Experiment Number:

Name of the experiment: To explain and implement Discrete Fourier Transform (DTF) and Inverse Discrete Fourier transform.

Objectives:

① To get basic and general knowledge about DTF and IDFT.

② To generate a computer code which implements the DFT and IDFT

Theory:

DFT: DFT (Discrete Fourier Transform), a mathematical technique used to convert a discrete time signal from the time domain to frequency domain. It is commonly used in signal processing and communication system to analyze or manipulate signals in the frequency domain. considering $x[n]$ as an N-point sequence. Hence DTF of $x[n]$ is given by

$$x[k] = \sum_{n=0}^{N-1} x[n] \, e^{-j\frac{2\pi}{N}nk}$$

IDFT: IDFT (Inverse Discrete ~~Time~~ Fourier Transform which is used to convert a signal from the frequency domain back to the time domain. It is reverse of DFT operation and it is used to reconstruct a signal from its frequency domain representation and the IDFT is given by

$$x[n] = \frac{1}{N} \sum_{k=0}^{N-1} x[k] \, e^{j\frac{2\pi}{N}nk}$$

Example

Let us consider an example and we have to determine DFT and IDFT of the given signal

$x(n) = \{1, 1, 1, 1\}$

$N = L = 4$

The DFT is given by $x[K] = \sum_{n=0}^{N-1} x(n)\, e^{-j\frac{2\pi}{N}nK}$ $\quad K = 0, 1, \ldots N-1$

Here, $N = 4$ and $N-1 = 3$ and the equation becomes

$$x[K] = \sum_{0}^{3} x(n)\, e^{-j\frac{2\pi}{4}K}$$

when $K = 0$; $x[0] = \sum_{0}^{3} x(n) e^{0}$

$$= x(0) + x(1) + x(2) + x(3)$$

$$= 4$$

when $K = 1$; $x[1] = \sum_{0}^{3} x(n)\, e^{-j\frac{\pi}{2}n}$

$$= x(0)e^{0} + x(1)\, e^{-j\frac{\pi}{2}} + x(2)e^{-j\pi} + e^{-j\frac{3\pi}{2}} x(3)$$

$$= 1 + 1(\cos \pi/2 - j\sin \pi/2) + 1(\cos\pi - j\sin\pi) + 1\left(\cos\frac{3\pi}{2} - j\sin\frac{3\pi}{2}\right)$$

$$= 0$$

when $K = 2$; $x[2] = \sum_{0}^{3} x(n)\, e^{-j\pi n}$

$$= x(0)e^{0} + x(1)e^{-j\pi} + x(2)e^{-j2\pi} + x(3)e^{-j3\pi}$$

$$= 1 + 1(\cos\pi - j\sin\pi) + 1(\cos 2\pi - j\sin 2\pi) + 1(\cos 3\pi - j\sin 3\pi)$$

$$= 0$$

When $k=3$; $x[3]=\sum_{0}^{3} x(n)\, e^{-j\frac{3\pi}{2}n}$

$= x(0)e^{0}+x(1)e^{-j\frac{3\pi}{2}}+x(2)^{-j3\pi}+x(3)^{-j\frac{9\pi}{2}}$

$=0$

Therefore, DFT of $x(n)$ is $x(k)=\{4,0,0,0\}$

To find IDFT, $x(n)=\frac{1}{N}\sum_{k=0}^{N-1} x(k)\, e^{\frac{2\pi}{N}nk}$

or, $x(n)=1/4\sum_{0}^{3} x(k)\, e^{j\frac{\pi}{2}nk}$

When $n=0$; $x(0)=1/4\sum_{0}^{3} x(k)e^{0}$

$=1/4\,[x(0)+x(1)+x(2)+x(3)]$

$=1$

When $n=1$; $x(1)=1/4\sum_{0}^{3} x(k)e^{j\pi/2k}$

$=1/4\left[x(0)e^{0}+x(1)e^{j\frac{\pi}{2}}+x(2)e^{j\pi}+x(3)e^{j\frac{3\pi}{2}}\right]$

