = x(0)$
$y(-3) = x(1)$
$y(-4) = x(2)$
$y(-5) = x(3)$

$$x(-n-2) = \{4, 3, 2, 1, 0, \underset{\uparrow}{0}\}$$

D. Magnitude / Time Scaling

- Magnitude Scaling - Perform $2x(n)$

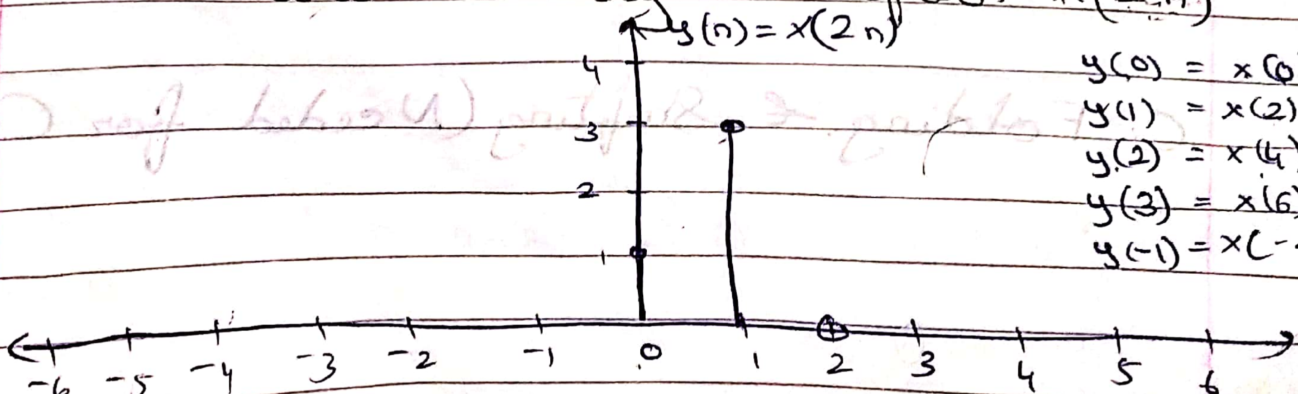


$y(0) = 2x(0)$
$y(1) = 2x(1)$
$y(2) = 2x(2)$
$y(3) = 2x(3)$
$y(4) = 2x(4)$

$$x(n) = \{\underset{\uparrow}{2}, 4, 6, 8\}$$

- Time Scaling - Perform $x(2n)$

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



$y(0) = x(0)$
$y(1) = x(2)$
$y(2) = x(4)$
$y(3) = x(6)$
$y(-1) = x(-2)$

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

→ Arithmetic Operations between two signals

∴ Let $x_1(n) = \{4, 5, \underset{\uparrow}{2}, 1, 4, 3\}$

$x_2(n) = \{3, 2, \underset{\uparrow}{1}, 2, 3, 4\}$

- Perform Addition of Same Index Element

$x_1(n) + x_2(n)$

$\therefore x_1(n) + x_2(n) = \{7, 7, \underset{\uparrow}{3}, 3, 7, 7\}$

- Perform $x_1(n) - x_2(n)$

$\therefore x_1(n) - x_2(n) = \{1, 3, \underset{\uparrow}{1}, -1, 1, -1\}$

- Perform $x_1(n) \cdot x_2(n)$

$\therefore x_1(n) \cdot x_2(n) = \{12, 10, \underset{\uparrow}{2}, 2, 12, 12\}$

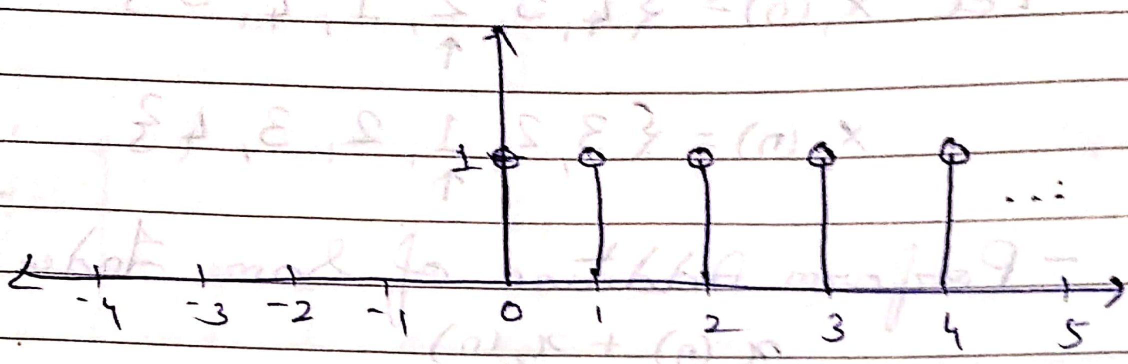
Example - Obtain following

1. $u(-n)$
2. $u(-n-1)$

P.T.O.

