SIMULATION LABORATORY

LAB MANUAL

Subject Code	:	AHS107
Regulations	:	IARE - R16
Class	:	III SEMESTER
Branch	:	ECE

Prepared by
Ms. G. Mary Swarnalatha, Asst. Professor
Mr. V. Naresh Kumar, Asst. Professor

Department of Electronics & Communication Engineering
INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal – 500 043, Hyderabad

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal – 500 043, Hyderabad

Electronics & Communication Engineering

Vision
To produce professionally competent Electronics and Communication Engineers capable of effectively and efficiently addressing the technical challenges with social responsibility.

Mission
The mission of the Department is to provide an academic environment that will ensure high quality education, training and research by keeping the students abreast of latest developments in the field of Electronics and Communication Engineering aimed at promoting employability, leadership qualities with humanity, ethics, research aptitude and team spirit.

Quality Policy
Our policy is to nurture and build diligent and dedicated community of engineers providing a professional and unprejudiced environment, thus justifying the purpose of teaching and satisfying the stake holders. A team of well qualified and experienced professionals ensure quality education with its practical application in all areas of the Institute.

Philosophy
The essence of learning lies in pursuing the truth that liberates one from the darkness of ignorance and Institute of Aeronautical Engineering firmly believes that education is for liberation. Contained therein is the notion that engineering education includes all fields of science that plays a pivotal role in the development of world-wide community contributing to the progress of civilization. This institute, adhering to the above understanding, is committed to the development of science and technology in congruence with the natural environs. It lays great emphasis on intensive research and education that blends professional skills and high moral standards with a sense of individuality and humanity. We thus promote ties with local communities and encourage transnational interactions in order to be socially accountable. This accelerates the process of transfiguring the students into complete human beings making the learning process relevant to life, instilling in them a sense of courtesy and responsibility.

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

Electronics & Communication Engineering

	Program Outcomes
PO 1	An ability to apply knowledge of basic sciences, mathematical skills, engineering and technology to solve complex electronics and communication engineering problems
PO 2	An ability to identify, formulate and analyze engineering problems using knowledge of Basic Mathematics and Engineering Sciences
PO 3	An ability to provide solution and to design Electronics and Communication Systems as per social needs
PO 4	An ability to investigate the problems in Electronics and Communication field and develop suitable solutions.
PO 5	An ability to use latest hardware and software tools to solve complex engineering problems
PO 6	An ability to apply knowledge of contemporary issues like health, Safety and legal which influences engineering design
PO 7	An ability to have awareness on society and environment for sustainable solutions to Electronics and Communication Engineering problems
PO 8	An ability to demonstrate understanding of professional and ethical responsibilities
PO 9	An ability to work efficiently as an individual and in multidisciplinary teams
PO 10	An ability to communicate effectively and efficiently both in verbal and written form
PO 11	An ability to develop confidence to pursue higher education and for life-long learning
PO 12	An ability to design, implement and manage the electronic projects for real world applications with optimum financial resources
	Program Specific Outcomes
PSO1	**Professional Skills:** The ability to research, understand and implement computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient analysis and design of computer-based systems of varying complexity.
PSO2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.
PSO3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths, to be an entrepreneur, and a zest for higher studies.

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

S. No.	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Basic Operations on Matrices.	PO1, PO2	PSO1
2	Generation of Various Signals and Sequences (Periodic and a periodic), such as Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc.	PO1, PO2	PSO1
3	Operations on Signals and Sequences such as Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy and Average Power.	PO1, PO2	PSO1, PSO2
4	Gibbs Phenomenon	PO1, PO2, PO3	PSO1
5	Finding the Fourier Transform of a given signal and plotting its magnitude and phase spectrum.	PO1, PO2, PO3	PSO1, PSO2
6	Properties of fourier transforms	PO1, PO2, PO3	PSO1
7	Waveform Synthesis using Laplace Transform.	PO1, PO2, PO4, PO12	PSO1, PSO2
8	Locating the Zeros and Poles and plotting the Pole-Zero maps in S-plane and Z-Plane for the given transfer function.	PO1, PO2, PO3	PSO1
9	Convolution between Signals and sequences.	PO1, PO2, PO3	PSO1, PSO2
10	Auto Correlation and Cross Correlation between Signals and Sequences.	PO1, PO2, PO3	PSO1
11	Generation of Gaussian noise (Real and Complex), Computation of its mean, M.S. Value and its Skew, Kurtosis, and PSD, Probability Distribution Function.	PO1, PO2, PO4, PO12	PSO1
12	Verification of Weiner-Khinchine Relations.	PO1, PO2, PO3	PSO1
13	Distribution and density functions of standard random variables	PO1, PO2, PO3	PSO1, PSO2
14	Checking a Random Process for Stationary in Wide sense.	PO1, PO2, PO3	PSO1, PSO2

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

Certificate

This is to Certify that it is a bonafied record of Practical work done

by Sri / Kum. ______________________________

bearing the Roll No. ______________ *of* __________ *Class*

______________________________ *Branch*

in the ______________________________ *laboratory*

during the Academic year ______________ *under our supervision.*

Head of the Department **Lecture In-Charge**

External Examiner **Internal Examiner**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal – 500 043, Hyderabad

Electronics and Communication Engineering

Course Overview:

This laboratory course builds on the lecture course "TRANSFORM TECHNIQUES" which is mandatory for all students of electronics and communication engineering . The course aims at practical experience with the generation and simulation of basic signals, using standardized environments such as MATLAB. Experiments cover fundamental concepts of basic operation on matrices,generation of various signals and sequences,operation on signals and sequences, convolution, autocorrelation and cross correlation between signals and sequences. The objective of this laboratory is to enable the students to acknowledge with basic signals. They can critically analyze the behavior of their implementation, and observe the specific limitations inherent to the computational platform like Matlab.

Course Out-Come:

After completion of this lab, students will be able to understand:

1. Basics of MATLAB syntax, functions and programming.
2. Ability to write programs for signal processing algorithms in MATLAB.
3. Implementation of various signal processing techniques like linear convolution, FT, LT and ZT etc. using MATLAB.
4. Study of Correlation and Gaussin Noise.
5. Matlab implementation of Random Variables, PDF and CDF.

.

INSTRUCTIONS TO THE STUDENTS

1. Students are required to attend all labs.
2. Students should work individually in the hardware and software laboratories.
3. Students have to bring the lab manual cum observation book, record etc along with them whenever they come for lab work.
4. Should take only the lab manual, calculator (if needed) and a pen or pencil to the work area.
5. Should learn the prelab questions. Read through the lab experiment to familiarize themselves with the components and assembly sequence.
6. Should utilize 3 hour's time properly to perform the experiment and to record the readings. Do the calculations, draw the graphs and take signature from the instructor.
7. If the experiment is not completed in the stipulated time, the pending work has to be carried out in the leisure hours or extended hours.
8. Should submit the completed record book according to the deadlines set up by the instructor.
9. For practical subjects there shall be a continuous evaluation during the semester for 25 sessional marks and 50 end examination marks.
10. Out of 25 internal marks, 15 marks shall be awarded for day-to-day work and 10 marks to be awarded by conducting an internal laboratory test.

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal – 500 043, Hyderabad

SIMULATION LABORATORY SYLLABUS

Recommended Systems/Software Requirements:

Intel based desktop PC with minimum of 166 MHZ or faster processor with at least 64 MB RAM and 100MB free disk space. MATLAB.

S. No.	List of Experiments	Page No.	Date	Remarks
1	Basic Operations on Matrices			
2	Generation of Various Signals and Sequences (periodic & Aperiodic), Such as Unit Impluse, Units step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc function			
3	Operations on signals and Sequences such as Addition, Multiplication, Scaling, Shifting, Folding, Computation of energy and Average Power			
4	Demonstration of Gibb's Phenomenon			
5	Finding the Fourier Transform of given signal and plotting its magnitude and phase spectrum			
6	Properties of fourier transforms			
7	Wave form synthesis using Laplace Transform			
8	Locating Poles and Zeros, and plotting the pole zero maps in s-plane and Z-plane for a given Transfer Function			
9	Convolution between signals and Sequences.			
10	Auto Correlation and Cross Correlation between signals and Sequences			
11	Generation of Gaussian Noise(Real & Complex), computation of its mean, Mean Square values and its Skew, Kurtosis and PSD, Probability Distribution function			
12	Verification of Wiener-Khinchin relations			
13	Distribution and density functions of standard random variables			
14	Checking a Random Process for Stationary in Wide Sense			

INSTITUTE OF AERONAUTICAL ENGINEERING

(AUTONOMOUS)

DUNDIGAL, HYDERABAD - 500 043

SIMULATION LABORATORY

WORK BOOK

Name of the Student			
Roll No.			
Branch			
Class		**Section**	

List of Experiments:

The following experiments have to be conducted and verified.

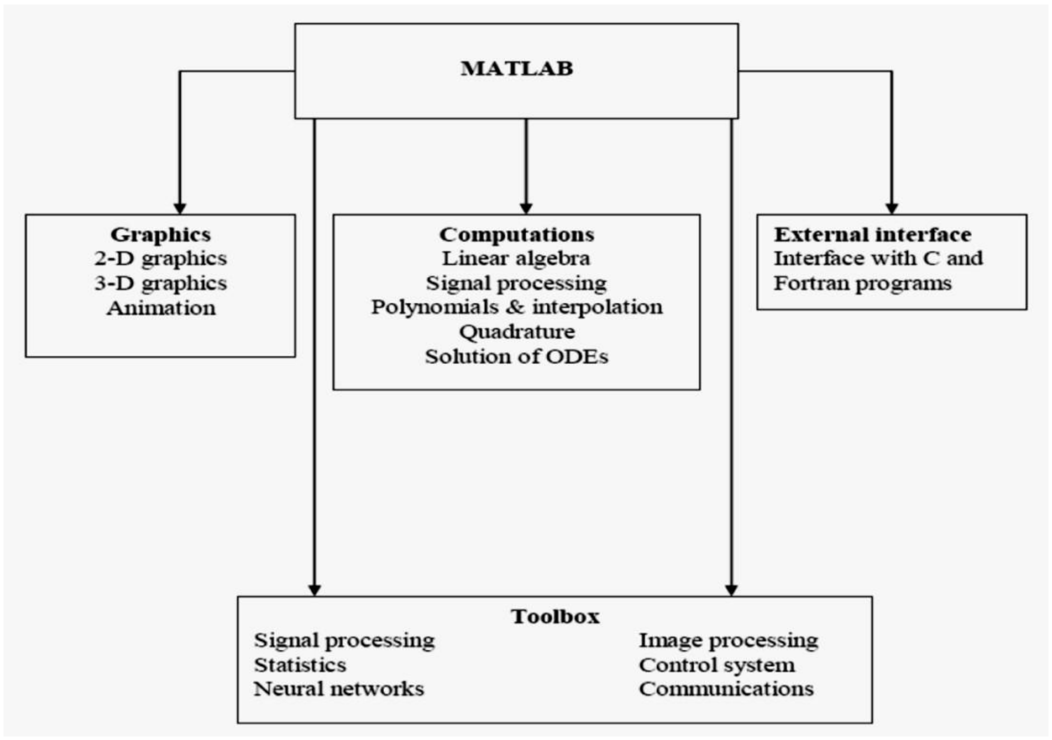
S. No.	Experiment	Name of the Experiment
1	1	Basic Operations on Matrices
2	2	Generation of Various Signals and Sequences (periodic & Aperiodic), Such as Unit Impluse, Units step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc function
3	3	Operations on signals and Sequences such as Addition, Multiplication, Scaling, Shifting, Folding, Computation of energy and Average Power
4	4	Demonstration of Gibb's Phenomenon
5	5	Finding the Fourier Transform of given signal and plotting its magnitude and phase spectrum
6	6	Properties of fourier transforms
7	7	Wave form synthesis using Laplace Transform
8	8	Locating Poles and Zeros, and plotting the pole zero maps in s-plane and Z-plane for a given Transfer Function
9	9	Convolution between signals and Sequences.
10	10	Auto Correlation and Cross Correlation between signals and Sequences
11	11	Generation of Gaussian Noise(Real & Complex), computation of its mean, Mean Square values and its Skew, Kurtosis and PSD, Probability Distribution function
12	12	Verification of Wiener-Khinchin relations
13	13	Distribution and density functions of standard random variables
14	14	Checking a Random Process for Stationary in Wide Sense

INTRODUCTION TO MATLAB

MATLAB (Matrix Laboratory):

MATLAB is a software package for high-performance language for technical computing. It integrates computation, visualization, and PROGRAMming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include the following:

- Math and computation
- Algorithm development
- Data acquisition
- Modeling, simulation, and prototyping
- Data analysis, exploration, and visualization
- Scientific and engineering graphics
- Application development, including graphical user interface building



At its core ,MATLAB is essentially a set (a “toolbox”) of routines (called “m files” or “mex files”) that sit on your computer and a window that allows you to create new variables with names (e.g. voltage and time) and process those variables with any of those routines (e.g. plot voltage against time, find the largest voltage, etc).

It also allows you to put a list of your processing requests together in a file and save that combined list with a name so that you can run all of those commands in the same order at some later time. Furthermore, it allows you to run such lists of commands such that you pass in data and/or get data back out (i.e. the list of commands is like a function in most programming languages). Once you save a function, it becomes part of your toolbox (i.e. it now looks to you as if it were part of the basic toolbox that you started with). For those with computer programming backgrounds: Note that MATLAB runs as an interpretive language (like the old BASIC). That is, it does not need to be compiled. It simply reads through each line of the function, executes it, and then goes on to the next line. (In practice, a form of compilation occurs when you first run a function, so that it can run faster the next time you run it.)

The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow learning and applying specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include Image processing, signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

The main features of MATLAB

1. Advance algorithm for high performance numerical computation, especially in the Field matrix Algebra.
2. A large collection of predefined mathematical functions and the ability to define one's own functions.
3. Two-and three dimensional graphics for plotting and displaying data.
4. A complete online help system.
5. Powerful, matrix or vector oriented high level programming language for individual applications.
6. Toolboxes available for solving advanced problems in several application areas.

MATLAB Windows: MATLAB works through three basic windows

1.Command Window : This is the main window .It is characterized by MATLAB command prompt **>>** when you launch the application PROGRAM MATLAB puts you in this window all commands including those for user-written PROGRAMs ,are typed in this window at the MATLAB prompt .

2.Graphics window: the OUTPUT of all graphics commands typed in the command window are flushed to the graphics or figure window, a separate gray window with white background color the user can create as many windows as the system memory will allow .

3. Edit window: This is where you **write, edit, create** and **save** your own PROGRAMs in files called M files.

Write OUTPUT files. **Input-OUTPUT:** MATLAB supports interactive computation taking the input from the screen and flushing, the OUTPUT to the screen. In addition it can read input files and

Data Type: the fundamental data–type in MATLAB is the array. It encompasses several distinct data objects- integers, real numbers, matrices, character strings, structures and cells. There is no need to declare variables as real or complex, MATLAB automatically sets the variable to be real.

Dimensioning: Dimensioning is automatic in MATLAB. No dimension statements are required for vectors or arrays .we can find the dimensions of an existing matrix or a vector with the **size** and **length** commands.

- The functional unit of data in any MATLAB PROGRAM is the array. An array is a collection of data values organized into rows and columns, and known by a single name.
- MATLAB variable is a region of memory containing an array, which is known by a user specified name. MATLAB variable names must begin with a letter, followed by any combination of letters, numbers, and the underscore (_) character. Only the first 31 characters are significant; if more than 31 are used, the remaining characters will be ignored. If two variables are declared with names that only differ in the 32nd character, MATLAB will treat them as same variable.
- Spaces cannot be used in MATLAB variable names, underscore letters can be substituted to create meaningful names.
- It is important to include a data dictionary in the header of any PROGRAM that you write. A data dictionary lists the definition of each variable used in a PROGRAM. The definition should include both a description of the contents of the item and the units in which it is measured.
- MATLAB language is case-sensitive. It is customary to use lower-case letters for ordinary variable names.
- The most common types of MATLAB variables are double and char.
- MATLAB is weakly typed language. Variables are not declared in a PROGRAM before it is used.
- MATLAB variables are created automatically when they are initialized. There are three

Common ways to initialize variables in MATLAB:

- ➢ Assign data to the variable in an assignment system.
- ➢ Input data into the variable from the keyboard.
- ➢ Read data from a file.

- The semicolon at the end of each assignment statement suppresses the automatic echoing of values that normally occurs whenever an expression is evaluated in an assignment statement.

How to invoke MATLAB?

- Double Click on the MATLAB icon on the desktop.
- You will find a Command window where in which you can type the commands and see the OUTPUT. For example if you type PWD in the command window, it will print current working directory.
- If you want to create a directory type mkdir *mydir* in the command window, it will create a directory called *pes.*
- If you want delete a directory type rmdir *mydir* in the command window.
- How to open a file in MATLAB?
- Go to **File _ New_ M-File** and click
- Then type the PROGRAM in the file and save the file with an extension of **.m.** While giving filename we should make sure that given file name should not be a command. It is better to give the filename as myconvolution .
- How to run a MATLAB file?
- Go to **Debug->run** and **click**

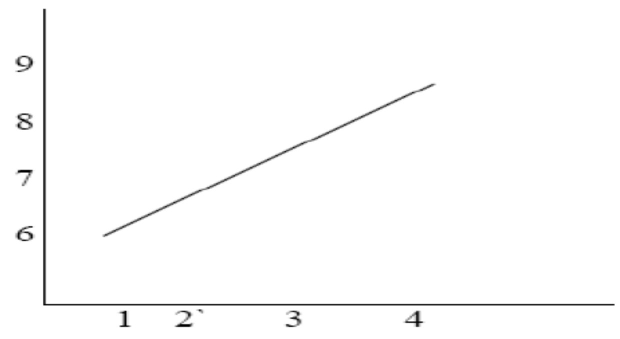
Where to work in MATLAB?