$=1$

When $n=2$; $x(2)=\frac{1}{4}\sum_{0}^{3} x(k)\, e^{j\pi k}$

$=1/4\left[x(0)e^{0}+x(1)e^{j\pi}+x(2)\, e^{j2\pi}+x(3)e^{j3\pi}\right.$

$=1$

When $n=3$; $x(3)=1/4\sum_{0}^{3} x(3)\, e^{j\frac{3\pi}{2}k}$

$=1/4\left[x(0)\, e^{0}+x(1)\, e^{j\frac{3\pi}{2}}+x(2)e^{j3\pi}+\right.$

$\left.x(3)\, e^{j\frac{9\pi}{2}}\right]$

$=1$

Therefore the IDFT is $x(n)=\{1,1,1,1\}$

## Experiment Number: 02

## Name of the Experiment:

Let, $x(n) = \{1, 2, 3, 4, 5, 6, 7, 6, 5, 4, 3, 2, 1\}$ Determine and plot the following sequence

$x(n) = 2x(n-5) - 3x(n+4)$

## Objectives:

① To determine and plot sequence.

② To get knowledge about sifting and coding as well

## Theory:

A signal is defined as a function of one or more variables which conveys information on the nature of physical phenomenom. Sifting is an important properties that a signal can perform.

Let us consider $x(n)$ is a discrete time signal

The sifting of the signal is defined by

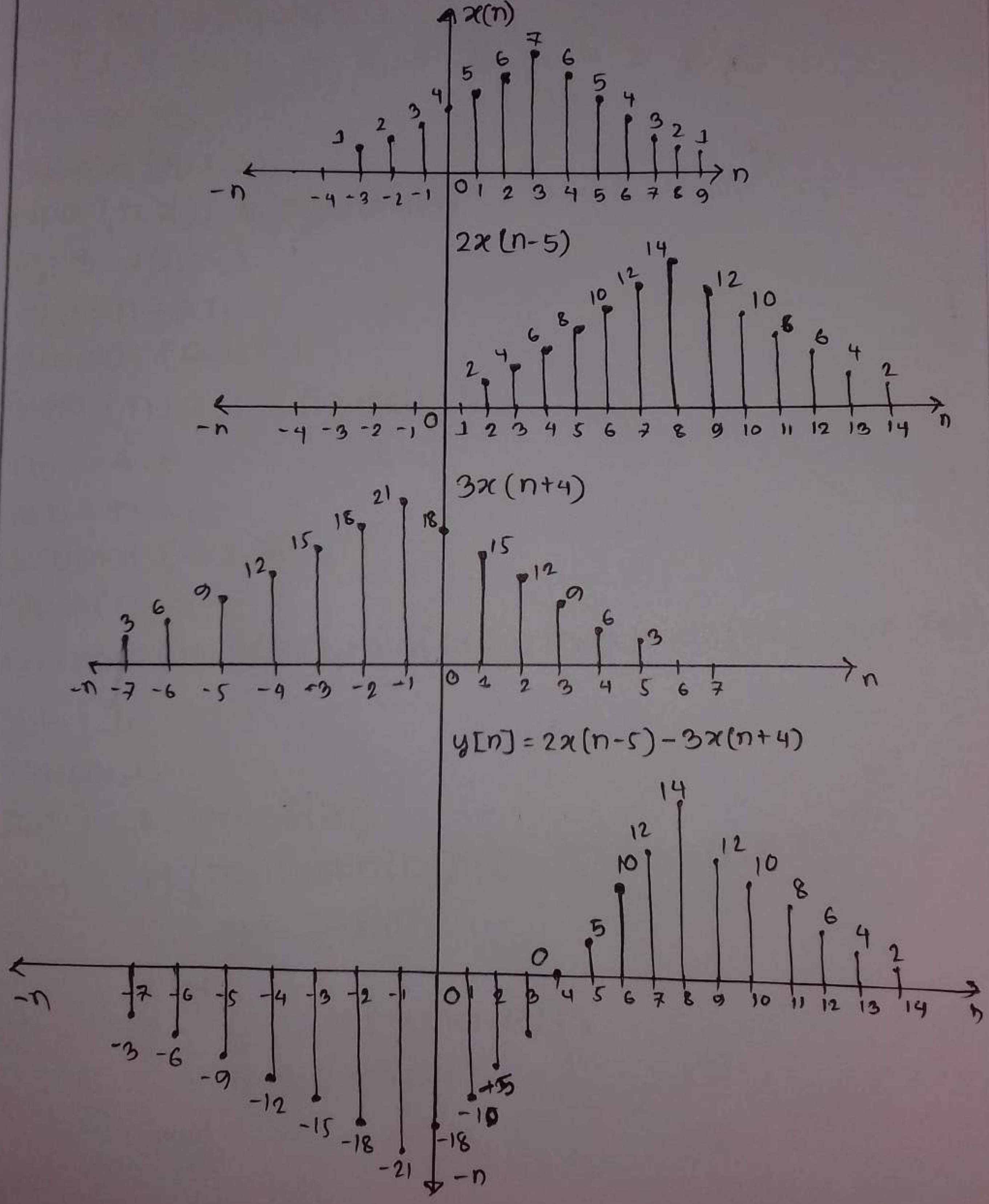
$y(n) = x(n - n_0)$

Here we want to sift the signal no unit

if $n_0 > 0$ then it sifts towards left else it sifts towards right.

Let us consider the above given signal

$x(n) = \{1, 2, 3, \underset{\uparrow}{4}, 5, 6, 7, 6, 5, 4, 3, 2, 1\}$



Experiment Number: 03

Name of The Experiment:

To write a matlab program to perform the following operation i) Sampling ii) Quantization iii) Coding

Objectives:

① To get general knowledge about sampling, Quantization and coding in signals and systems.

② To develop a computer code that generate sampling Quantization and coding

Theory:

Sampling: Sampling is a process by which continious time message signal converts into a sequence of numbers. In the case of sampling we have to select minimum of two sample per cycle. If we take more sample that's better for future process.

Quantization: Quantization is the process of representing the sampled values to the nearest level per selected values. which represent a finite number of amplitude level.

Coding: Representing each quantized value by a code word is know as coding. This is the final process of making $2^n$ input line to n output line. which is suitable for digital machine to under stand.

Source Code:

```
clc;
clear all;
close all;
A=5;
f=5;
t=0:0.001:2;
x=A*sin(2*pi*f*t);
subplot(4,1,1);
plot(t,x);
title('continious time signal');
xlabel('Time');
ylabel('Amplitude');
subplot(4,1,2);
title('sampling');
xlabel('Time');
```

Experiment Number: 04

Name of the experiment:

To determine and plot following sequences:

$$x(n) = 2\delta(n+2) - \delta(n-4), \; -5 \le n \le 5$$

Objectives:

① To get knowledge about discrete time unit implue

② To generate a MATLAB code that can explain it.

Theory:

Discrete Time unit impluse: In discrete time, the unit impluse is simply a sequence that is zero except $n=0$. In other words, it is determined as