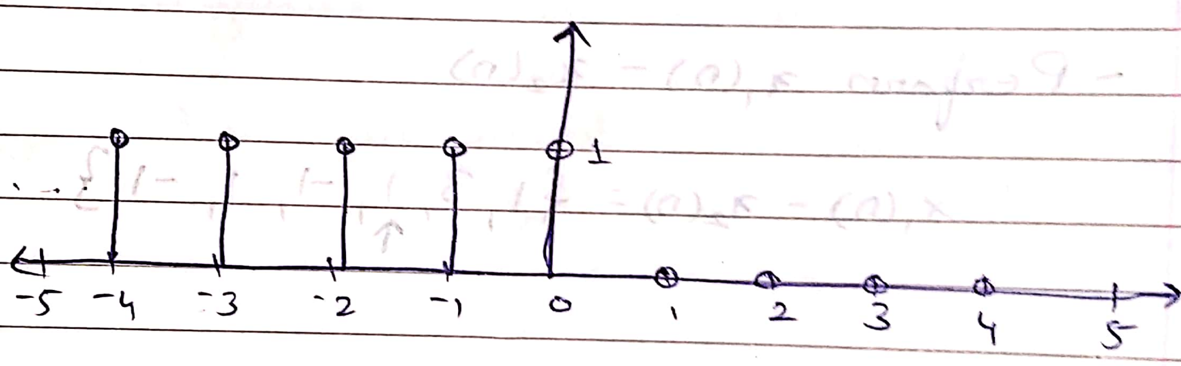
Solution:- Consider Unit Step Signal

$u(n)$



1. Folding Operation $u(-n)$

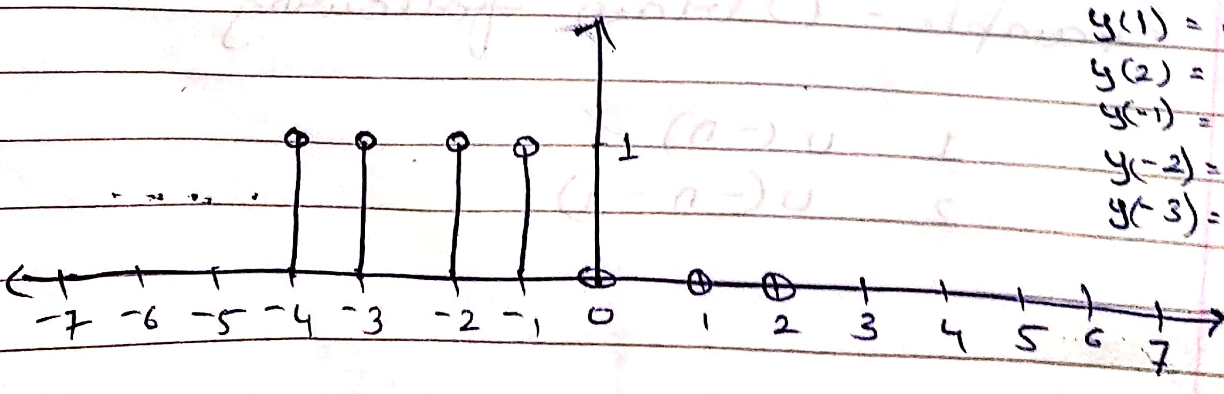
$$y(n) = u(-n)$$



2. Folding & Shifting Operation $u(-n-1)$

$$y(n) = u(-n-1)$$

$y(0) = y(-1)$
$y(1) = y(-2)$
$y(2) = u(-3)$
$y(-1) = y(0)$
$y(-2) = u(1)$
$y(-3) = u(2)$
⋮