All PROGRAMs and commands can be entered either in the a) Command window b) As an M file using MATLAB editor

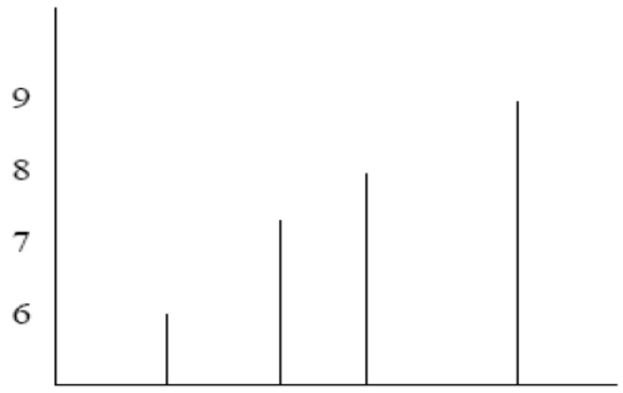
Note: Save all M files in the folder 'work' in the current directory. Otherwise you have to locate the file during compiling. Typing quit in the command prompt >> quit, will close MATLAB Development Environment. For any clarification regarding plot etc, which are built in functions type help topic

I.e. help plot

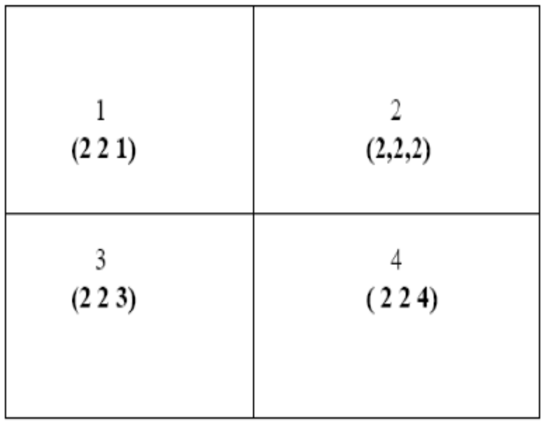
Basic Instructions in MATLAB:

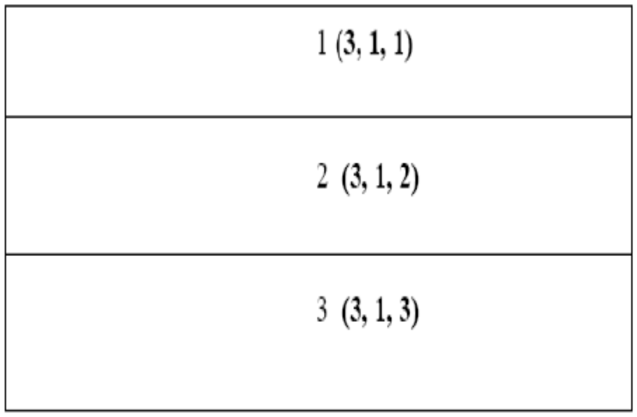


10. **stem (t,x)** :- This instruction will display a figure window as shown



11. **Subplot:** This function divides the figure window into rows and columns. Subplot(2 2 1) divides the figure window into 2 rows and 2 columns 1 represent number of the figure





Subplot (3 1 2) divides the figure window into 3 rows and 1 column 2 represent the figure number

12. **Conv** Syntax: w = conv(u,v) Description: w = conv(u,v) convolves vectors u and v. Algebraically, convolution is the same operation as multiplying the polynomials whose coefficients are the elements of u and v.

13. **Disp** Syntax: disp(X) Description: disp(X) displays an array, without printing the array name. If X contains a text string, the string is displayed. Another way to display an array on the screen is to type its name, but this prints a leading "X=," which is not always desirable.

    Note: disp does not display empty arrays.

14. **xlabel** Syntax: xlabel('string')

    Description: xlabel('string') labels the x-axis of the current axes.

15. **ylabel** Syntax : ylabel('string')

    Description: ylabel('string') labels the y-axis of the current axes.

16. **Title** Syntax : title('string') Description: title('string') OUTPUTs the string at the top and in the center of the current axes.

17. **grid on** Syntax : grid on Description: grid on adds major grid lines to the current axes.

18. **FFT** Discrete Fourier transform. FFT(X) is the discrete Fourier transform (DFT) of vector X. For matrices, the FFT operation is applied to each column. For N-D arrays, the FFT operation operates on the first non-singleton dimension. FFT(X,N) is the N-point FFT, padded with zeros if X has less than N points and truncated if it has more.

19. **ABS** Absolute value. ABS(X) is the absolute value of the elements of X. When X is complex, ABS(X) is the complex modulus (magnitude) of the elements of X.

20. **ANGLE** Phase angle. ANGLE (H) returns the phase angles, in radians, of a matrix with complex elements.

21. **INTERP** Resample data at a higher rate using lowpass interpolation. **Y = INTERP(X,L)** resamples the sequence in vector X at L times the original sample rate. The resulting resampled vector Y is L times longer, LENGTH(Y) = L*LENGTH(X).

22. **DECIMATE** Resample data at a lower rate after low pass filtering.

Y = DECIMATE(X, M) resample the sequence in vector X at 1/M times the original sample rate. The resulting resample vector Y is M times shorter, i.e., LENGTH(Y) = CEIL (LENGTH(X)/M). By default, DECIMATE filters the data with an 8th order Chebyshev Type I low pass filter with cutoff frequency .8*(Fs/2)/R, before resampling.

1. BASIC OPERATIONS ON MATRICES

AIM:

To generate matrix and perform basic operation on matrices Using MATLAB Software.

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

MATLAB treats all variables as matrices. For our purposes a matrix can be thought of as an array, in fact, that is how it is stored.

• Vectors are special forms of matrices and contain only one row OR one column.

• Scalars are matrices with only one row AND one column.A matrix with only one row AND one column is a scalar. A scalar can be reated in MATLAB as follows:

```
≫ a_value=23
a_value =23
```

• A matrix with only one row is called a row vector. A row vector can be created in MATLAB as follows :

```
≫ rowvec = [12 , 14 , 63]
rowvec =
12 14 63
```

• A matrix with only one column is called a column vector. A column vector can be created in MATLAB as follows:

```
≫ colvec = [13 ; 45 ; -2]
colvec =
13
45
-2
```

• A matrix can be created in MATLAB as follows:

```
≫ matrix = [1 , 2 , 3 ; 4 , 5 ,6 ; 7 , 8 , 9]
matrix =
```

1 2 3

4 5 6

7 8 9

Extracting a Sub-Matrix

A portion of a matrix can be extracted and stored in a smaller matrix by

specifying the names of both matrices and the rows and columns to extract. The syntax

is:

sub_matrix = matrix (r1 : r2 , c1 : c2) ;

Where r1 and r2 specify the beginning and ending rows and c1 and c2 specify the

beginning and ending columns to be extracted to make the new matrix.

• A column vector can beextracted from a matrix.

• As an example we create a matrix below:

```
>> matrix=[1,2,3;4,5,6;7,8,9]
matrix =
1 2 3
4 5 6
7 8 9
```

Here we extract column 2 of the matrix and make a column vector:

```
>> col_two=matrix( : , 2)
col_two =
2 5 8
```

• A row vector can be extracted from a matrix. As
an example we create a matrix below:

```
>> matrix=[1,2,3;4,5,6;7,8,9]
matrix =
1 2 3
4 5 6
7 8 9
```

• Here we extract row 2 of the matrix and make a row vector. Note that the 2:2
specifies the second row and the 1:3 specifies which columns of the row.

```
>> rowvec=matrix(2 : 2 , 1 :3)
rowvec =4 5 6
```

```
≫ a=3;
≫ b=[1, 2, 3;4, 5, 6]
b    =
1 2 3
4 5 6
≫ c= b+a % Add a to each element of b
c =
4 5 6
7 8 9
```

- Scalar - Matrix Subtraction

```
≫ a=3;
≫ b=[1, 2, 3;4, 5, 6]
b    =
1 2 3
4 5 6
≫ c = b - a %Subtract a from each element of b
c =
-2 -1 0
1 2 3
```

- Scalar - Matrix Multiplication

```
≫ a=3;
≫ b=[1, 2, 3; 4, 5, 6]
b    =
1 2 3
4 5 6
≫ c = a * b % Multiply each element of b by a
c =
3 6 9
12 15 18
```

- Scalar - Matrix Division

```
≫ a=3;
≫ b=[1, 2, 3; 4, 5, 6]
```

```
b =
1 2 3
4 5 6
≫ c = b / a % Divide each element of b by a
c =
0.3333 0.6667 1.0000
1.3333 1.6667 2.0000
```

PROGRAM:

```
clc;
clear all;
close all;

a=input('enter  the  first  matrix  a');
b=input('enter the second matrix b');

%addition of two matrices


y=a+b;
disp('the addition value is');
disp(y);

%subtraction of two matrices


x=a-b;
disp('the subtraction value is');
disp(x);

%multiplication of two matrices
 z=a*b;
disp('the multiplication value is');
disp(z);
```

```
%multiplication of two matrices element by element
 z=a.*b;
disp('the multiplication value is');
disp(z);

 %division of a matrix by a scalar value

r=a/2;
disp('the  matrix  division  by  a  value  2  is');
disp(r);

%transpose of a matrix
p=a';
disp('the transpose of matrix a is');
disp(p);

%inverse of matrix
q=inv(a);
disp('the inverse of matrix a is');
disp(q);

%determinant  of  a  matrix
r=det(a);
disp('the  detrerment  of  matrix  a  is');
disp(r);
```

CONCLUSION:

Inthis experiment basic operations on matrices Using MATLAB have been demonstrated.

Exercises

.1 Enter the matrix M by

```
>    M = [1,3,-1,6;2,4,0,-1;0,-2,3,-1;-1,2,-5,1]
```

and also the matrix

$$N = \begin{bmatrix} -1 & -3 & 3 \\ 2 & -1 & 6 \\ 1 & 4 & -1 \\ 2 & -1 & 2 \end{bmatrix}.$$

Multiply M and N using `M * N`. Can the order of multiplication be switched? Why or why not? Try it to see how MATLAB reacts.

.2 By hand, calculate $A\mathbf{v}$, AB, and BA for:

$$A = \begin{pmatrix} 2 & 4 & -1 \\ -2 & 1 & 9 \\ -1 & -1 & 0 \end{pmatrix}, \quad B = \begin{pmatrix} 0 & -1 & -1 \\ 1 & 0 & 2 \\ -1 & -2 & 0 \end{pmatrix}, \quad \mathbf{v} = \begin{pmatrix} 3 \\ 1 \\ -1 \end{pmatrix}.$$

Check the results using MATLAB. Think about how fast computers are. Turn in your hand work.

RESULT:

2. GENERATION ON VARIOUS SIGNALS AND SEQUENCES (PERIODIC AND APERIODIC), SUCH AS UNIT IMPULSE, UNIT STEP, SQUARE, SAWTOOTH, TRIANGULAR, SINUSOIDAL, RAMP, SINC.

AIM:

To generate different types of signals Using MATLAB Software.

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

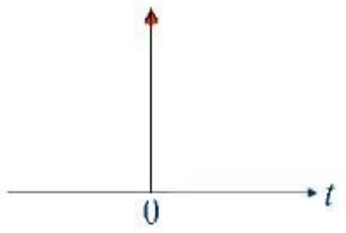
THEORY :

UNIT IMPULSE: a) Continous signal:

$$\delta(t) = \begin{cases} 0 & t \neq 0 \\ \infty & t = 0 \end{cases}$$

And

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



Also called unit impulse function. The value of delta function can also be defined in the sense of generalized function

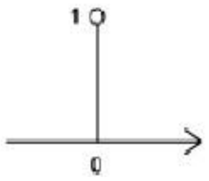
$$\int_{-\infty}^{\infty} \delta(t)\phi(t)dt = \phi(0)$$

$\phi(t)$: Test Function

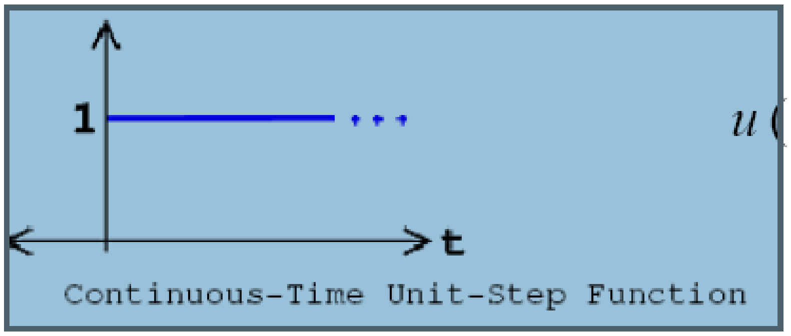
b) Unit Sample sequence: $\delta(n)=\begin{cases} 1, & n=0 \\ 0, & n\neq 0 \end{cases}$

i.e

```
δn= 1  if  n=0
    0  otherwise
```

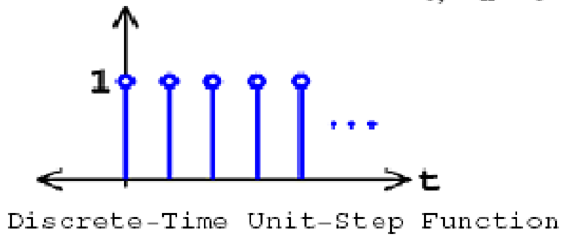


2)Unit Step Function *u*(*t*): $\int_{-\infty}^{\infty} u(t)\phi(t)dt = \int_{0}^{\infty} \phi(t)dt$

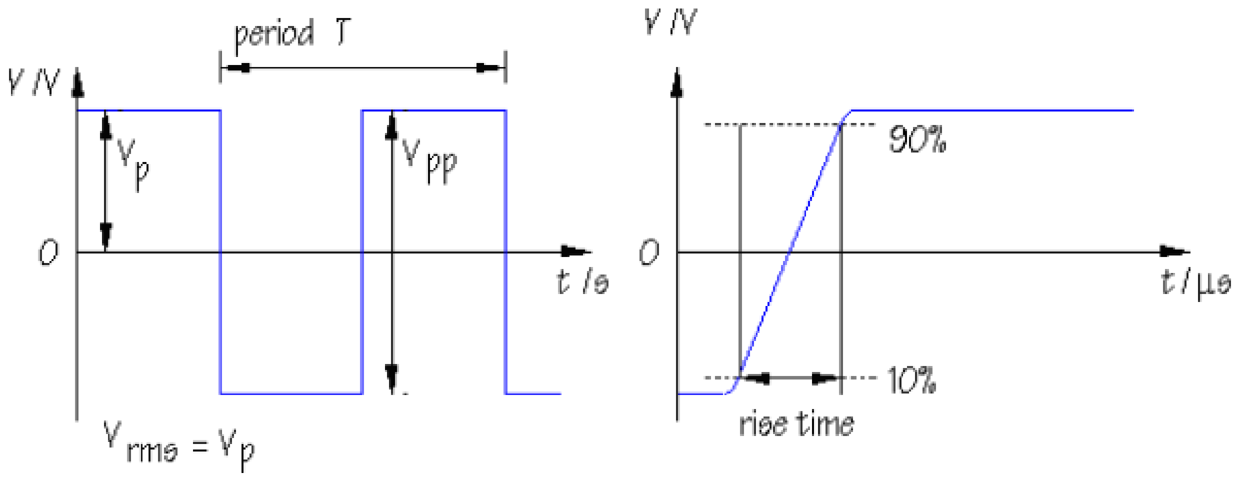


$$u(t) = \begin{cases} 1 & t > 0 \\ 0 & t < 0 \end{cases}$$

b)Unit Step Sequence *u*(n):)= $\begin{cases} 1, & n \geq 0 \\ 0, & n < 0 \end{cases}$



Square waves: Like sine waves, square waves are described in terms of period, frequency and amplitude:



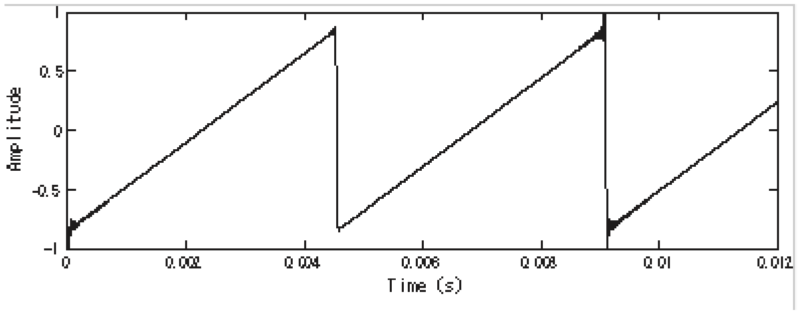
Peak amplitude, *V*p , and peak-to-peak amplitude, *V*pp , are measured as you might expect. However, the rms amplitude, *V*rms , is greater than that of a sine wave. Remember that the rms amplitude is the DC voltage which will deliver the same power as the signal.

If a square wave supply is connected across a lamp, the current flows first one way and then the other. The current switches direction but its *magnitude* remains the same. In other words, the square wave delivers its maximum power throughout the cycle so that *V*rms is equal to *V*p . (If this is confusing, don't worry, the rms amplitude of a square wave is not something you need to think about very often.)

Although a square wave may change very rapidly from its minimum to maximum voltage, this change cannot be instaneous. The **rise time** of the signal is defined as the time taken for the voltage to change from 10% to 90% of its maximum value. Rise timesare usually very short, with durations measured in nanoseconds (1 ns = 10-9 s), or microseconds (1 μs = 10-6 s), as indicated in the graph

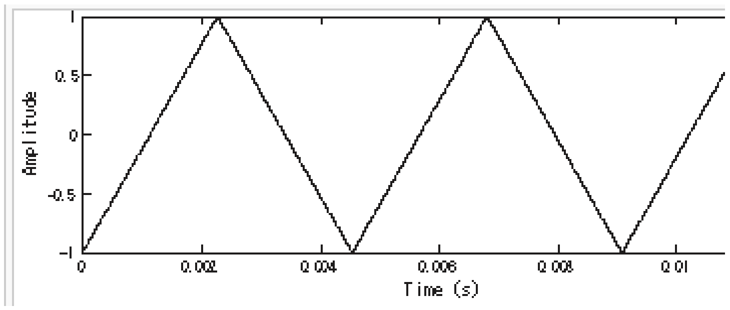
SAW TOOTH:

The sawtooth wave (or saw wave) is a kind of non-sinusoidal waveform. It is named a sawtooth based on its resemblance to the teeth on the blade of a saw. The Convention is that a sawtooth wave ramps upward and then sharply drops. However, there are also sawtooth waves in which the wave ramps downward and then sharply rises. The latter type of sawtooth wave is called a 'reverse sawtooth wave' or 'inverse sawtooth wave'. As audio signals, the two orientations of sawtooth wave sound identical. The piecewise linear function based on the floor function of time *t*, is an example of a sawtooth wave with period 1. A more general form, in the range −1 to 1, and with period *a*, is this sawtooth function has the same phase as the sine function. A sawtooth wave's sound is harsh and clear and its spectrum contains both even and odd harmonics of the fundamental frequency. Because it contains all the integer harmonics, it is one of the best waveforms to use for synthesizing musical sounds, particularly bowed string instruments like violins and cellos, using subtractive synthesis.