$$\delta(n) = \begin{cases} 0; & n \neq 0 \\ 1; & n = 0 \end{cases}$$

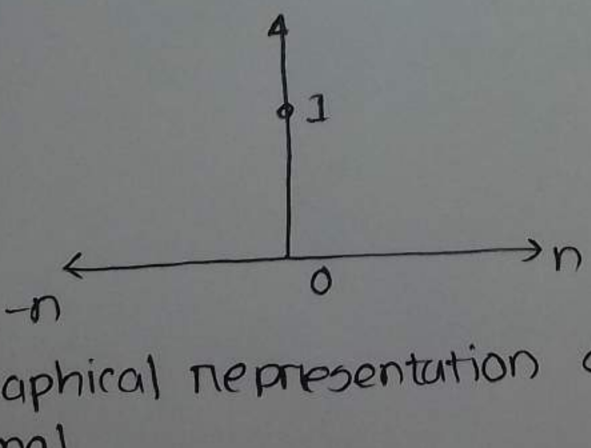



Figure: Graphical representation of the unit sample signal

Let us consider the sequence as same

$$x(n) = 2\delta(n+2) - \delta(n-4) \;;\; -5 \le n \le 5$$

when $n = -5$,

$$x(-5) = 2\delta(-3) - \delta(-9)$$

$$= 0$$

when $n = -4$,

$$x(-4) = 2\delta(-2) - \delta(-8)$$

$$= 0$$

when $n = -3$,

$$x(-3) = 2\delta(-1) - \delta(-7)$$

$$= 0$$

when $n = -2$,

$$x(-2) = 2\delta(0) - \delta(-6)$$

$$= 2$$

when $n = -1$

$$x(-1) = 2\delta(1) - \delta(-5)$$

$$= 0$$

when $n = 0$,

$$x(0) = 2\delta(2) - \delta(-4)$$

$$= 0$$

when $n = 1$,

$$x(1) = 2\delta(3) - \delta(-3)$$

$$= 0$$

when $n=2$,

$$x(2) = 2\delta(4) - \delta(-2)$$
$$= 0$$

when $n=3$,

$$x(3) = 2\delta(5) - \delta(-1)$$
$$= 0$$

when $n=4$,

$$x(4) = 2\delta(6) - \delta(0)$$
$$= 0 - 1$$
$$= -1$$

when $n=5$,

$$x(5) = 2\delta(7) - \delta(1)$$
$$= 0$$

Now the graphical representation of the given sequences are as follow

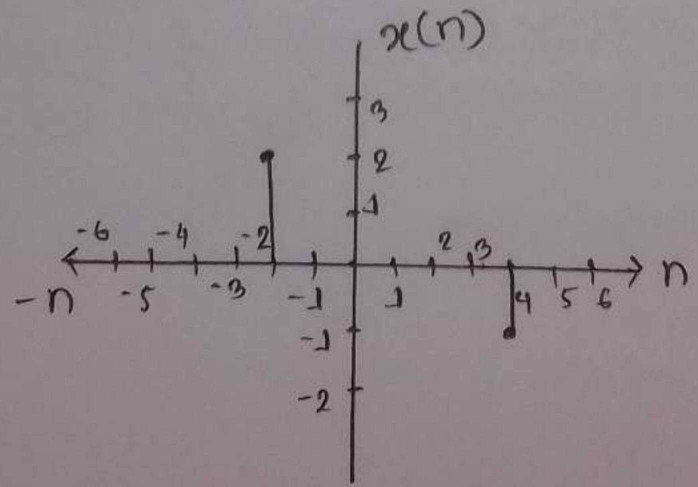



Figure: Discrete time implulse sequence

Experiment Number: 05

Name of the Experiment: To penform the following signal openations: (i) signal addition and ii) Signal folding using MATLAB and plot each of them.

Objectives

(1) To get knowledge about signal addition and signal folding.

(2) To generate a code that can perform those operation

Theory:

Signal Addition: For continuous time signal, If $x_1(t)$ and $x_2(t)$ are two signals, the signal $y(t)$ obtained by the addition of $x_1(t)$ and $x_2(t)$ is defined by

$$y(t) = x_1(t) + x_2(t)$$

For discrete time signal the signal addition is defined by

$$y[n] = x_1[n] + x_2[n]$$

Signal Folding: Signal folding is defined as, If $x(t)$ is a continious time signal, the signal $y(t)$ obtained by replacing t by -n [for discrete time n by -n] is called the reflected version of $x(t)$ [for discrete $x(n)$]. The reflected version represent signal folding