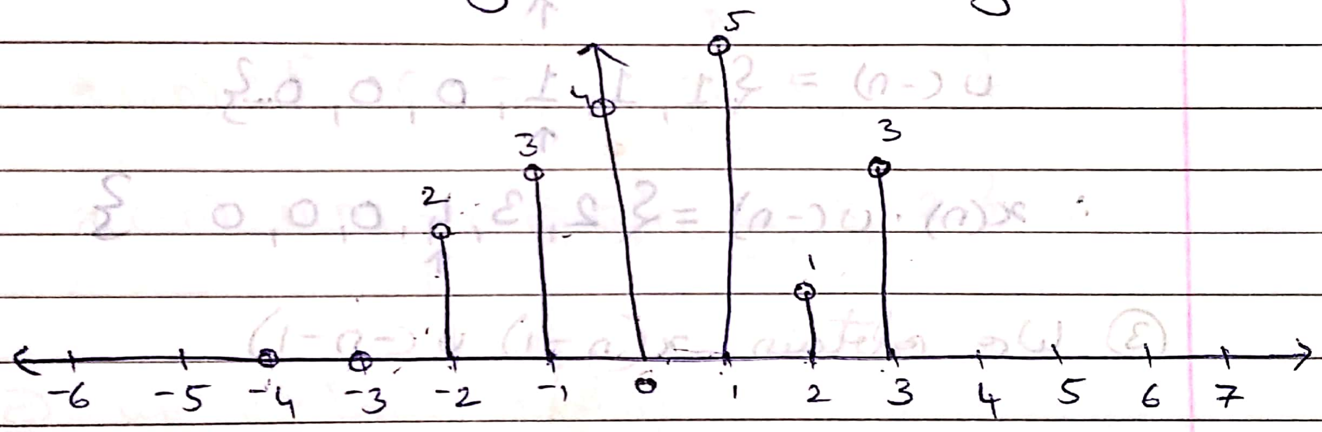
Eg- Signal Manipulation 10 Marks

May 2016 → Q 3.A

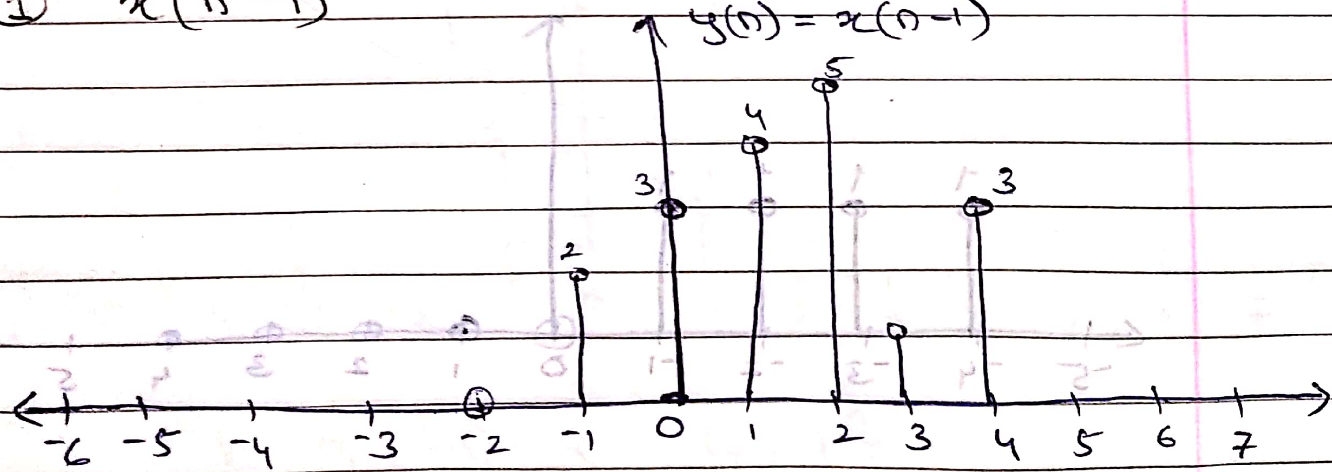
For $x(n) = \{2, 3, \underset{\uparrow}{4}, 5, 1, 3\}$ plot the following Discrete Time Signals