Triangle wave

A triangle wave is a non-sinusoidal waveform named for its triangular shape.A bandlimited triangle wave pictured in the time domain (top) and frequency domain (bottom). The fundamental is at 220 Hz (A2).Like a square wave, the triangle wave contains only odd harmonics. However, the higher harmonics roll off much faster than in a square wave (proportional to the inverse square of the harmonic number as opposed to just the inverse).It is possible to approximate a triangle wave with additive synthesis by adding odd harmonics of the fundamental, multiplying every (4n−1)th harmonic by −1 (or changing its phase by π), and rolling off the harmonics by the inverse square of their relative frequency to the fundamental.This infinite Fourier series converges to the triangle wave:



Sinusoidal Signal Generation

The sine wave or sinusoid is a mathematical function that describes a smooth repetitive Oscillation. It occurs often in pure mathematics, as well as physics, signal processing, electrical engineering and many other fields. It’s most basic form as a function of time

(*t*) is: where:

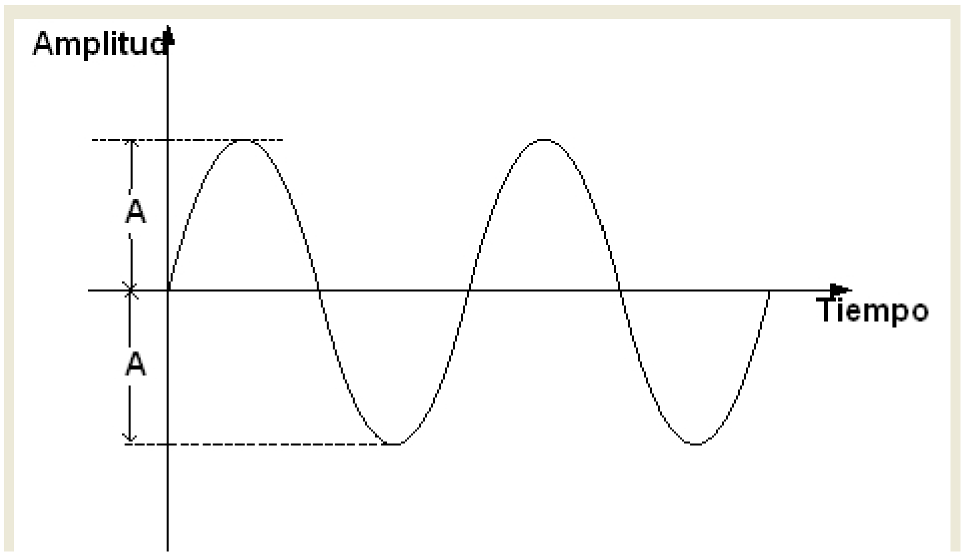
• A, the amplitude, is the peak deviation of the function from its center position.

• ω, the angular frequency, specifies how many oscillations occur in a unit time interval, in radians per second

• ϕ, the phase, specifies where in its cycle the oscillation begins at t = 0. A sampled sinusoid may be written as:

where *f* is the signal frequency, fs is the sampling frequency, θ is the phase and *A* is the amplitude of the signal. The PROGRAM and its OUTPUT is shown below:

Note that there are 64 samples with sampling frequency of 8000Hz or sampling time of 0.125 mS (i.e. 1/8000). Hence the record length of the signal is 64x0.125=8mS. There are exactly 8 cycles of sinewave, indicating that the period of one cycle is 1mS which means that the signal frequency is 1KHz.

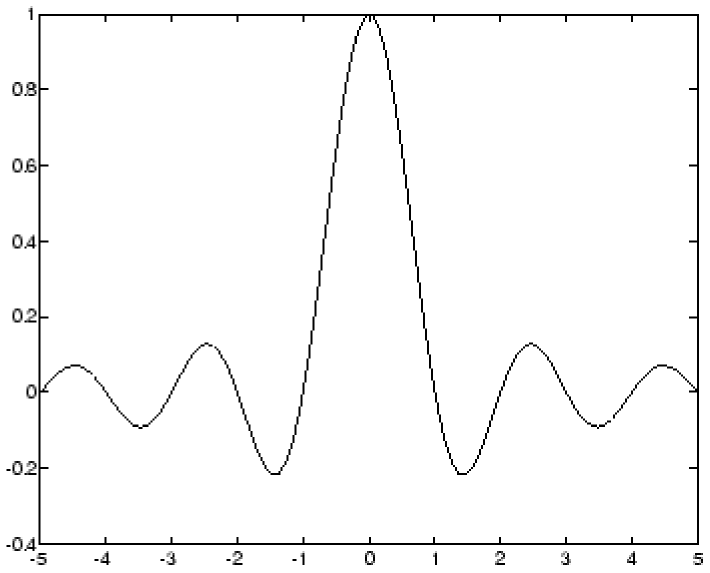


SINC FUNCTION:

The sinc function computes the mathematical sinc function for an input vector or matrix x. Viewed as a function of time, or space, the sinc function is the inverse Fourier transform of the rectangular pulse in frequency centered at zero of width 2π and height 1.

The following equation defines the sinc function:

$$\frac{\sin(\pi x)}{\pi x} = \frac{1}{2\pi}\int_{-\pi}^{\pi} e^{j\omega x}\,d\omega.$$



PROGRAM:

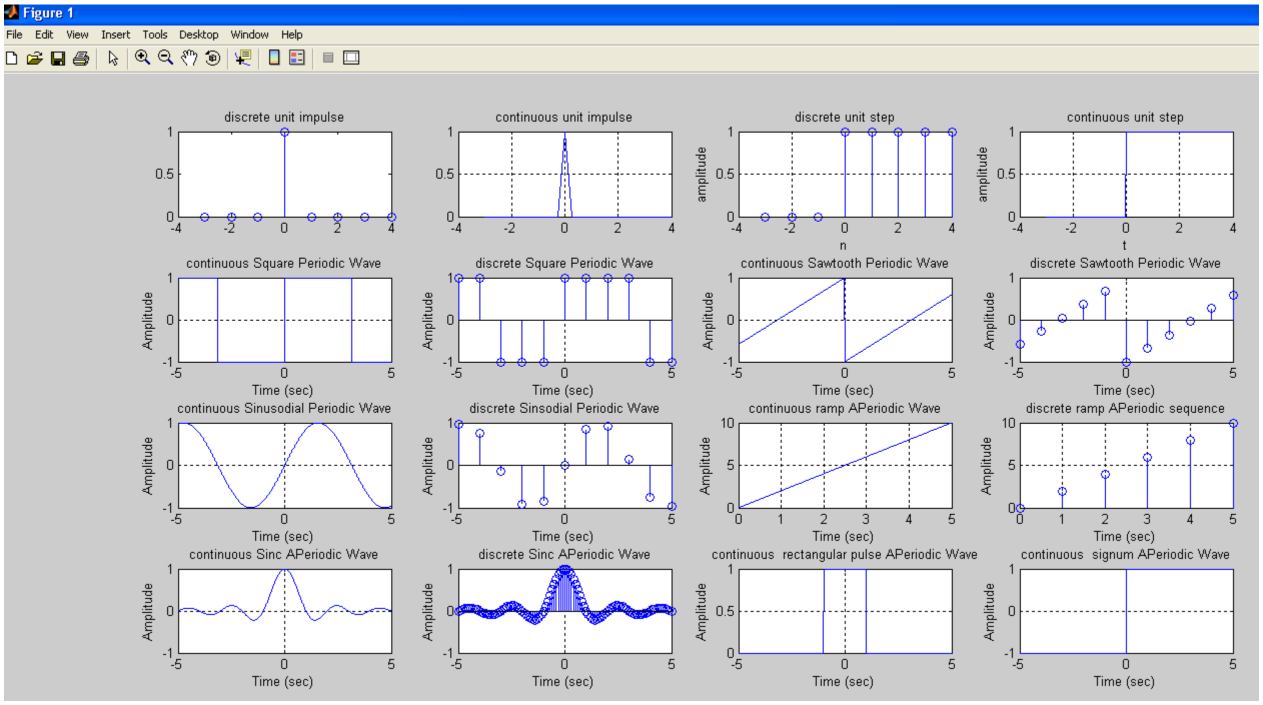
```
%discrete unit impulse sequence generation
clc;
close all;
n=-3:4;
x=[n==0];
subplot(4,4,1),stem(n,x);
title('discrete unit impulse');
%continuous unit impulse signal generation

t=-3:.25:4;
x=[t==0];
subplot(4,4,2),plot(t,x);
title('continuous unit impulse');grid;

% discrete unit step sequence generation

n=-3:4;
 y=[n>=0];
subplot(4,4,3),stem(n,y);
xlabel('n')
```

```
ylabel('amplitude');
title('discrete unit step');grid;

% continuous unit step signal generation
t=-3:.025:4;
y=[t>=0];
subplot(4,4,4),plot(t,y);
xlabel('t');ylabel('amplitude');title('continuous unit step');grid;

% continuous square wave wave generator

t = -5:.01:5;
x = square(t);
subplot(4,4,5),plot(t,x);
xlabel('Time (sec)');ylabel('Amplitude'); title('continuous Square Periodic Wave');grid;

% discrete square wave wave generator

n = -5:5;
x = square(n);
subplot(4,4,6),stem(n,x);
xlabel('Time (sec)');ylabel('Amplitude');title('discrete Square Periodic Wave');grid;

% continuous sawtooth wave generator

t = -5:.01:5;
x = sawtooth(t);
subplot(4,4,7),plot(t,x);
xlabel('Time (sec)');ylabel('Amplitude'); title('continuous Sawtooth Periodic Wave');grid;

% discrete sawtooth sequence generator
```

```
n = -5:5;

x = sawtooth(n);

subplot(4,4,8),stem(n,x);

xlabel('Time (sec)');ylabel('Amplitude');title('discrete Sawtooth Periodic Wave');grid;

% continuous sinsodial signal generator


t = -5:.01:5;

x = sin(t);

subplot(4,4,9),plot(t,x);

xlabel('Time (sec)');ylabel('Amplitude'); title('continuous Sinusodial Periodic Wave');grid;

% discrete sinsodial sequence generator


n = -5:5;

x = sin(n);

subplot(4,4,10),stem(n,x);

xlabel('Time (sec)');ylabel('Amplitude');title('discrete Sinsodial Periodic Wave');grid;

% continuous ramp signal generator


t = 0:.01:5;

x=2*t;

subplot(4,4,11),plot(t,x);

xlabel('Time (sec)');ylabel('Amplitude'); title('continuous ramp APeriodic Wave');grid;

% discrete ramp sequence generator


n = 0:5;

x=2*n;

subplot(4,4,12),stem(n,x);

xlabel('Time (sec)');ylabel('Amplitude');title('discrete ramp APeriodic sequence');grid;
```

```
% continuous sinc signal generator

t = -5:.01:5;
x = sinc(t);
subplot(4,4,13),plot(t,x);
xlabel('Time (sec)');ylabel('Amplitude'); title('continuous Sinc APeriodic Wave');grid;

% discrete sinc sequence generator

n = -5:.1:5;
x = sinc(n);
subplot(4,4,14),stem(n,x);
xlabel('Time (sec)');ylabel('Amplitude');title('discrete Sinc APeriodic Wave');grid;

%To generate a Aperiodic rectangular pulse
t=-5:0.01:5;
pulse = rectpuls(t,2); %pulse of width 2 time units
subplot(4,4,15),plot(t,pulse);
xlabel('Time (sec)');ylabel('Amplitude');title('continuous rectangular pulse APeriodic
Wave');grid;

%To generate a Aperiodic signum function
t=-5:0.01:5;
pulse = sign(t); %pulse of width 2 time units
subplot(4,4,16),plot(t,pulse);
xlabel('Time (sec)');ylabel('Amplitude');title('continuous  signum APeriodic Wave');grid;
```

OUTPUT:



CONCLUSION: In this experiment various signals have been generated Using

MATLAB

Exercise questions: generate following signals using MATLAB

1.x(t)=e-t

2.x(t)= t 2 / 2

3.generate rectangular pulse function

4.generate signum sunction sinc(t)= 1 t > 0 0

t=0

-1 t<0

5. generate complex exponential signal x(t)= e st for different values of σ and]

RESULT:

VIVA QUESTIONS:

1. Define Signal
2. Define determistic and Random Signal
3. Define Delta Function
4. What is Signal Modeling
5. Define Periodic and a periodic Signal
6. Define Symetric and Anti-Symmetric Signals
7. Define Continuous and Discrete Time Signals
8. What are the Different types of representation of discrete time

3. OPERATIONS ON SIGNALS AND SEQUENCES

AIM:

To performs functions on signals and sequences such as addition, multiplication, scaling, shifting, folding, computation of energy and average power.

EQUIPMENT AND SOFTWARE:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

Basic Operation on Signals:

Time shifting: y(t)=x(t-T)The effect that a time shift has on the appearance of a signal If T is a positive number, the time shifted signal, x (t -T) gets shifted to the right, otherwise it gets shifted left.

Signal Shifting and Delay:

Time reversal: Y(t)=y(-t) Time reversal _ips the signal about t = 0

Signal Addition and Substraction :

Addition: any two signals can be added to form a third signal, z (t) = x (t) + y (t)

Multiplication/Divition : of two signals, their product is also a signal. z (t) = x (t) y (t)

ENERGY AND POWER SIGNAL:A signal can be categorized into energy signal or power signal: An **energy signal** has a finite energy, 0 < E < ∞. In other words, energy signals have values only in the limited time duration. For example, a signal having only one square pulse is energy signal. A signal that decays exponentially has finite energy, so, it is also an energy signal. The power of an energy signal is 0, because of dividing finite energy by infinite time (or length).

$$E(t) = \lim_{L\to\infty}\int_{-L}^{L}|x(t)|^2\,dt = \int_{-\infty}^{\infty}|x(t)|^2\,dt \qquad E[n] = \lim_{N\to\infty}\sum_{n=-N}^{N}|x[n]|^2 = \sum_{n=-\infty}^{\infty}|x[n]|^2$$

On the contrary, the **power signal** is not limited in time. It always exists from beginning to end and it never ends. For example, sine wave in infinite length is power signal. Since the energy of a power signal is infinite, it has no meaning to us. Thus, we use power (energy per given time) for power signal, because the power of power signal is finite, 0 < P < ∞.

$$P(t) = \lim_{L\to\infty} \frac{1}{2L}\int_{-L}^{L} |x(t)|^2\, dt = \lim_{L\to\infty} \frac{E(t)}{2L} \qquad P[n] = \lim_{N\to\infty} \frac{1}{2N+1}\sum_{n=-N}^{N} |x[n]|^2$$

PROGRAM:

PROGRAM1:Operations on signals such as addition,subtraction,multiplication,amplitude scaling

```
clc;
clear all;
close all;
%plot 2 hz sinusodial signal
t=0:.01:1;
f1=2;
A=8;
s1=A*sin(2*pi*f1*t);
figure,
subplot(2,1,1),plot(t,s1,'r');grid;
xlabel('---time');
ylabel('amplitude');
title('signal 1');
%plot 10 hz sinusodial signal
t=0:.01:1;
f2=10;
A=6;
s2=A*sin(2*pi*f2*t);
subplot(2,1,2),plot(t,s2,'g');grid;
xlabel('---time');
ylabel('amplitude');
title('signal 2');
%signal addition
y=s1+s2;
```

```
figure,
subplot(2,1,1),plot(t,y);grid;
xlabel('-->time');
ylabel('amplitude');
title('the summed signal s1+s2');
%signal subtraction
y=s1-s2;
subplot(2,1,2),plot(t,y,'r');grid;
xlabel('-->time');
ylabel('amplitude');
title('the subtracted signal s1-s2');
%signal multiplication element by element
y=s1.*s2;
figure,
plot(t,y,'g');
xlabel('-->time');
ylabel('amplitude');
title('the multiplied signal s1.*s2');
%Amplitude scaling of signal s1
alpa= 3;
y=alpha*s1;
figure,
subplot(2,1,1),plot(t,y);
xlabel('-->time');
ylabel('amplitude');
title('the signal s1 amplitude is multiplied by alpha');
%amplitude scaling of signal s2
alpha=1/2;
y=alpha*s2;
subplot(2,1,2),plot(t,y);
xlabel('-->time');
ylabel('amplitude');
```

title('the signal s2 is amplitude scaled by 1/alpha');

PROGRAM2: Operations on signals such as time shifting, time scaling & time reversal

```
clc;
clear all;
close all;
%plot ramp signal
t=[0:0.01:5];
x=1*t;
subplot(2,2,1),plot(t,x);grid;axis([0 5 0 5]);
title('ramp signal');xlabel('t');ylabel('amplitude');
%plot advanced ramp signal
t=[-3:0.01:2]
x=1*(t+3);
subplot(2,2,2),plot(t,x);grid;axis([-3 2 0 5]);
title('advanced ramp signal');xlabel('t');ylabel('amplitude');
%plot delayed ramp signal
t=[3:0.01:8];
x=1*(t-3);
subplot(2,2,3),plot(t,x);grid;axis([3 8 0 5]);
title('delayed ramp signal');xlabel('t');ylabel('amplitude');
%plot folding or time reversal operation
t=[-5:.01:0];
x=1*-t;
subplot(2,2,4),plot(t,x);grid;
title('time reversal operation');xlabel('t');ylabel('amplitude');
%plot time scaling
t=[-6:.01:6];
x=2*rectpuls(t,4);
figure;
subplot(3,1,1),plot(t,x);grid;
title('original signal');xlabel('t');ylabel('amplitude');
```

```
%plot compressed signal
t=[-6:.01:6];
x=2*rectpuls(2*t,4);
subplot(3,1,2),plot(t,x,'g');grid;
title('compressed signal');xlabel('t');ylabel('amplitude');
%plot('expanded signal
t=[-6:.01:6];
x=2*rectpuls(1/2*t,4);
subplot(3,1,3),plot(t,x,'r');grid;
title('expanded signal');xlabel('t');ylabel('amplitude');
```