Examples of signal addition

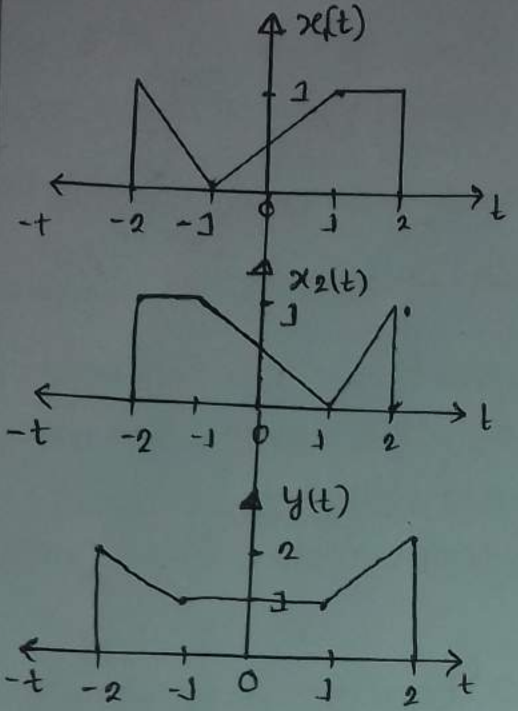



Figure: Continuous time signal Addition

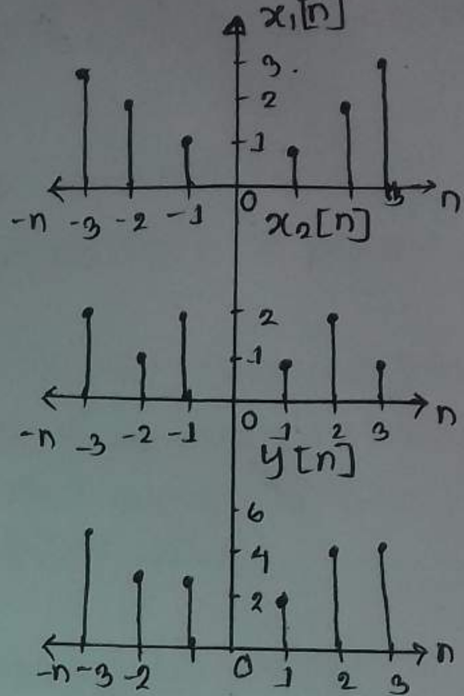



Figure: Discrete time signal Addition

## Example of signal folding

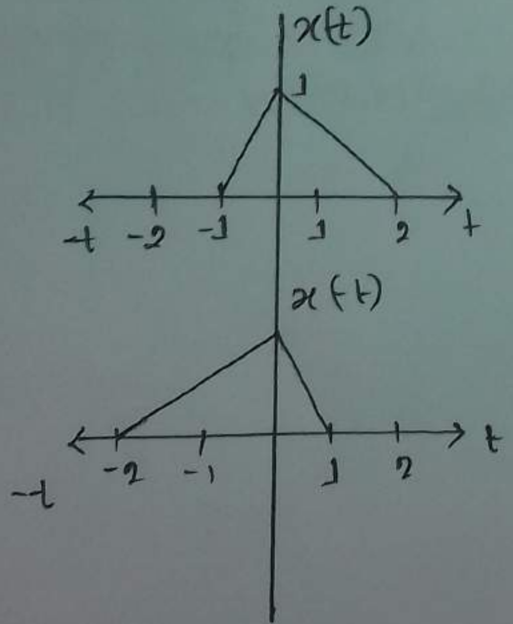



figure: Continious time Signal folding

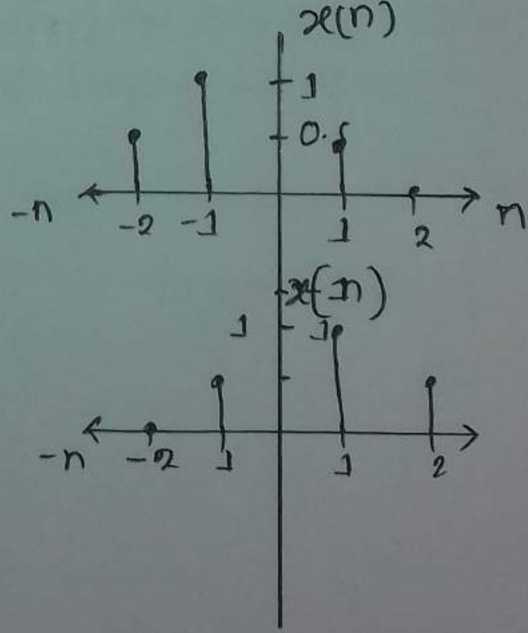



figure: Discrete time signal folding

Experiment Number: 06

Name of the experiment:
To perform the following signal operations: i) Signal multiplication ii) signal shifting using MATLAB and plot each of them.

## Objectives:

① To get knowledge about multiple operations on a ~~sigal~~ signal.

② To generate a code that can perform these operation

## Theory:

**Signal Multiplication:** The signal multiplication is defined as. if $x_1(t)$ and $x_2(t)$ are two signals, the signal $y(t)$ obtained by the multiplication of $x_1(t)$ and $x_2(t)$ is defined by

$$y(t) = x_1(t) * x_2(t)$$

For discrete time signal it is defined as

$$y(n) = x_1(n) * x_2(n)$$

**Signal Shifting:** If $x(t)$ is a continuous-time signal the signal (time) sifted version of $x(t)$ defined by

$y(t) = x(t - t_0)$ here $t_0$ is the time shift

* If $t_0 > 0$, the signat $x(t)$ is shifted intact to right
* If $t_0 < 0$, the signat $x(t)$ is shifted intact to left