① $x(n-1)$. ② $x(n) \cdot u(-n)$ ③ $x(n-1)\, u(-n-1)$
④ $x(-n)\, u(n)$ ⑤ $x(2n)$

- Consider given D.T. Signal



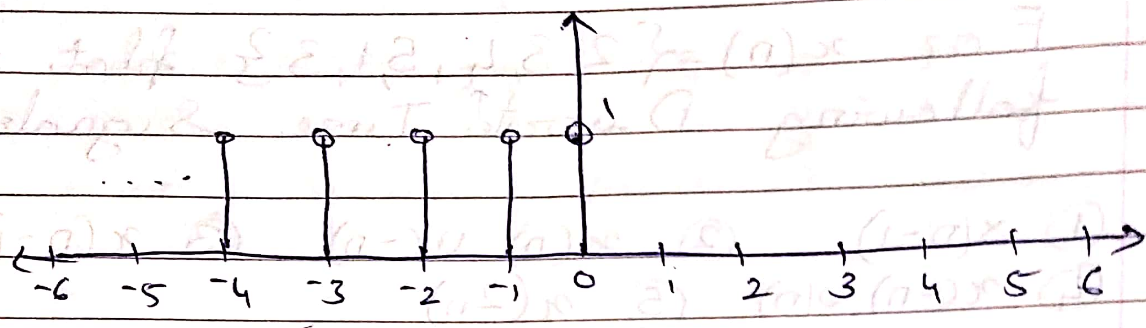
① $x(n-1)$



$\therefore x(n-1) = \{2, \underset{\uparrow}{3}, 4, 5, 1, 3\}$

(2) We obtain $x(n) \cdot u(-n)$

Consider $u(-n)$



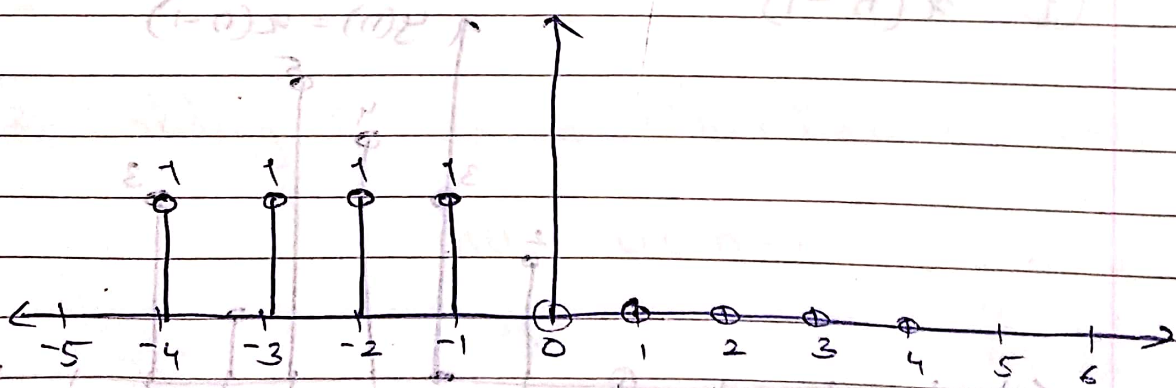
$$\therefore x(n) = \{2, 3, \underset{\uparrow}{4}, 5, 1, 3\}$$

$$u(-n) = \{\ldots 1, 1, \underset{\uparrow}{1}, 0, 0, 0 \ldots\}$$

$$\therefore x(n) \cdot u(-n) = \{2, 3, \underset{\uparrow}{4}, 0, 0, 0\}$$

(3) We obtain $x(n-1)\, u(-n-1)$

Consider $u(-n-1)$



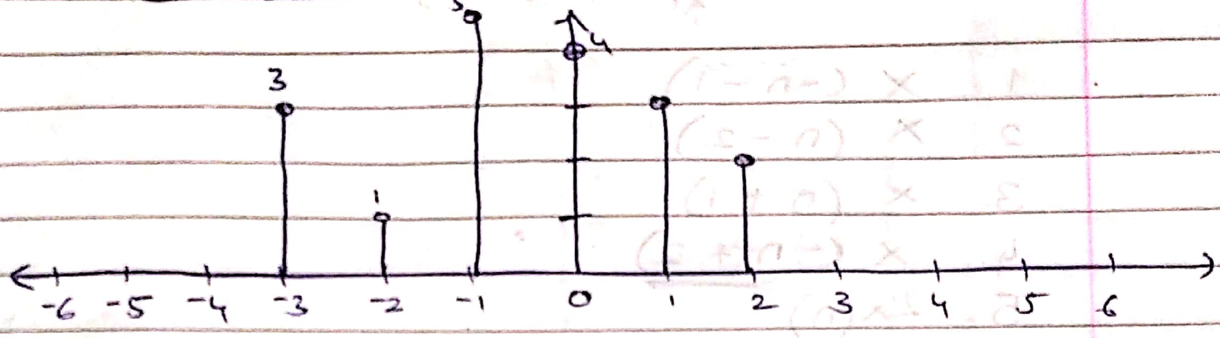
$$x(n-1) = \{2, \underset{\uparrow}{3}, 4, 5, 1, 3\}$$