PROGRAM3: Operations on sequences

```
%PROGRAM on operations on sequences
clc;
clear all;
close all;
%plot addition sequences
N=input('enter the number of elements');
x1=input('enter the first sequence');
x2=input('enter the second sequence');
n=0:N-1;
subplot(4,4,1),stem(n,x1);title('first sequence');axis([-3 3 0 10]);grid;
subplot(4,4,2),stem(n,x2);title('second sequence');axis([-3 3 0 10]);grid;
subplot(4,4,3),stem(n,x1+x2);title('additon sequence');axis([0 3 0 15 ]);grid;
subplot(4,4,4),stem(n,x1-x2);title('subtraction sequence');axis([-3 3 -2 5]);grid;
subplot(4,4,5),stem(n,x1.*x2);title('multiplication sequence');axis([-3 3 0 54]);grid;
%amplitude scaling sequence
y=5*x1;
subplot(4,4,6),stem(n,y);
title('amplitude scaling sequence');grid;axis([-3 3 0 50]);
%time delay sequence
subplot(4,4,7),stem(n+2,x1);
title('time delayed signal');grid;
```

```
%time advance sequence
subplot(4,4,8),stem(n-2,x1);grid;
title('time advance sequence');
%time folding sequence;
subplot(4,4,9),stem((-n),x1);
xlabel('n');ylabel('amplitude');grid;
title('time folding sequence');
%time scaling sequence
subplot(4,4,10),stem(2*n,x1);
xlabel('n');ylabel('amplitude');grid;
title('time scaling sequence');
```

PROGRAM4:energy & power

```
clc;
clear all;
close all;
%energy of a signal
N=input('enter the value of N');
n=-N:N;
x=cos((pi*n)/2);
E=sum(norm(x)^2);
disp('energy is');
disp(E);
%power of a signal
p=E/((2*N)+1);
disp('power is');
disp(p);
```

OUTPUT:

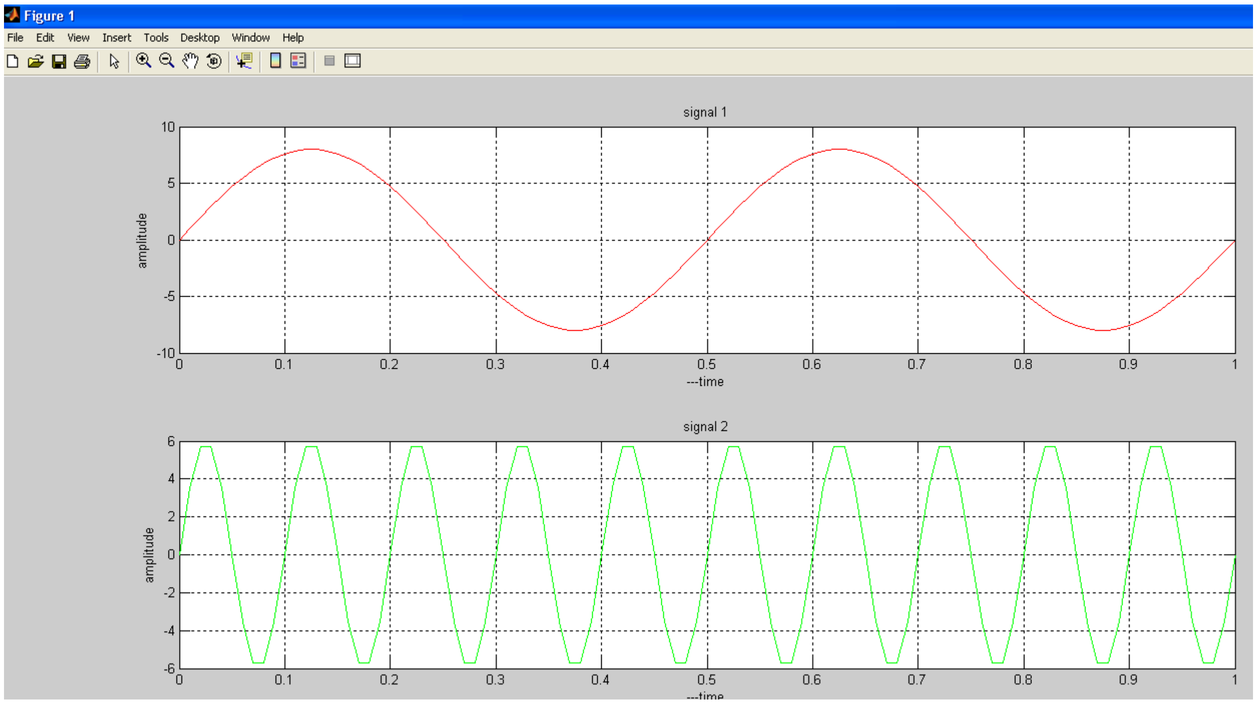


Figure 1
File Edit View Insert Tools Desktop Window Help
signal 1
amplitude
---time
signal 2
amplitude
---time

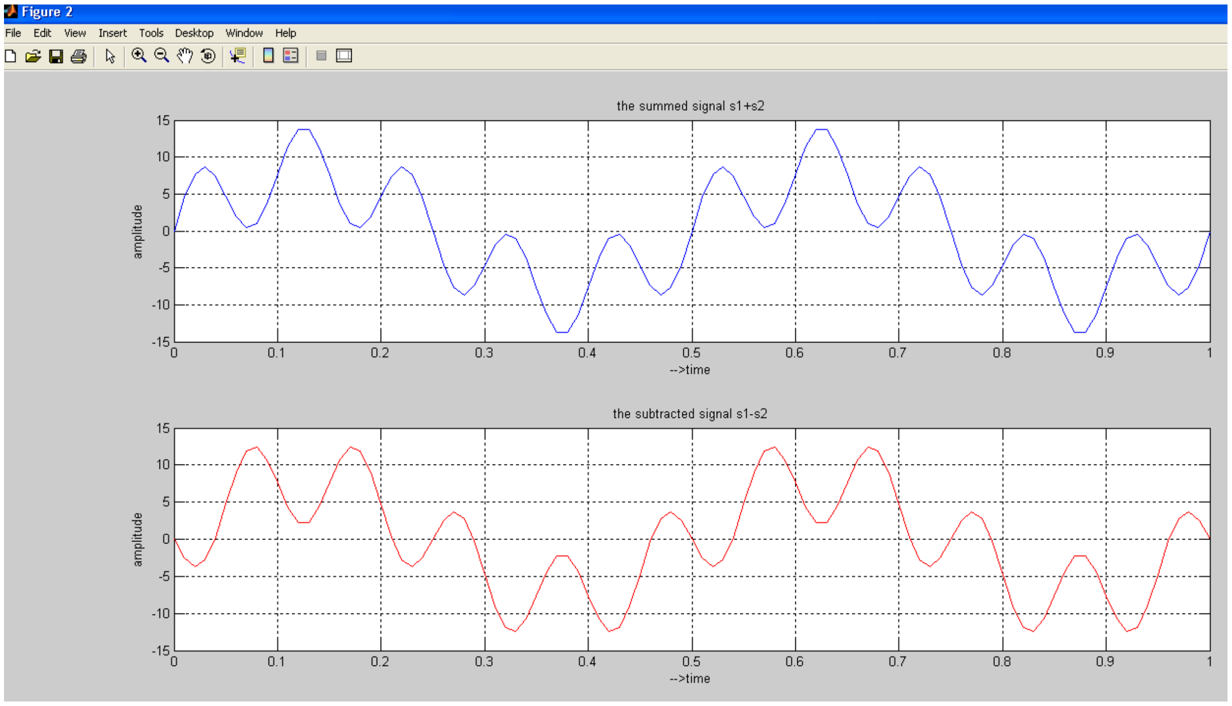


Figure 2
File Edit View Insert Tools Desktop Window Help
the summed signal s1+s2
amplitude
-->time
the subtracted signal s1-s2
amplitude
-->time

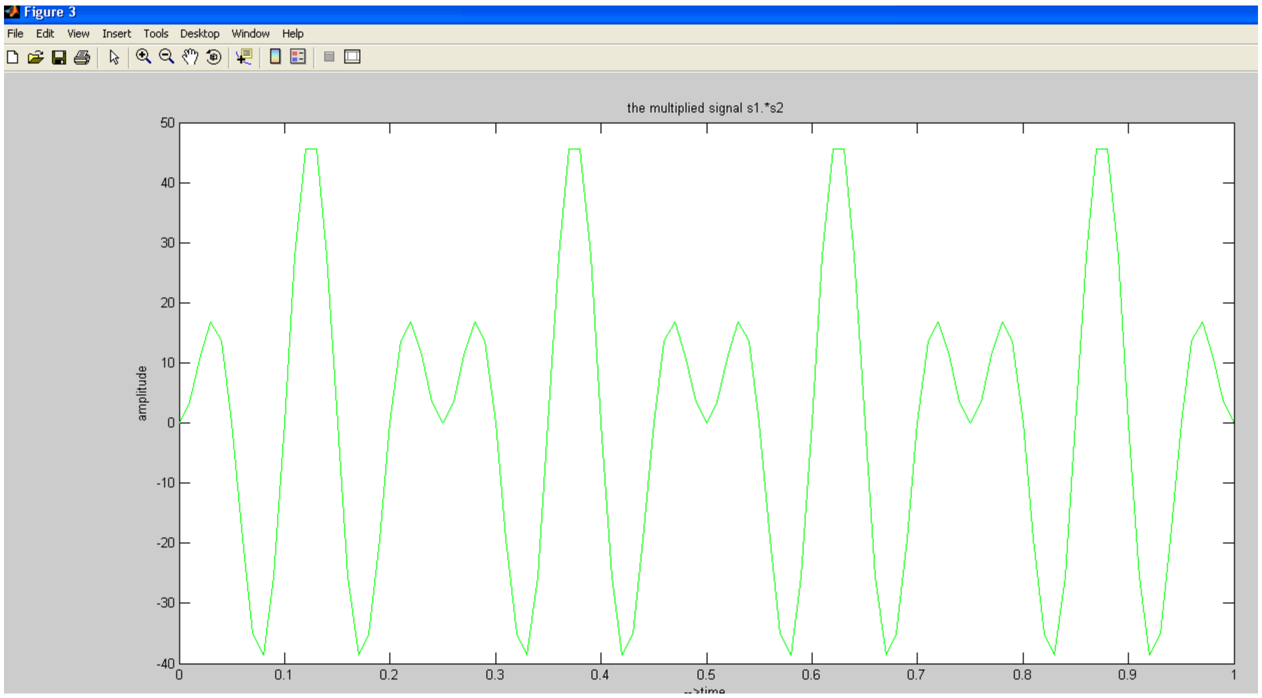


Figure 3
File Edit View Insert Tools Desktop Window Help
the multiplied signal s1.*s2
amplitude
-->time
50
40
30
20
10
0
-10
-20
-30
-40
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

PROGRAM2o/p:

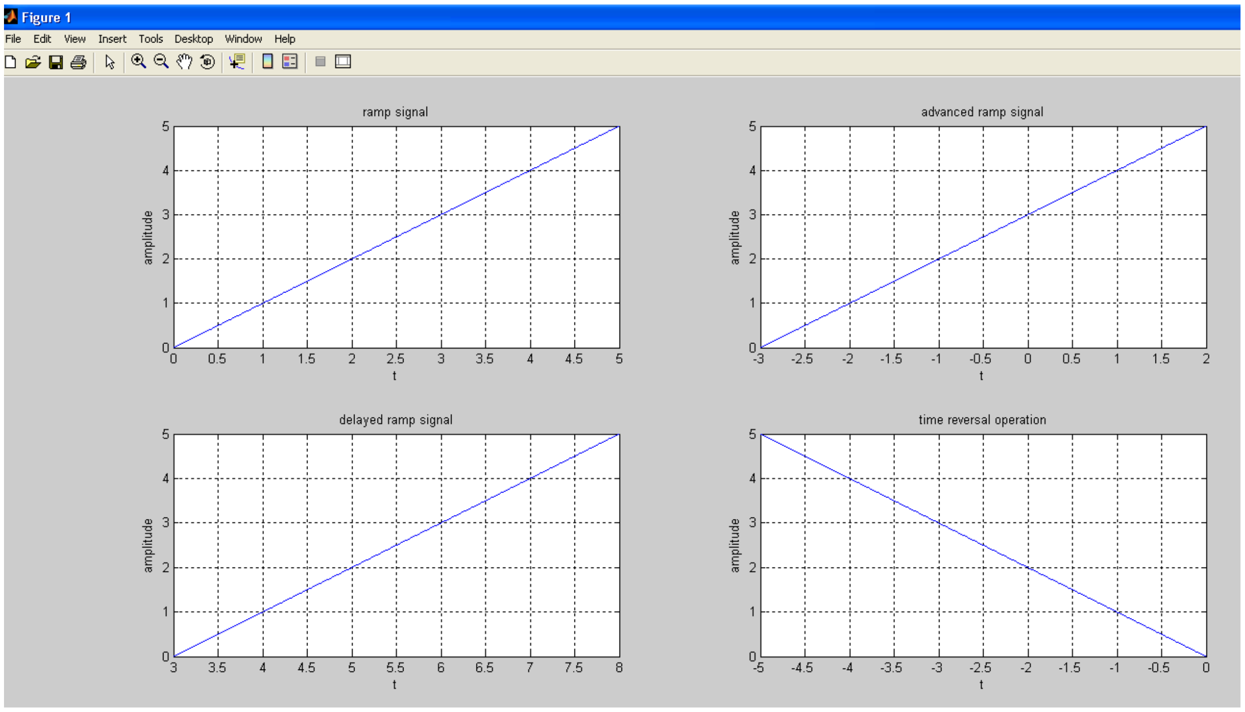
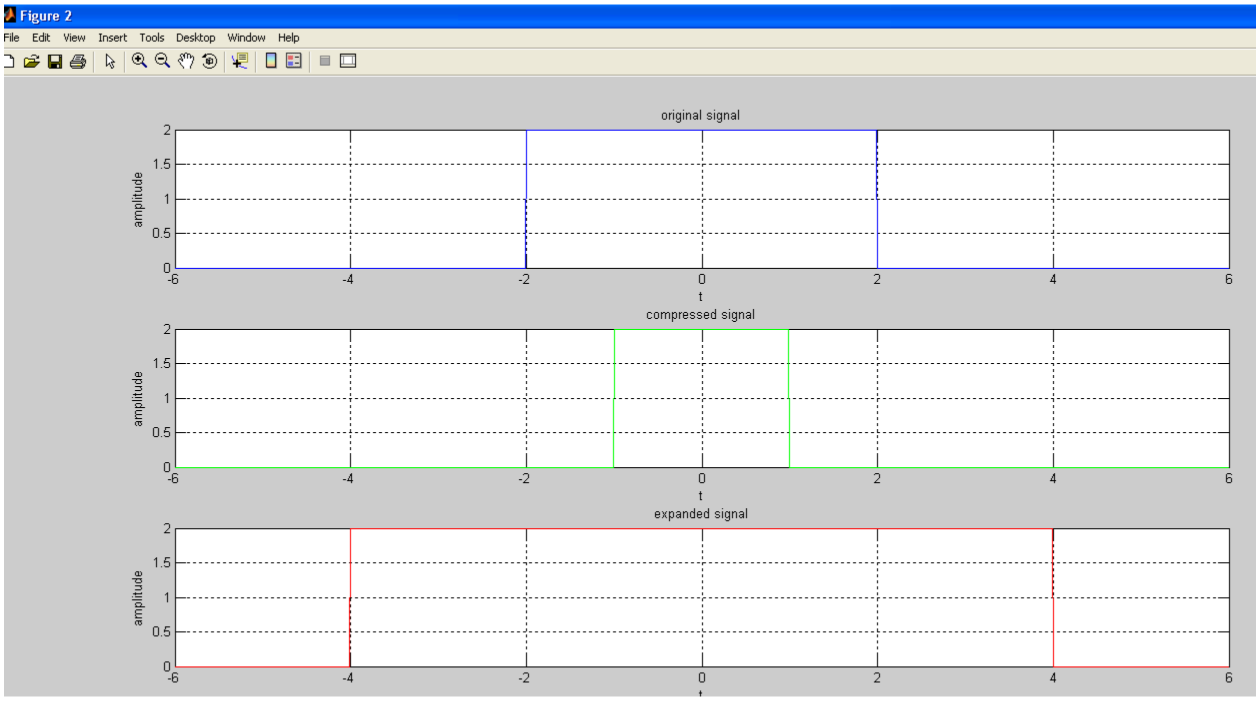


Figure 1
File Edit View Insert Tools Desktop Window Help
ramp signal
advanced ramp signal
delayed ramp signal
time reversal operation
amplitude
t
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
-3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2
3 3.5 4 4.5 5 5.5 6 6.5 7 7.5 8
-5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0
0 1 2 3 4 5

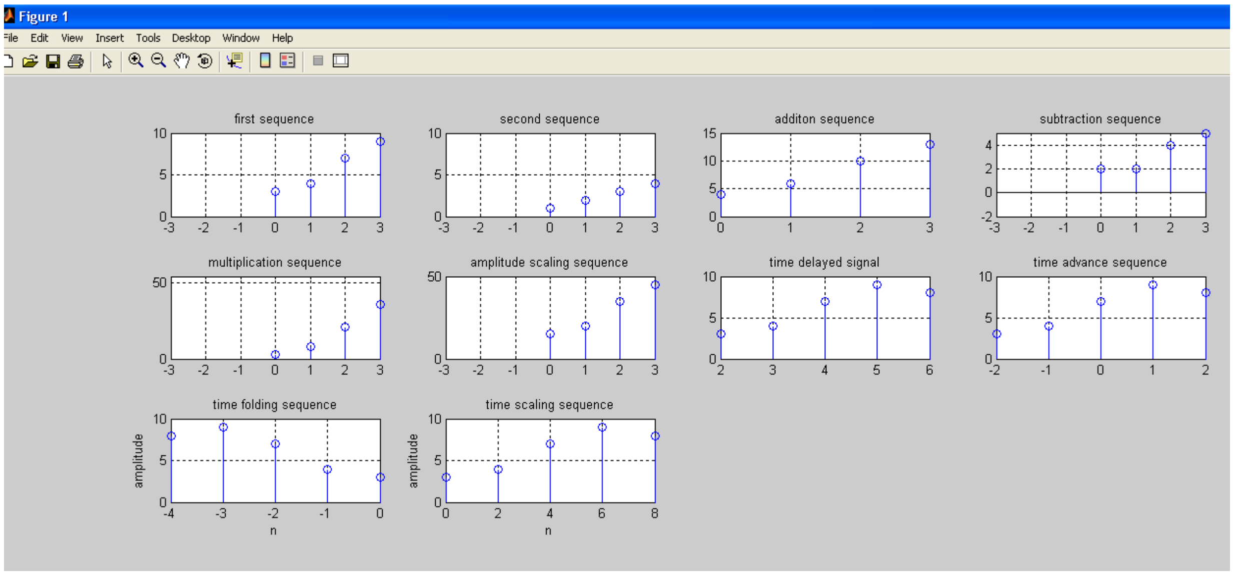


PROGRAM3 o/p:

enter the number of elements5

enter the first sequence[3 4 7 9 8]

enter the second sequence[1 2 3 4 6]



PROGRAM4 o/p:

```
enter the value of N200
energy is
  201
power is 0.5012
```

CONCLUSION:

In this experiment various oprations on signals and sequences and energyand power of signals have been calculated Using MATLAB

Exersize questions:

1.x(t)= u(-t+1)

2. x(t)=3r(t-1)

3. x(t)=U(n+2-u(n-3)

4. x(n)=x1(n)+x2(n)where x1(n)={1,3,2,1},x2(n)={1,-2,3,2}

5. x(t)=r(t)-2r(t-1)+r(t-2)

6. x(n)=2δ(n+2)-2δ(n-4), -5≤ n ≥5.