For discrete time it is $y[n] = x[n-m]$ $\left\{ \begin{array}{l} m \text{ must be} \\ \text{an integer} \end{array} \right\}$

## Example of Signal Multiplication

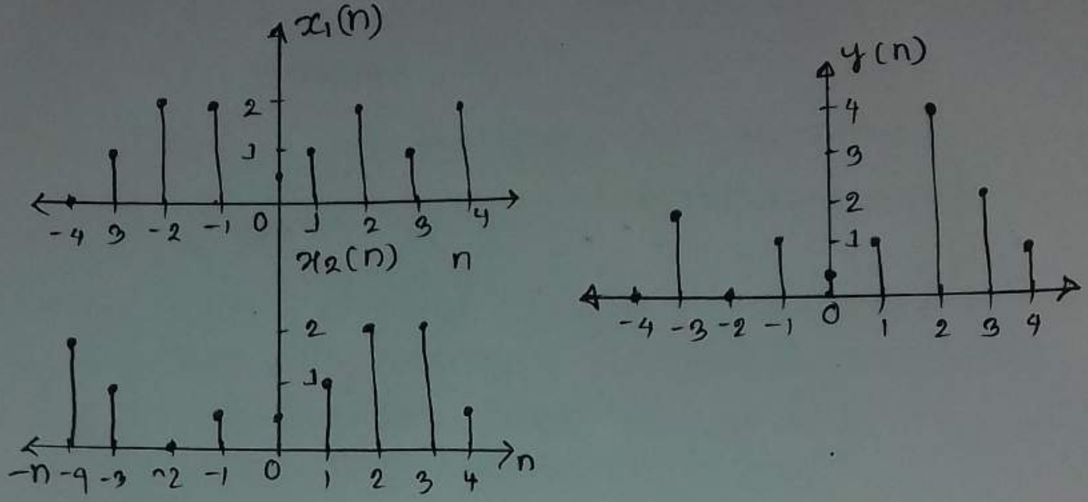



Figure: Signal Multiplication of Discrete time

## Example of signal shifting

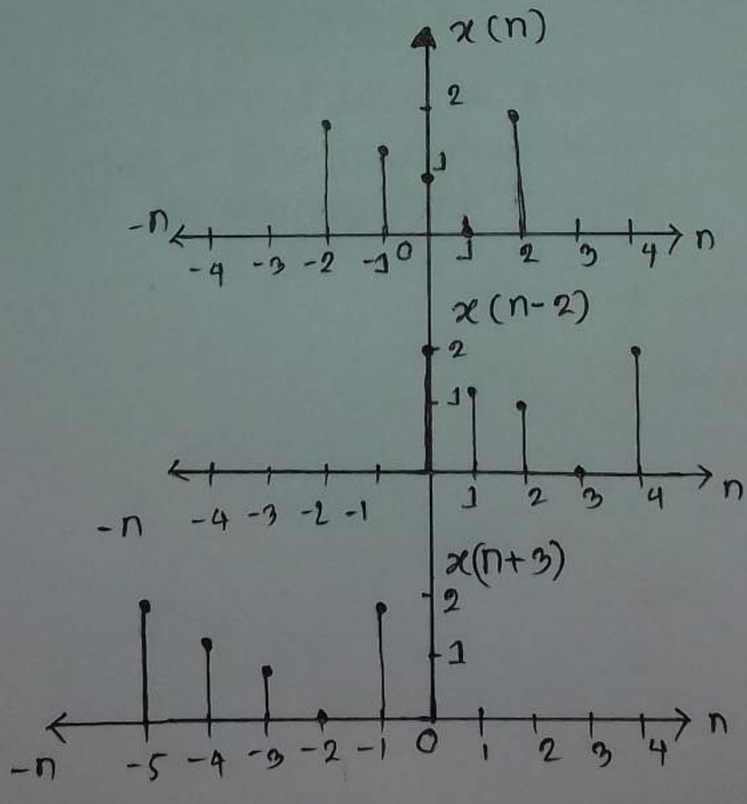



Figure: Discrete time signal shifting

Experiment Number:

Name of The Experiment: To write a MATLAB code to generate (i) sine and ii) cosine signals with different frequencies.