$$u(-n-1) = \{\ldots 1, \underset{\uparrow}{0}, 0, 0, 0, 0 \ldots\}$$

$$\therefore x(n-1)\, u(-n-1) = \{2, \underset{\uparrow}{0}, 0, 0, 0, 0\}$$

④ We obtain $x(-n)\,u(n)$

Consider $x(-n)$



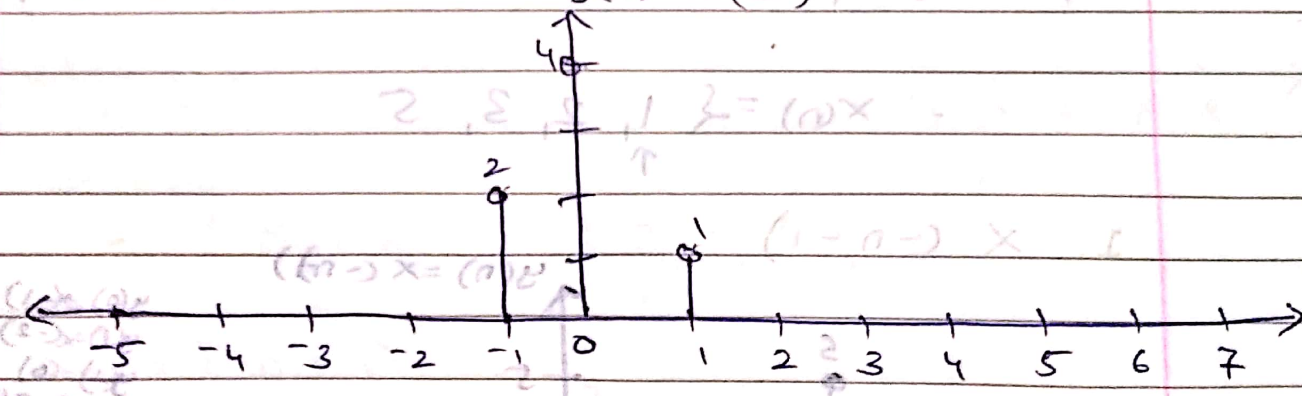
$x(-n) = \{3, 1, 5, \underset{\uparrow}{4}, 3, 2\}$