7. X(n)={1,2,3,4,5,6,7,6,5,4,2,1} determine and plot the following sequence

a. x1(n)=2x(n-5-3x(n+4))

1. b. x2(n)=x(3-n)+x(n)x(n-2)

4 calculate the following signals energies

1.x(t)= e j(2t+Π/4)

2.x(t)=cos(t)

3.x(t)=cos(Π/4 n

RESULT:

VIVA QUESTIONS:

1. What are the Different types of Operation performed on signals.
2. Define Energy and Power signal.
3. What is the result of adding & subtracting two unit step signals.
4. Consider any one signal and perform shifting, scaling and reversal operations
5. Define the Properties of Impulse Signal
6. What is Causality Condition of the Signal

4. GIBBS PHENOMENON

AIM:

To verify the Gibbs Phenomenon.

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

The **Gibbs phenomenon,** the Fourier series of a piecewise continuously differentiable periodic function behaves at a jump discontinuity.the *n* the approximated function shows amounts of ripples at the points of discontinuity. This is known as the Gibbs Phenomina . partial sum of the Fourier series has large oscillations near the jump, which might increase the maximum of the partial sum above that of the function itself. The overshoot does not die out as the frequency increases, but approaches a finite limit

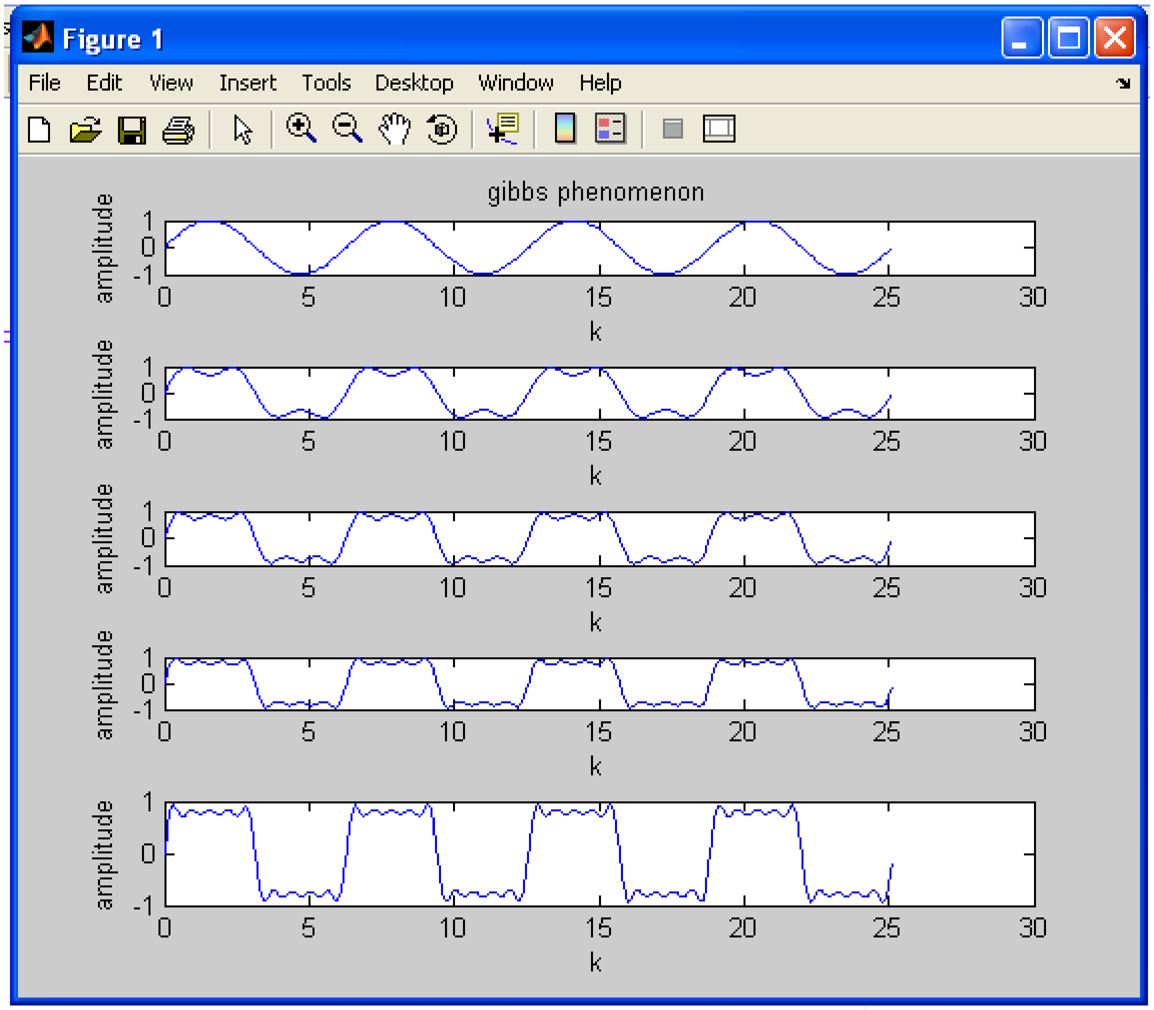
The Gibbs phenomenon involves both the fact that Fourier sums overshoot at a jump discontinuity, and that this overshoot does not die out as the frequency increases **Gibbs Phenomina**

PROGRAM :

```
t=0:0.1:(pi*8);
y=sin(t);
subplot(5,1,1);
plot(t,y);
xlabel('k');
ylabel('amplitude');
title('gibbs phenomenon');
h=2;
%k=3;
for k=3:2:9
y=y+sin(k*t)/k;
subplot(5,1,h);
plot(t,y);
xlabel('k');
```

```
ylabel('amplitude');
h=h+1;
end
```

OUTPUT:



CONCLUSION:

In this experiment Gibbs phenomenon have been demonstrated

Using MATLAB

RESULT:

VIVA QUESTION:

1. State Gibbs phenomenon

5. FINDING THE FOURIER TRANSFORM OF A GIVEN SIGNAL AND PLOTTING ITS MAGNITUDE AND PHASE SPECTRUM

AIM:

To find the Fourier Transform of a given signal and plotting its
magnitude and phase spectrum

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

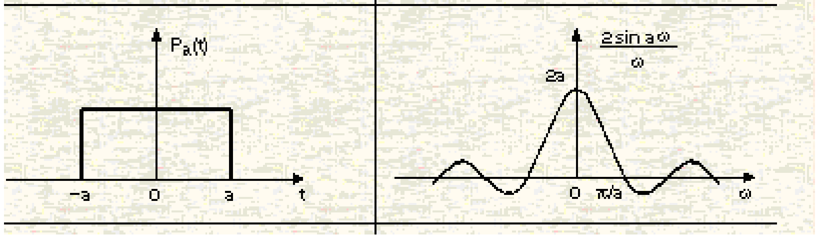
THEORY:

Fourier Transform Theorems:

We may use Fourier series to motivate the Fourier transform as follows. Suppose that *f*
is
a function which is zero outside of some interval [−*L*/2, *L*/2]. Then for any *T* ≥ *L* we may expand *f* in a Fourier series on the interval [−*T*/2,*T*/2], where the "amount" of the wave *e* 2*πinx/T* in the Fourier series of *f* is given by By definition

$$F(w) = \int_{-\infty}^{\infty} f(x) e^{-iwx}\, dx$$

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\omega) e^{j\omega t}\, d\omega \qquad F(W) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t}\, dt$$



DFT of a sequence

$$X[K] = \sum_{K=0}^{N-1} x[n] e^{\frac{-j2\Pi Kn}{N}}$$

Where N= Length of sequence.

K= Frequency Coefficient.

n = Samples in time domain.

FFT : -Fast Fourier transformer .

There are Two methods.

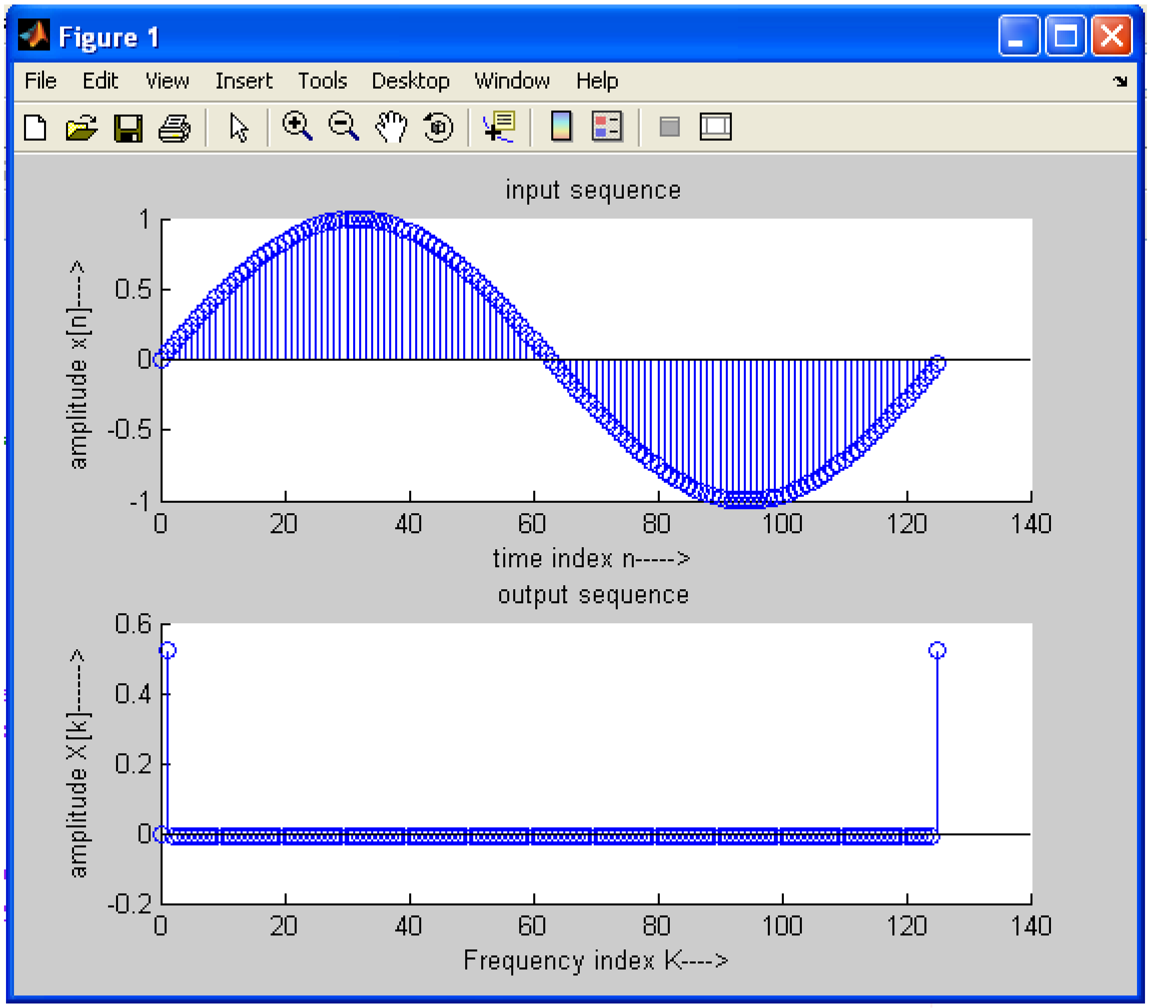
1. Decimation in time (DIT FFT).

2. Decimation in Frequency (DIF FFT).

PROGRAM:

```
clc;
close all;
clear all;
x=input('enter the sequence');
N=length(x);
n=0:1:N-1;
y=fft(x,N)
subplot(2,1,1);
stem(n,x);
title('input sequence');
xlabel('time index n----->');
ylabel('amplitude x[n]----> ');
subplot(2,1,2);
stem(n,y);
title('OUTPUT sequence');
xlabel(' Frequency index K---->');
ylabel('amplitude X[k]------>');
```

OUTPUT:

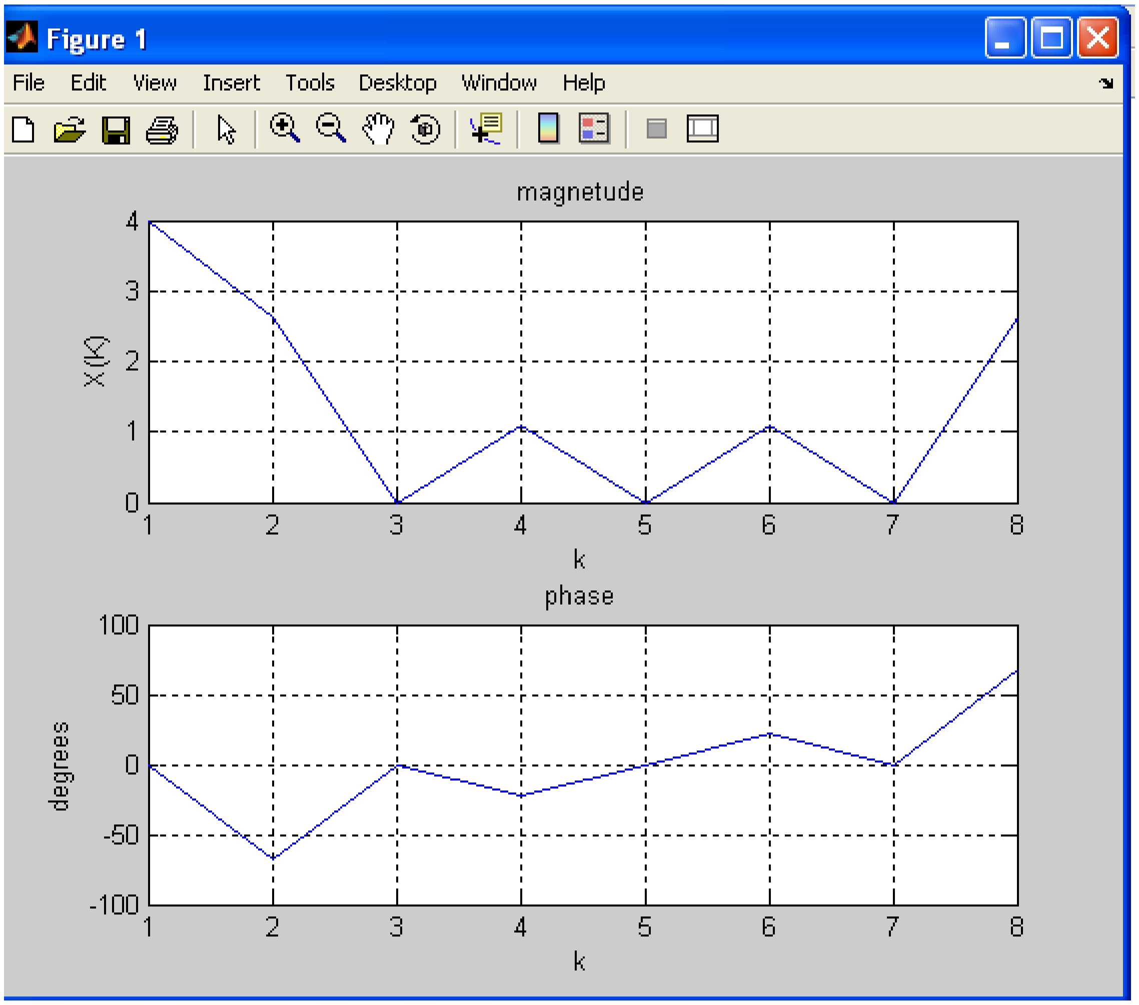


FFT magnitude and Phase plot:

```
clc
close all
x=[1,1,1,1,zeros(1,4)];
N=8;
X=fft(x,N);
magX=abs(X),phase=angle(X)*180/pi;
subplot(2,1,1)
plot(magX);
grid
xlabel('k')
```

```
ylabel('X(K)')
subplot(2,1,2)
plot(phase);
grid
xlabel('k')
ylabel('degrees')
```

OUTPUT:



Applications:

The no of multiplications in DFT = N2.