Theory:

A sine wave or a cose wave is also known as a sinusoidal wave. A sinusoidal wave is a smooth, periodic oscillation characterized by a sine function. It has an amplitude(maximum displacement), wavelength (distance between corresponding points), frequency (number of cycles perunit of the time) and phase (starting point within one cycle). It is a fundamental type of wave commonly found in nature and used in various scientific and engineering application

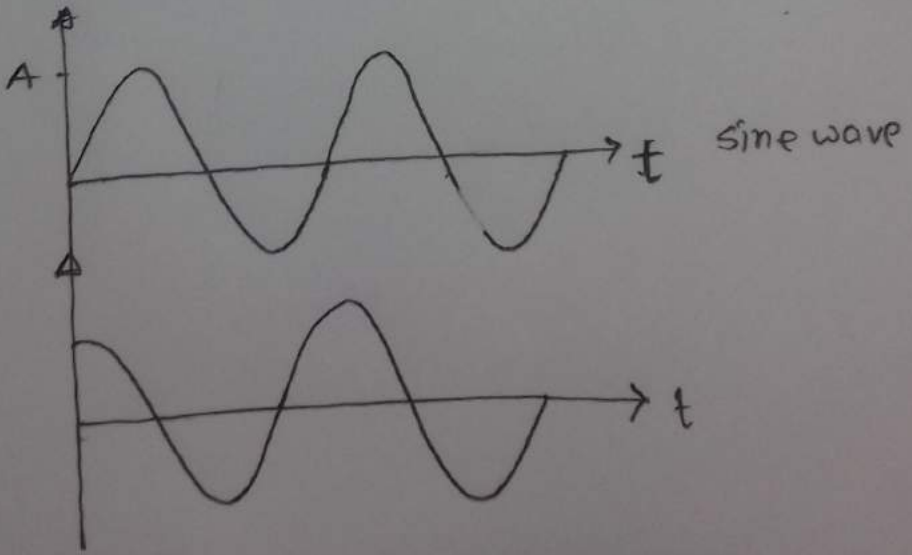



Figure: A sin and cos wave

The equation of ~~of~~ sin wave and cos wave given bellow

$$V_{sin} = A_{sin} * \sin((2\pi f_{sin} t) + \theta_{sin})$$

$$V_{cos} = A_{cos} * \cos((2\pi f_{cos} t) + \theta_{cos})$$

where $A$ = Amplitude
$f$ = frequency
$\theta$ = phase

MATLAB code

```
clc;
clear all;
close all;
t = 0:0.0001:0.2;
fsin = input('Enter sin wave frequency:');
asin = input('Enter sin wave amplitude:');
sphase = input('Enter sin wave phase:');
sinwave = asin.*sin((2*pi*fsin*t) + sphase);
subplot(2,1,1);
plot(t,sinwave);
title('The sine wave');
xlabel('Time');
ylabel('Amplitude');
grid on;
fcos = input('Enter coswave frequency:');
acos = input('Enter coswave amplitude:');
pcos = input('Enter phase of coswave:');
coswave = acos.*cos((2*pi*fcos*t) + pcos);
subplot(2,1,2);
plot(t,coswave);
title('The cos wave');
xlabel('Time');
ylabel('Amplitude);
```

Experiment Number:

Name of the experiments: To explain and implement the following elementary discrete time signals using MATLAB

I) Unit sample sequence

II) Unit step signal

III) Ramp signal

Theory:

Unit sample sequence: Unit sample sequence is also called unit impulse function. A function that has zero duration infinite amplitude and unit area under it. Unit impulse function is designed by $\delta(t)$ where

$$\delta(t) = 0 \text{ for } t \neq 0$$

$$\text{and } \int_{-\infty}^{\infty} \delta(t) dt = 1$$

The unit impulse properties are ① $\delta(t) = \delta(-t)$
② $\delta(at) = \frac{1}{a}\delta(t)$, $a>0$ ③ $\delta(t) = \frac{d}{dt}u(t)$, $t \neq 0$