$u(n) = \{0, 0, 0, \underset{\uparrow}{1}, 1, 1\}$

$\therefore x(-n)\cdot u(n) = \{0, 0, 0, \underset{\uparrow}{4}, 3, 2\}$

⑤ We obtain $x(2n)$

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



$x(2n) = \{2, \underset{\uparrow}{4}, 1\}$

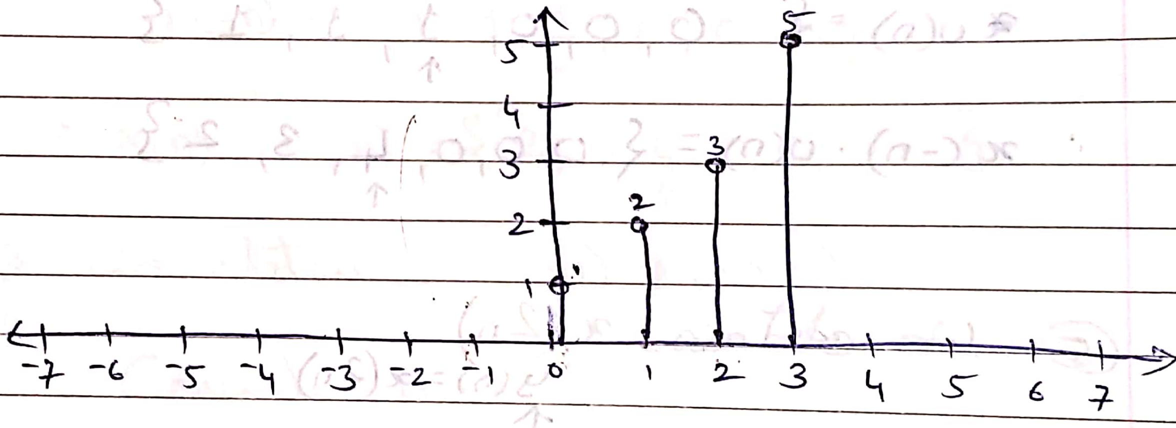
Eg

21. $x(n) = \{\underset{\uparrow}{1}, 2, 3, 5\}$

1. $x(-n-1)$
2. $x(n-2)$
3. $x(n+1)$
4. $x(-n+2)$