The no of Additions in DFT = N(N-1).

For FFT.

The no of multiplication = N/2 log 2N.

The no of additions = N log2 N.

CONCLUSION:

In this experiment the fourier transform of a given signal and plotting

its magnitude and phase spectrum have been demonstrated using matlab

RESULT:

VIVA QUESTIONS:

1 .Define Fourier Series
2. What is Half Wave Symmetry
3. What are the properties of Continuous-Time Fourier Series
4. Define Fourier Transform

6. PROPERTIES OF FOURIER TRNASFORM

AIM:

To verify thE properties of DTFT of a given discrete-time signal

EQUIPMENTS:
PC with windows (95/98/XP/NT/2000).
MATLAB Software

THEORY:

We will represent the spectrum of DTFT by X(e^{jw})

$$X(e^{j\omega}) = \sum_{n=-\infty}^{\infty} x(n)e^{-j\omega n} \qquad x(n) = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(e^{j\omega})e^{j\omega n}d\omega$$

DTFT Properties

- **Time shifting**

If $x(n)$ has a DTFT $X(e^{j\omega})$, then $x(n-k)$ has a DTFT equal to $e^{-j\omega k}X(e^{j\omega})$, where k is an integer. This is known as the *time-shifting property* and it is easily proved as follows: DTFT of $x(n-k) = \sum_{n=-\infty}^{\infty} x(n-k)e^{-j\omega n} = e^{-j\omega k}\sum_{n=-\infty}^{\infty} x(n)e^{-j\omega n} = e^{-j\omega k}X(e^{j\omega})$. So we denote this property by

$$x(n-k) \Leftrightarrow e^{-j\omega k}X(e^{j\omega})$$

- **Time reversal**

$$x(-n) \Leftrightarrow X(e^{-j\omega})$$

Proof: DTFT of $x(-n) = \sum_{n=-\infty}^{\infty} x(-n)e^{-j\omega n}$. We substitute $(-n) = m$, and we get $\sum_{n=-\infty}^{\infty} x(-n)e^{-j\omega n} = \sum_{m=-\infty}^{\infty} x(m)e^{j\omega m} = \sum_{m=-\infty}^{\infty} x(m)e^{-j(-\omega)m} = X(e^{-j\omega})$.

- **Convolution**

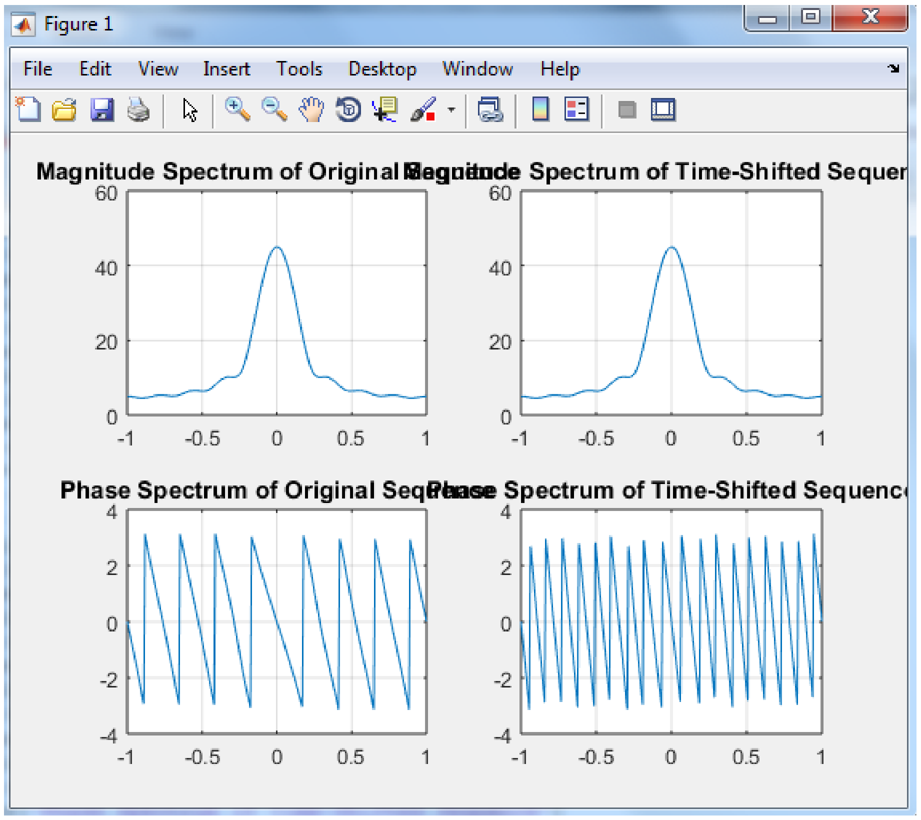
Let x[n] ↔ X(e^{jw}) and h[n] ↔ H(e^{jw}).
If y[n] = x[n] ∗ h[n], then
Y(e^{jw}) = X(e^{jw})H(e^{jw})

PROGRAM:

```
% Time-Shifting Property of DTFT
clc;
clear all;
close all;
w = -pi:2*pi/255:pi; wo = 0.4*pi; D = 10;
num = [1 2 3 4 5 6 7 8 9];
h1 = freqz(num, 1, w);
h2 = freqz([zeros(1,D) num], 1, w);
subplot(2,2,1)
```

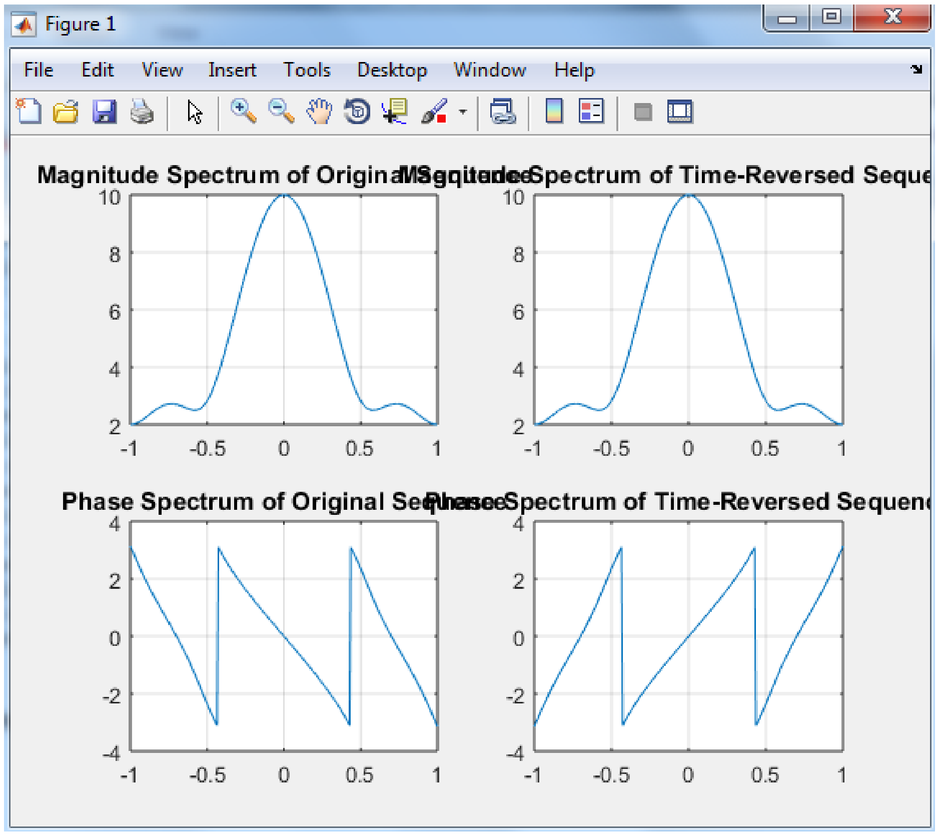
```
plot(w/pi,abs(h1));grid
title('Magnitude Spectrum of Original Sequence')
subplot(2,2,2)
plot(w/pi,abs(h2));grid
title('Magnitude Spectrum of Time-Shifted Sequence')
subplot(2,2,3)
plot(w/pi,angle(h1));grid
title('Phase Spectrum of Original Sequence')
subplot(2,2,4)
plot(w/pi,angle(h2));grid
title('Phase Spectrum of Time-Shifted Sequence')
w = -pi:2*pi/255:pi; wo = 0.4*pi; D = 10;
num = [1 2 3 4 5 6 7 8 9];
h1 = freqz(num, 1, w);
h2 = freqz([zeros(1,D) num], 1, w);
subplot(2,2,1)
plot(w/pi,abs(h1));grid
title('Magnitude Spectrum of Original Sequence')
subplot(2,2,2)
plot(w/pi,abs(h2));grid
title('Magnitude Spectrum of Time-Shifted Sequence')
subplot(2,2,3)
plot(w/pi,angle(h1));grid
title('Phase Spectrum of Original Sequence')
subplot(2,2,4)
plot(w/pi,angle(h2));grid
title('Phase Spectrum of Time-Shifted Sequence')
```

OUTPUT:



```
% Time-Reversal Property of  DTFT
clc;
clear all;
close all;
w = -pi:2*pi/255:pi;
num = [1 2 3 4];
L = length(num)-1;
h1 = freqz(num, 1, w);
h2 = freqz(fliplr(num), 1, w);
h3 = exp(w*L*i).*h2;
subplot(2,2,1)
plot(w/pi,abs(h1));grid
title('Magnitude Spectrum of Original Sequence')
subplot(2,2,2)
plot(w/pi,abs(h3));grid
title('Magnitude Spectrum of Time-Reversed Sequence')
subplot(2,2,3)
plot(w/pi,angle(h1));grid
title('Phase Spectrum of Original Sequence')
subplot(2,2,4)
plot(w/pi,angle(h3));grid
title('Phase Spectrum of Time-Reversed Sequence')
```

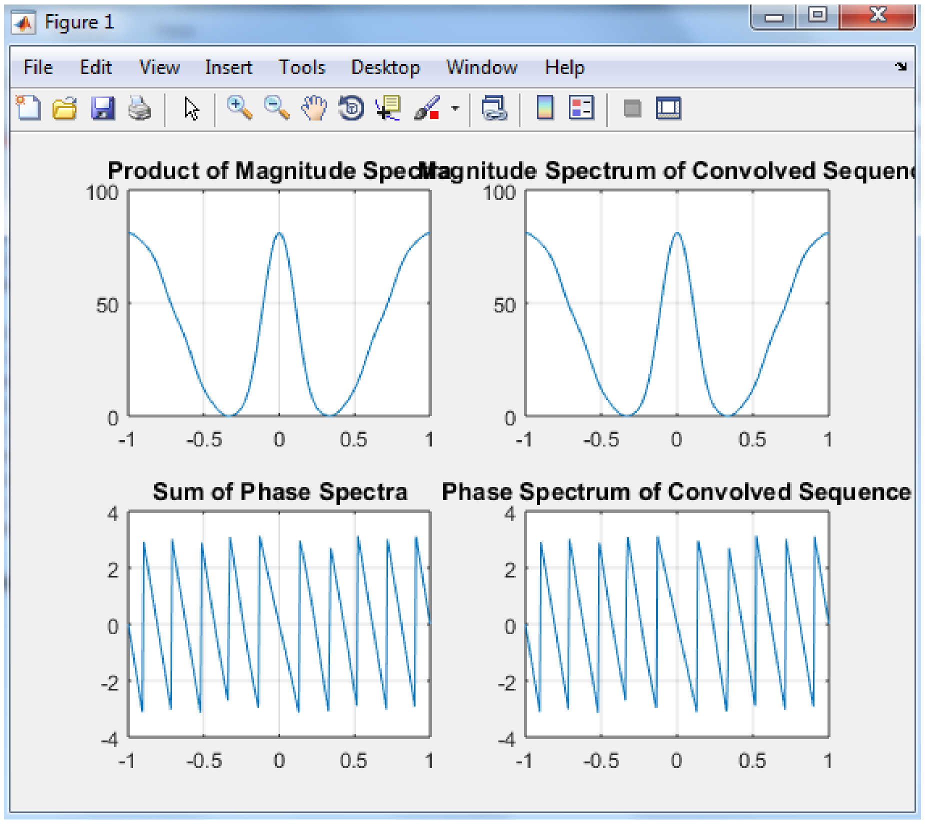
OUTPUT:



```
% Convolution Property of DTFT
clc;
clear all;
close all;
w = -pi:2*pi/255:pi;
x1 = [1 3 5 7 9 11 13 15 17];
x2 = [1 -2 3 -2 1];
y = conv(x1,x2);
h1 = freqz(x1, 1, w);
h2 = freqz(x2, 1, w);
hp = h1.*h2;
h3 = freqz(y,1,w);
subplot(2,2,1)
plot(w/pi,abs(hp));grid
title('Product of Magnitude Spectra')

subplot(2,2,2)
plot(w/pi,abs(h3));grid
title('Magnitude Spectrum of Convolved Sequence')
subplot(2,2,3)
plot(w/pi,angle(hp));grid
```

```
title('Sum of Phase Spectra')
subplot(2,2,4)
plot(w/pi,angle(h3));grid
title('Phase Spectrum of Convolved Sequence')
```

OUTPUT:



CONCLUSION:
In this experiment the properties of DTFT are verified using MATLAB

RESULT:

PRE LAB QUESTIONS
1.Define DTFT
2.What is the convolution theorem of DTFT ?
3. What is the time shifting property of DTFT ?
4. State the Time-reversal property of DTFT.

LAB ASSIGNMENT
1. To verify the frequency-shifting property of the DTFT

POST LAB QUESTIONS
1. What is effect of time shifting property of DTFT?
2. What is effect of time reversal property of DTFT?

3. State the convolution property of DTFT.

7. WAVEFORM SYNTHESIS USING LAPLACE TRNASFORM

AIM:

To perform waveform synthesis using Laplace Transform of a given signal

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

Bilateral Laplace transform :

When one says "the Laplace transform" without qualification, the unilateral or one-sided transform is normally intended. The Laplace transform can be alternatively defined as the *bilateral Laplace transform* or two-sided Laplace transform by extending the limits of integration to be the entire real axis. If that is done the common unilateral transform simply becomes a special case of the bilateral transform where the definition of the function being transformed is multiplied by the Heaviside step function.

The bilateral Laplace transform is defined as follows:

$$F(s) = \mathcal{L}\left\{f(t)\right\} = \int_{-\infty}^{\infty} e^{-st} f(t)\, dt.$$

The inverse Laplace transform is given by the following complex integral, which is known by various names (the **Bromwich integral**, the **Fourier-Mellin integral**, and **Mellin's inverse formula**):

$$f(t) = \mathcal{L}^{-1}\{F(s)\} = \frac{1}{2\pi i} \lim_{T\to\infty} \int_{\gamma - iT}^{\gamma + iT} e^{st} F(s)\, ds,$$

PROGRAM:

```
syms f t;
f=t;
laplace(f)
PROGRAM for nverse Laplace Transform
f(s)=24/s(s+8) invese LT
syms F s
```

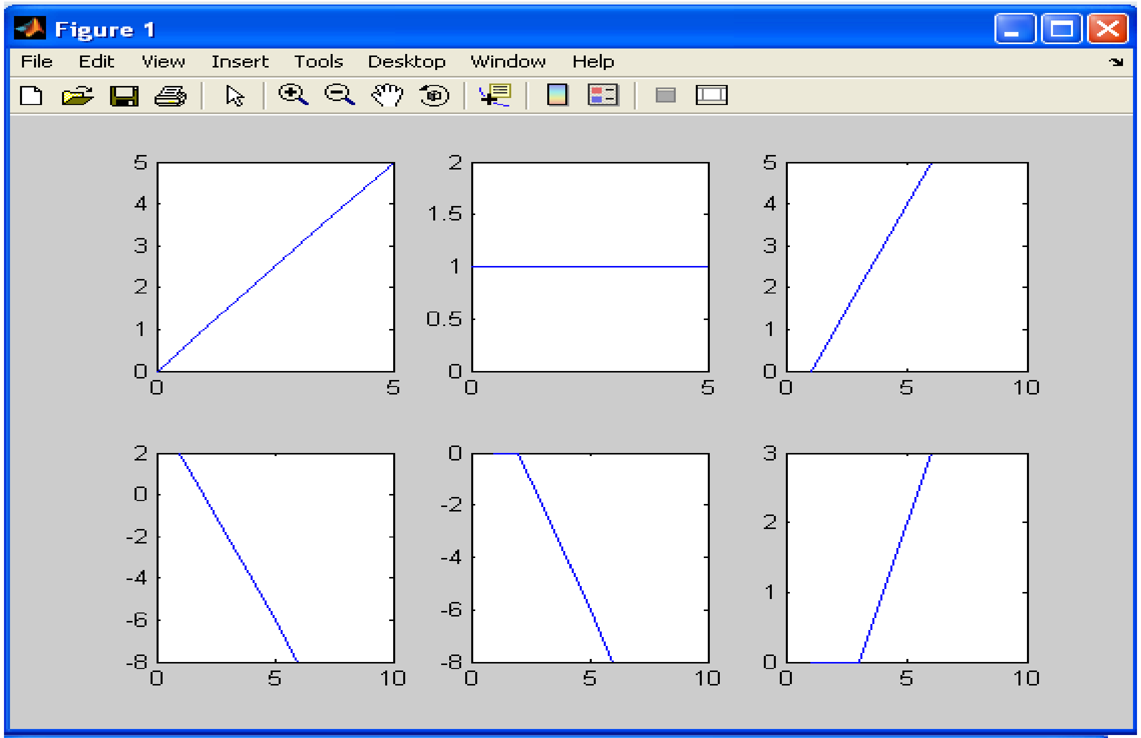
```
F=24/(s*(s+8));
ilaplace(F)
```

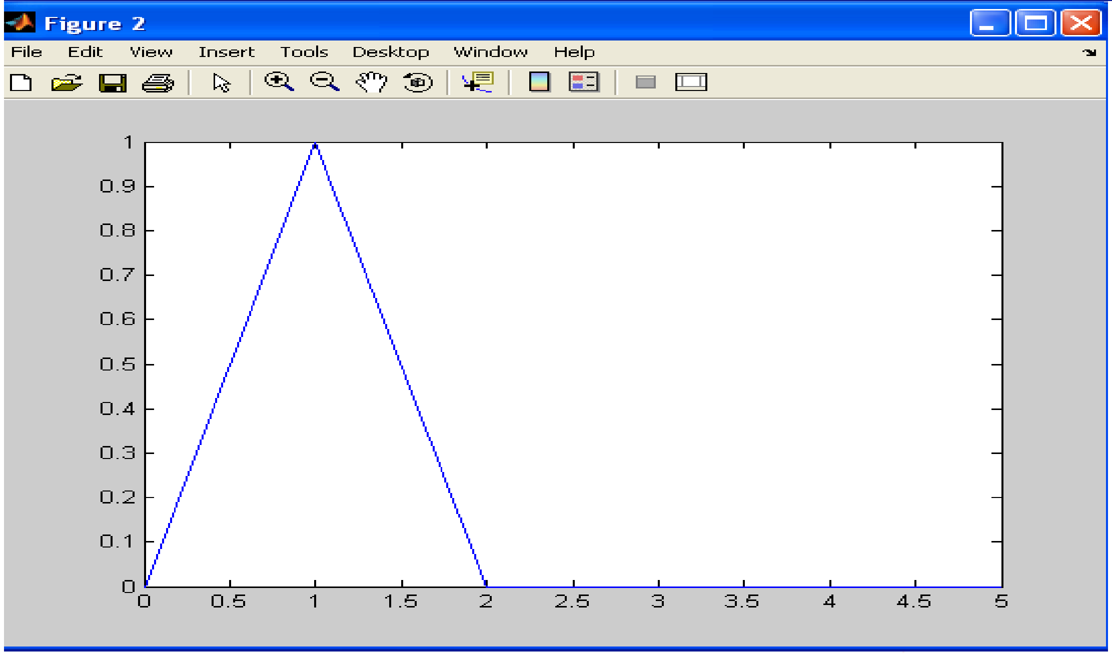
y(s)=24/s(s+8) invese LT poles and zeros