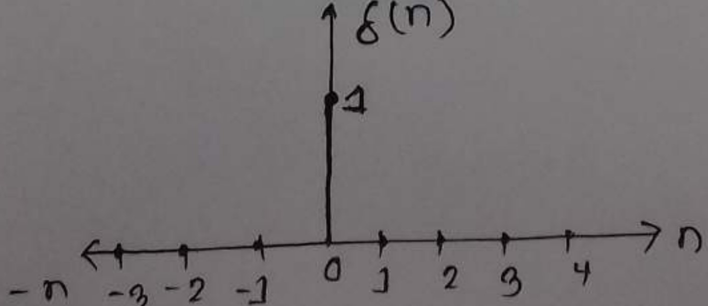



Figure: Graphical Representation of unit sample sequence

**Unit Step Signal:** The discrete time unit step signal is denoted as u(n) and its defined as

$$u(n) = \begin{cases} 1, & n \geq 0 \\ 0 & n < 0 \end{cases}$$

for continious time signal it becomes

$$u(t) = \begin{cases} 1, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

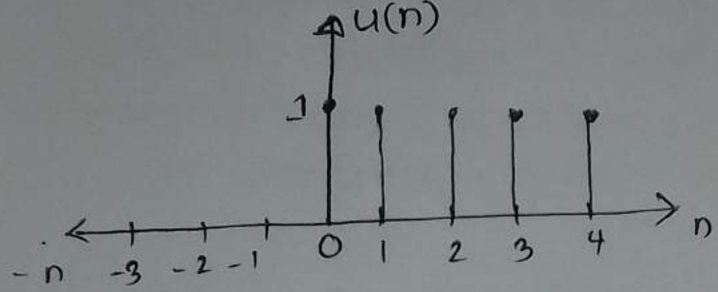



Figure: Graphical Representation of unit step signal

**Unit Ramp Signal:** The discrete time ramp signal is denoted as r(n) and defined as

$$r(n) \begin{cases} n, & n \geq 0 \\ 0, & n < 0 \end{cases}$$

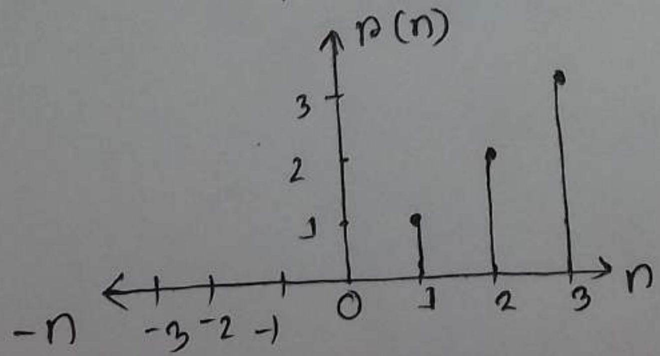
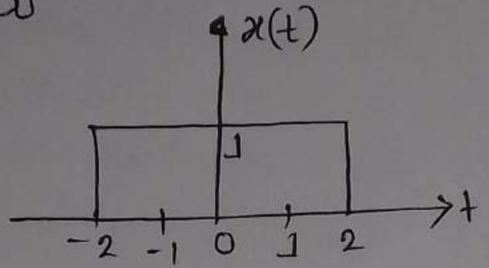



Figure: Graphical Representation of unit ramp signal.

Experiment Number:

Name of The Experiment:

To write a MATLAB code to plot fourier Transform of a time aperiodic pulse shown below




Theory:

A fourier transform is a mathematical term that transforms a time domain signal to a frequency domain signal. Or we can write that

$$X(j\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t}\, dt$$

Our given signal's time rang is [-2,2], so we can write

$$X j\omega = \int_{-2}^{2} x(t)\, e^{-j\omega t}$$

$$= \int_{-2}^{2} (1) e^{-j\omega t}$$

$$= \left[ \frac{e^{-j\omega 2} - e^{-j\omega(-2)}}{-j\omega} \right]$$

$$= \frac{e^{-2j\omega} + e^{-2j\omega}}{-j\omega}$$

$$= \frac{2}{\omega} \frac{e^{j\omega 2} - e^{-2j\omega}}{2j}$$

$= \frac{2}{w} \sin 2w$

$= \frac{2}{w} \sin \frac{4w}{2}$

$= \frac{\sin\left(4 \frac{w}{2}\right)}{\frac{w}{2}}$

$= 4 \operatorname{sinc}\left(\frac{4w}{2}\right) = 4 \operatorname{sinc}\left(4 \frac{2\pi f}{2}\right)$

$= 4 \operatorname{sinc}(4\pi f)$

And this is the aperiodic pulse