5. $2x(n)$

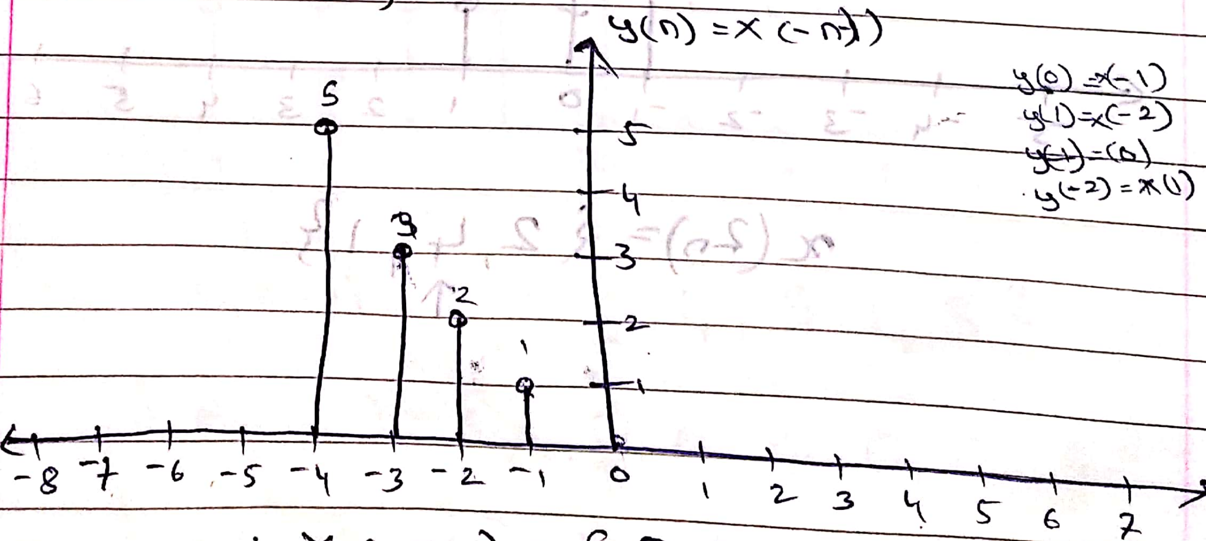
~~1 $x(-n-1)$~~

Consider $x(n)$



$\therefore x(n) = \{\underset{\uparrow}{1}, 2, 3, 5$

1. $x(-n-1)$

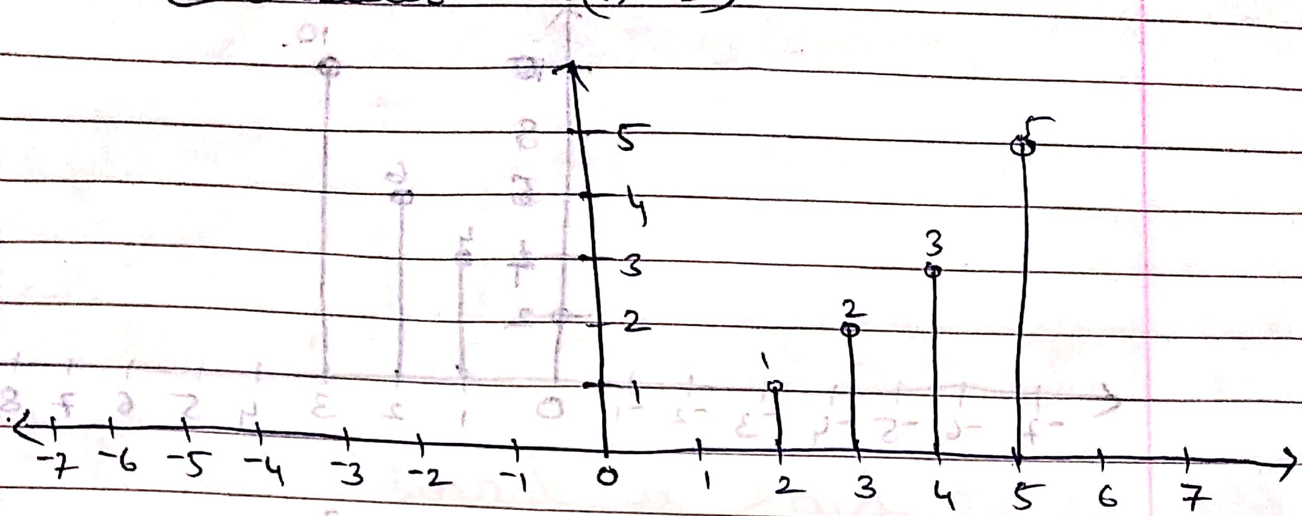


$y(0) = x(-1)$
$y(1) = x(-2)$
$y(-1) = x(0)$
$y(-2) = x(1)$

$\therefore x(-n-1) = \{5, 3, 2, 1, \underset{\uparrow}{0}\}$

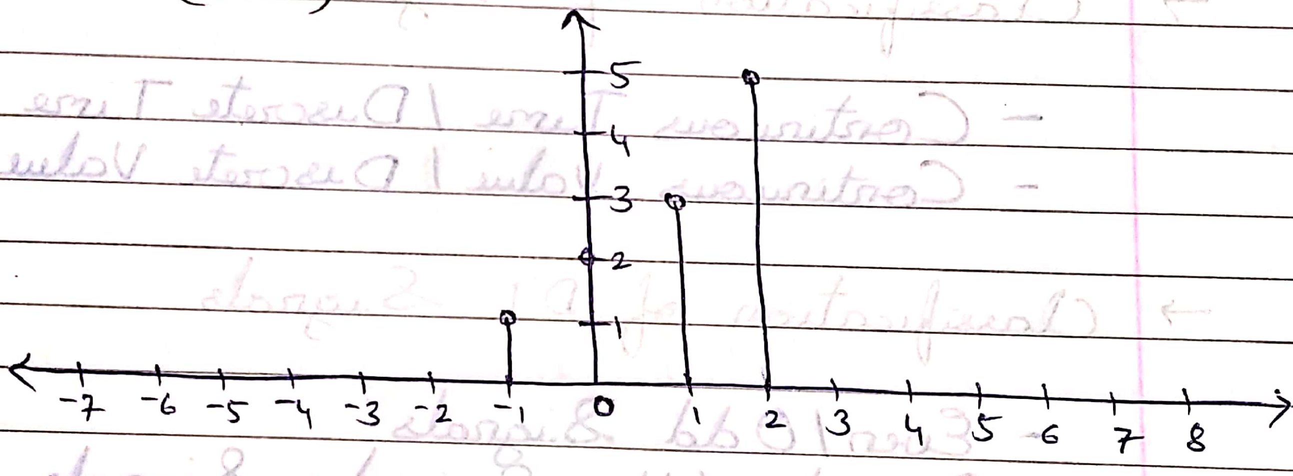
2. $x(n-2)$