Signal synthese using Laplace Tnasform:

```
clear all
clc
t=0:1:5
s=(t);
subplot(2,3,1)
plot(t,s);
u=ones(1,6)
subplot(2,3,2)
plot(t,u);
f1=t.*u;
subplot(2,3,3)
plot(f1);
s2=-2*(t-1);
subplot(2,3,4);
plot(s2);
u1=[0 1 1 1 1 1];
f2=-2*(t-1).*u1;
subplot(2,3,5);
plot(f2);
u2=[0 0 1 1 1 1];
f3=(t-2).*u2;
subplot(2,3,6);
plot(f3);
f=f1+f2+f3;
figure;
plot(t,f);
% n=exp(-t);
% n=uint8(n);
% f=uint8(f);
% R = int(f,n,0,6)
laplace(f);
```

OUTPUT:





CONCLUSION:

In this experiment the Triangular signal synthesised using

Laplece Trnasforms using MATLAB

Applications of laplace transforms:

1. Derive the circuit (differential) equations in the **time** domain, then transform these ODEs to the *s*-domain;

2. Transform the circuit to the *s*-domain, then derive the circuit equations in the

*S*domain (using the concept of "impedance").

The main idea behind the Laplace Transformation is that we can solve an equation (or system of equations) containing differential and integral terms by transforming the equation in "*t*-space" to one in "*s*-space". This makes the problem much easier to solve.

RESULT:

VIVA QUESTIONS:

1. Define Laplace-Transform
2. What is the Condition for Convergence of the L.T
3. What is the Region of Convergence(ROC)
4. State the Shifting property of L.T
5. State convolution Property of L.T
6. Define Transfer Function
7. Define Pole-Zeros of the Transfer Function

8.LOCATING THE ZEROS AND POLES AND PLOTTING THE POLE ZERO MAPS IN S-P LANE AND Z-PLANE FOR THE GIVEN TRANSFER FUNCTION

AIM: To locating the zeros and poles and plotting the pole zero maps in s-plane and Zplane for the given transfer function

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

Z-transforms

the **Z-transform** converts a discrete time-domain signal, which is a sequence of real or complex numbers, into a complex frequency-domain representation.The Z-transform, like

many other integral transforms, can be defined as either a *one-sided* or *two-sided* transform.

Bilateral Z-transform

The *bilateral* or *two-sided* Z-transform of a discrete-time signal *x[n]* is the function *X(z)* defined as

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=-\infty}^{\infty} x[n]z^{-n}$$

Unilateral Z-transform

Alternatively, in cases where *x*[*n*] is defined only for *n* ≥ 0, the *single-sided* or *unilateral* Z-transform is defined as

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=0}^{\infty} x[n]z^{-n}$$

In signal processing, this definition is used when the signal is causal.

$$\text{where } z = r.e^{j\omega}$$

$$X(z) = \frac{P(z)}{Q(z)}$$

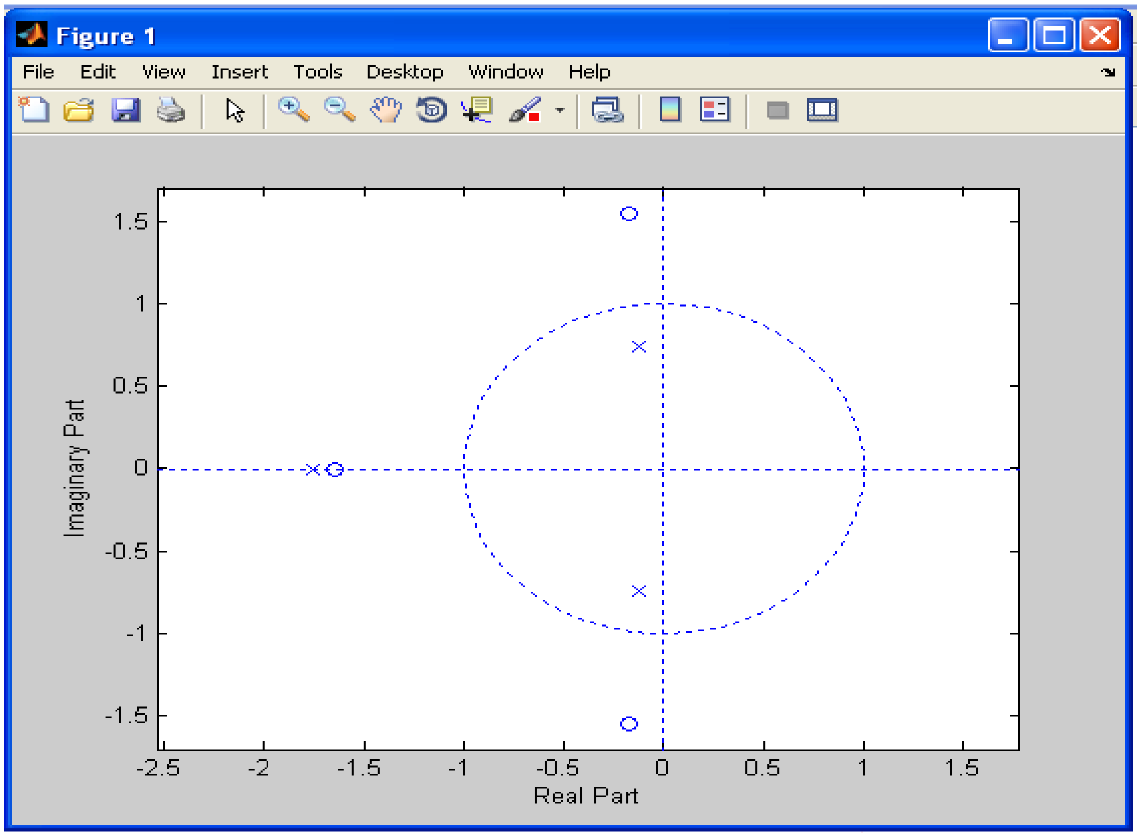
The roots of the equation P(z) = 0 correspond to the 'zeros' of X(z)

The roots of the equation Q(z) = 0 correspond to the 'poles' of X(z)

PROGRAM:

```
clc;
close all
clear all;
%b= input('enter the numarator cofficients')
%a= input('enter the denumi cofficients')
b=[1 2 3 4]
a=[1 2 1 1 ]
zplane(b,a);
```

OUTPUT:



CONCLUSION:

In this experiment the zeros and poles and plotting the pole zero maps in s-plane and z-plane for the given transfer function using MATLAB.

RESULT:

VIVA QUESTIONS:

1. What is the Relationship between L.T & F.T &Z.T
2. Fined the Z.T of a Impulse and step
3. What are the Different Methods of evaluating inverse z-T
4. Explain Time-Shifting property of a Z.T
5. what are the ROC properties of a Z.T
6. Define Initial Value Theorem of a Z.T
7. Define Final Value Theorem of a Z.T

9. CONVOLUTION BETWEEN SIGNALS AND SEQUENCE

AIM:

To find the output with linear convolution operation Using MATLAB Software.

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

Linear Convolution involves the following operations.

1. Folding
2. Multiplication
3. Addition
4. Shifting

These operations can be represented by a Mathematical Expression as follows:

$$y[n] = \sum_{k=-\infty} x[k]h[n-k]$$

x[ ]= Input signal Samples
h[ ]= Impulse response co-efficient.
y[ ]= Convolution output.
n = No. of Input samples
h = No. of Impulse response co-efficient.

Example : X(n)={1 2 -1 0 1}, h(n)={ 1,2,3,-1}

PROGRAM:

```
clc;
close all;
clear all;
x=input('enter input sequence');
h=input('enter impulse response');
y=conv(x,h);
subplot(3,1,1);
stem(x);
xlabel('n');ylabel('x(n)');
```

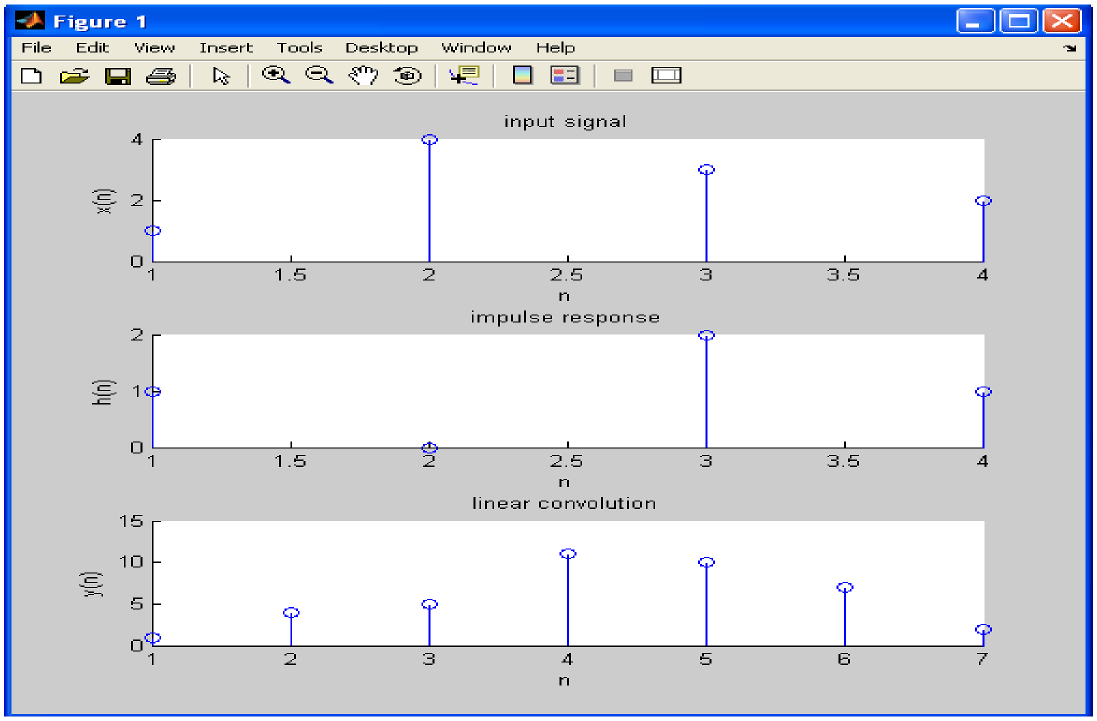
```
title('input signal')
subplot(3,1,2);
stem(h);
xlabel('n');ylabel('h(n)');
title('impulse response')
subplot(3,1,3);
stem(y);
xlabel('n');ylabel('y(n)');
title('linear convolution')
disp('The resultant signal is');
disp(y)
```

linear convolution

INTPUT:

```
enter input sequence[1 4 3 2]
enter impulse response[1 0 2 1]
The resultant signal is
1 4 5 11 10 7 2
```

OUTPUT:



CONCLUSION:

In this experiment convolution of various signals have been

performed Using MATLAB

Applications:

Convolution is used to obtain the response of an LTI system to an arbitrary input

signal.It

is used to find the filter response and finds application in speech processing and radar

signal processing.

Excersize questions: perform convolution between the following signals

1. X(n)=[1 -1 4], h(n) = [-1 2 -3 1]

2. perform convolution between the. Two periodic sequences

x1(t)=e-3t{u(t)-u(t-2)} , x2(t)= e -3t for $0 \leq t \leq 2$

RESULT:

VIVA QUESTIONS:

1. Define Convolution
2. Define Properties of Convolution

10. AUTO CORRELATION AND CROSS CORRELATION BETWEEN SIGNALS AND SEQUENCES

AIM: To compute auto correlation and cross correlation between signals and sequences

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

Correlations of sequences:

It is a measure of the degree to which two sequences are similar. Given two real valued Sequences *x*(*n*) and *y*(*n*) of finite energy,

Convolution involves the following operations.

1. Shifting
2. Multiplication
3. Addition

These operations can be represented by a Mathematical Expression as follows:

Cross correlation

$$r_{x,y}(l) = \sum_{n=-\infty}^{+\infty} x(n)y(n-l)$$

The index *l* is called the shift or lag parameter

Autocorrelation

$$r_{x,x}(l) = \sum_{n=-\infty}^{+\infty} x(n)x(n-l)$$

The special case: y(n)=x(n)

$$R_{yx}(\lambda) = \int_{-\infty}^{\infty} y(t)\ x(t+\lambda)\ dt$$

PROGRAM:

```
% Cross Correlation
        clc;
        close all;
```

```
clear all;
x=input('enter input sequence');
h=input('enter the impulse suquence');
subplot(3,1,1);
stem(x);
xlabel('n');
ylabel('x(n)');
title('input signal');
subplot(3,1,2);
stem(h);
xlabel('n');
ylabel('h(n)');
title('impulse signal');
y=xcorr(x,h);
subplot(3,1,3);
stem(y);
xlabel('n');
ylabel('y(n)');
disp('the resultant signal is');
disp(y);
title('correlation signal');
```

OUTPUT:

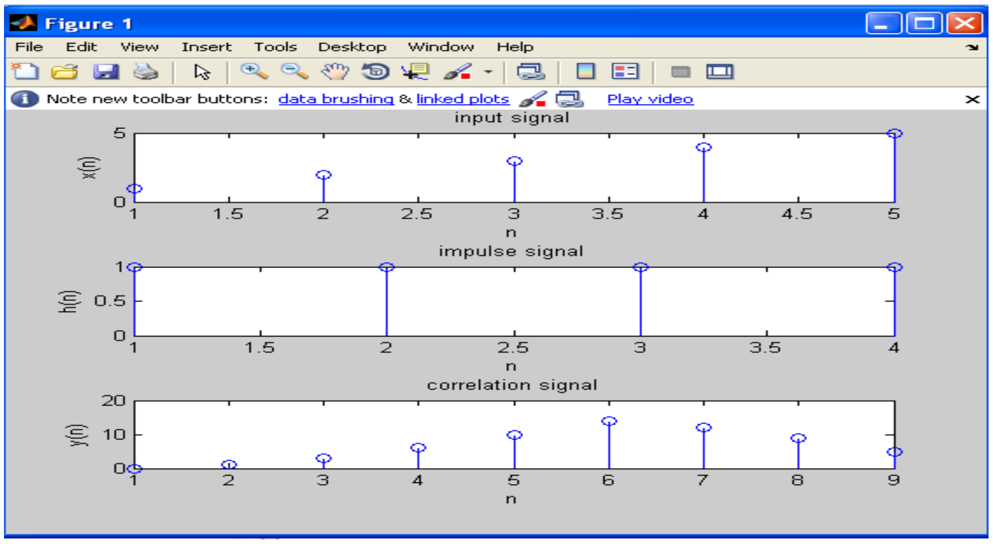


Figure 1
File Edit View Insert Tools Desktop Window Help
Note new toolbar buttons: data brushing & linked plots Play video
input signal
x(n)
n
impulse signal
h(n)
n
correlation signal
y(n)
n

PROGRAM:

```
% auto correlation

clc;

close all;

clear all;

x = [1,2,3,4,5]; y = [4,1,5,2,6];

subplot(3,1,1);

stem(x);

xlabel('n');

ylabel('x(n)');

title('input signal');

subplot(3,1,2);

stem(y);

xlabel('n');

ylabel('y(n)');

title('input signal');

z=xcorr(x,x);

subplot(3,1,3);

stem(z);

xlabel('n');

ylabel('z(n)');

title('resultant signal signal');
```

OUTPUT:

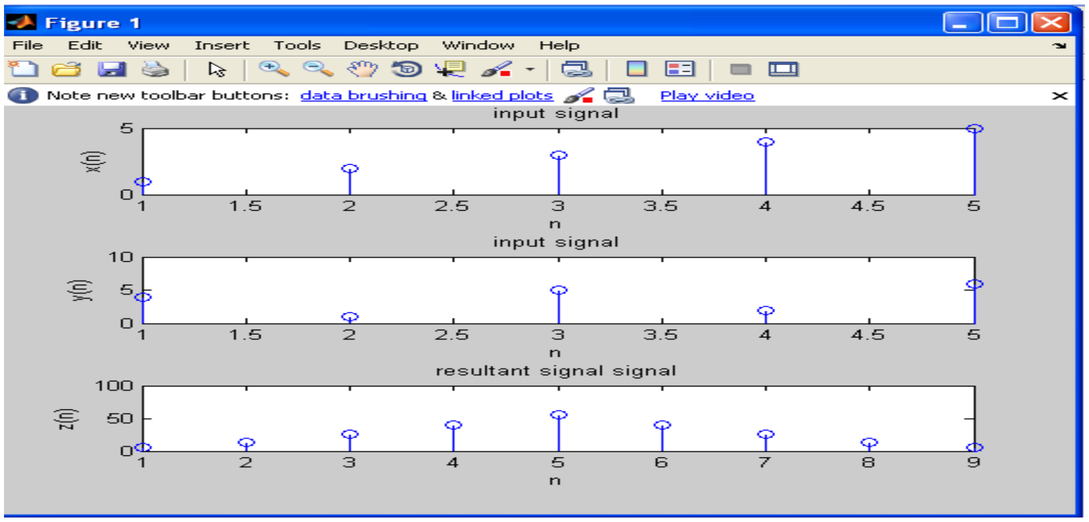


Figure 1
File Edit View Insert Tools Desktop Window Help
Note new toolbar buttons: data brushing & linked plots Play video
input signal
x(n)
n
input signal
y(n)
n
resultant signal signal
z(n)
n

CONCLUSION:

In this experiment correlation of various signals have been

performed Using MATLAB Applications:it is used to measure the degree to which the two signals are similar and it is also used for radar detection by estimating the time delay.it is also used in Digital communication, defence applications and sound navigation Excersize questions: perform convolution between the following signals 1. X(n)=[1 -1 4], h(n) = [-1 2 -3 1]

2. perform convolution between the. Two periodic sequences x1(t)=e-3t{u(t)-u(t-2)} , x2(t)= e -3t for 0 ≤ t ≤ 2

RESULT:

VIVA QUESTIONS:

1. Define Correlation
2. Define Auto Correlation and Cross Correlation
3. What is the Difference Between Convolution& Correlation

11. Generation of Gaussian Noise(Real & Complex), computation of its mean, Mean Square values and its Skew, Kurtosis and PSD, Probability Distribution function

AIM:

To Verify the Gaussian noise.