Consider $x(n-2)$



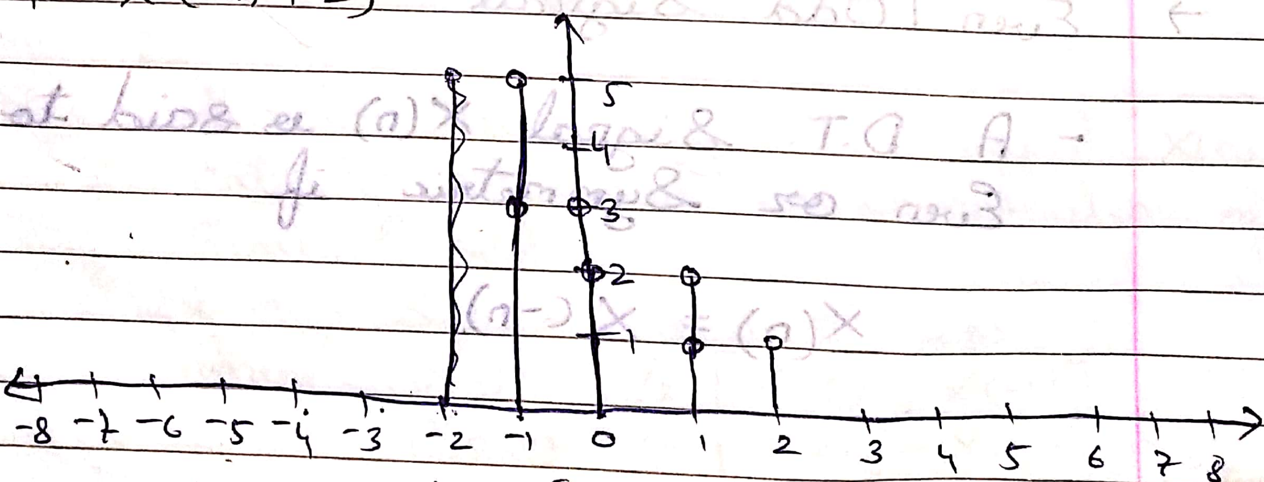
$\therefore x(n-2) = \{\underset{\uparrow}{0}, 0, 1, 2, 3, 5\}$

3. $x(n+1)$



$\therefore x(n+1) = \{1, \underset{\uparrow}{2}, 3, 5\}$

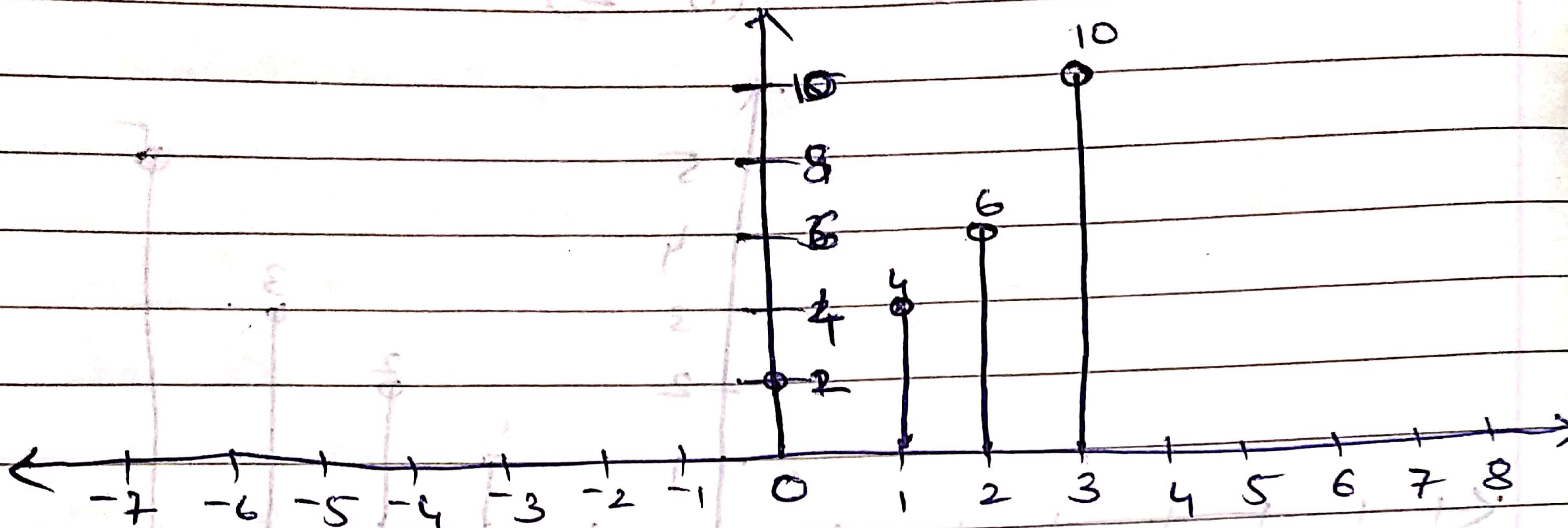
4. $x(-n+2)$



$\therefore x(-n+2) = \{5, \underset{\uparrow}{3}, 2, 1\}$

}

5. $2x(n)$



$\therefore 2x(n) = \{ \underset{\uparrow}{2}, 4, 6, 10 \}$