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

PROGRAM:

```
clc;
clear all;
close all;
%% Defining the range for the Random variable
dx=0.01; %delta x
x=-3:dx:3;
[m,n]=size(x);
%% Defining the parameters of the pdf
mu_x=0; % mu_x=input('Enter the value of mean');
sig_x=0.1; % sig_x=input('Enter the value of varience');
%% Computing the probability density function
px1=[];
a=1/(sqrt(2*pi)*sig_x);
for j=1:n
px1(j)=a*exp([-((x(j)-mu_x)/sig_x)^2]/2);
end
%% Computing the cumulative distribution function
cum_Px(1)=0;
for j=2:n
cum_Px(j)=cum_Px(j-1)+dx*px1(j);
end
%% Plotting the results
figure(1)
```

```
plot(x,px1);grid
axis([-3 3 0 1]);
title(['Gaussian pdf for mu_x=0 and sigma_x=', num2str(sig_x)]);
xlabel('--> x')
ylabel('--> pdf')
figure(2)
plot(x,cum_Px);grid
axis([-3 3 0 1]);
title(['Gaussian Probability Distribution Function for mu_x=0 and sigma_x=',
num2str(sig_x)]);
title('\ite^{\omega\tau} = cos(\omega\tau) + isin(\omega\tau)')
xlabel('--> x')
ylabel('--> PDF')
```

OUTPUT:

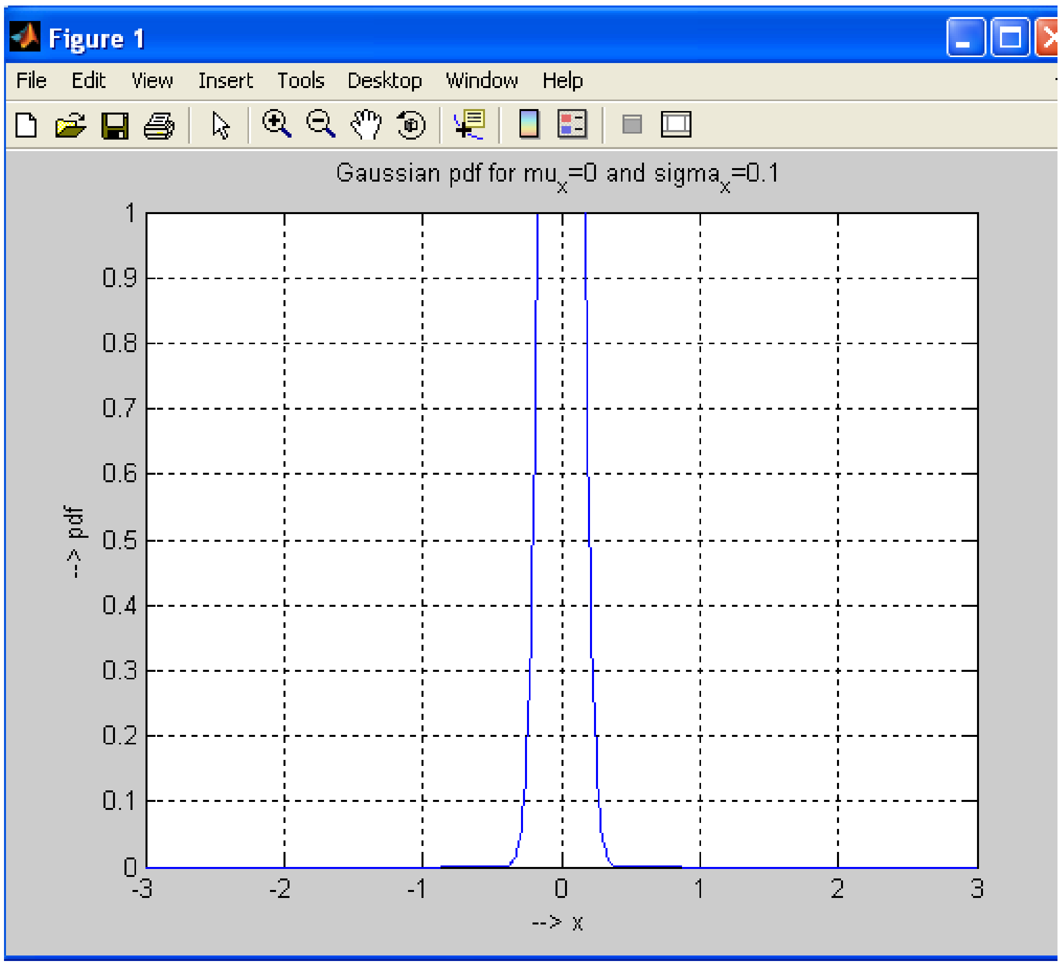


Figure 1
File Edit View Insert Tools Desktop Window Help
Gaussian pdf for mu$_x$=0 and sigma$_x$=0.1
--> pdf
--> x
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-3
-2
-1
0
1
2
3

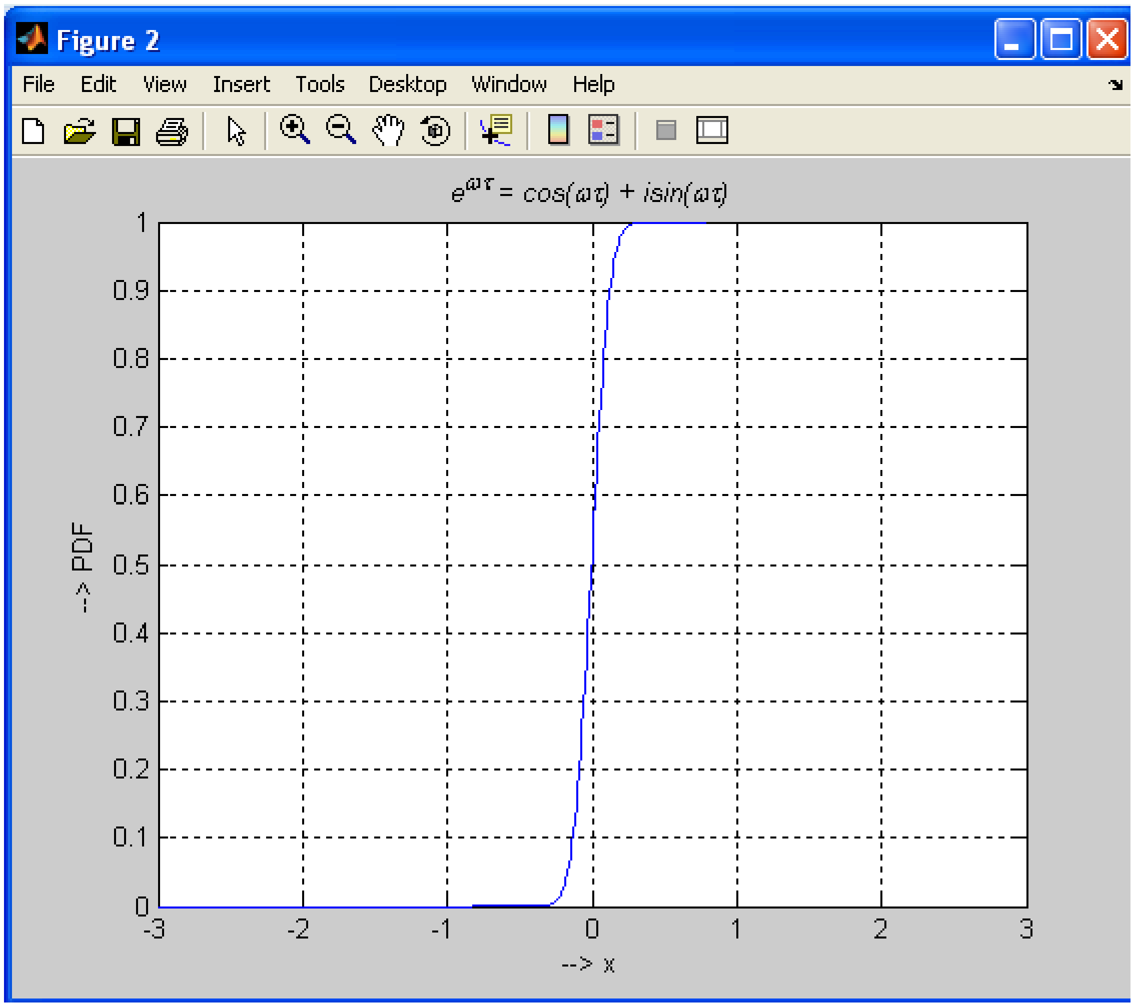


Figure 2
File Edit View Insert Tools Desktop Window Help
$e^{\omega\tau} = \cos(\omega\tau) + i\sin(\omega\tau)$
--> PDF
--> x
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-3
-2
-1
0
1
2
3

RESULT:

12. VERIFICATION OF WIENER–KHINCHIN RELATION

AIM:

Verification of wiener–khinchine relation

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

The **Wiener–Khinchin theorem** (also known as the **Wiener–Khintchine theorem** and sometimes as the **Wiener–Khinchin–Einstein theorem** or the **Khinchin–Kolmogorov theorem**) states that the power spectral density of a wide-sense-stationary random process is the Fourier transform of the corresponding autocorrelation function.

Continuous case:

$$S_{xx}(f) = \int_{-\infty}^{\infty} r_{xx}(\tau) e^{-j2\pi f \tau} \, d\tau$$

Where

$$r_{xx}(\tau) = \mathrm{E}\big[\, x(t)x^*(t-\tau) \,\big]$$

is the autocorrelation function defined in terms of statistical expectation, and where is the power spectral density of the function . Note that the autocorrelation function is defined in terms of the expected value of a product, and that the Fourier transform of does not exist in general, because stationary random functions are not square integrable. The asterisk denotes complex conjugate, and can be omitted if the random process is realvalued.

Discrete case:

$$S_{xx}(f) = \sum_{k=-\infty}^{\infty} r_{xx}[k] e^{-j2\pi k f}$$

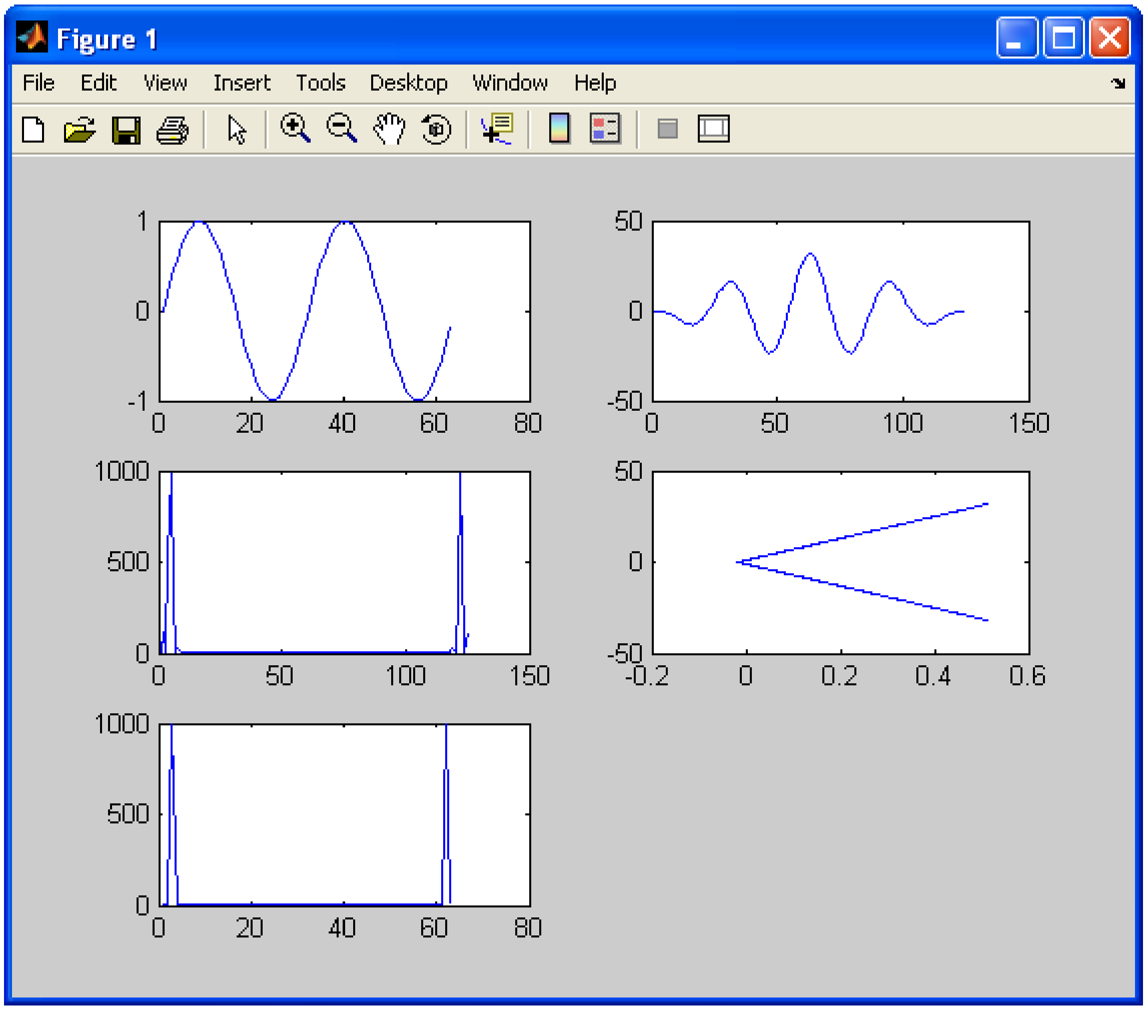
Where

$$r_{xx}[k] = \mathrm{E}\big[\, x[n]x^*[n-k] \,\big]$$

and where is the power spectral density of the function with discrete values . Being a sampled and discrete-time sequence, the spectral density is periodic in the frequency domain.

PROGRAM:

```
clc
clear all;
t=0:0.1:2*pi;
x=sin(2*t);
subplot(3,2,1);
plot(x);
au=xcorr(x,x);
subplot(3,2,2);
plot(au);
v=fft(au);
subplot(3,2,3);
plot(abs(v));
fw=fft(x);
subplot(3,2,4);
plot(fw);
fw2=(abs(fw)).^2;
subplot(3,2,5);
plot(fw2);
```



RESULT:

VIVA QUESTIONS:

1. State wiener-kinchen relationship?

14. DISTRIBUTION AND DENSITY FUNCTIONS OF STANDARD RANDOM VARIABLES

AIM: To calculate PDF and CDF of standard random variables

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

Uniform Random Variable

pdf is constant over the (a,b) interval and CDF is the ramp function in the same interval

$$f(x) = \begin{cases} \frac{1}{b-a}, & a < x < b \\ 0, & \text{otherwise} \end{cases}$$

$$F(x) = \begin{cases} 0, & x < a, \\ \frac{x-a}{b-a}, & a < x < b \\ 1, & x > b. \end{cases}$$

Exponential Random Variable

Mathematically (pdf and CDF, respectively)

$$f(x) = \begin{cases} \lambda e^{-\lambda x}, & \text{if } x > 0 \\ 0, & \text{otherwise} \end{cases}$$

$$F(x) = \begin{cases} 1 - e^{-\lambda x}, & \text{if } 0 \leq x < \infty \\ 0, & \text{otherwise} \end{cases}$$

Rayleigh Random Variable

The probability density function of the Rayleigh distribution is

$$f(x;\sigma) = \frac{x}{\sigma^2} e^{-x^2/(2\sigma^2)}, \quad x \geq 0,$$

where σ is the scale parameter of the distribution.

The cumulative distribution function is

$$F(x;\sigma) = 1 - e^{-x^2/(2\sigma^2)}$$

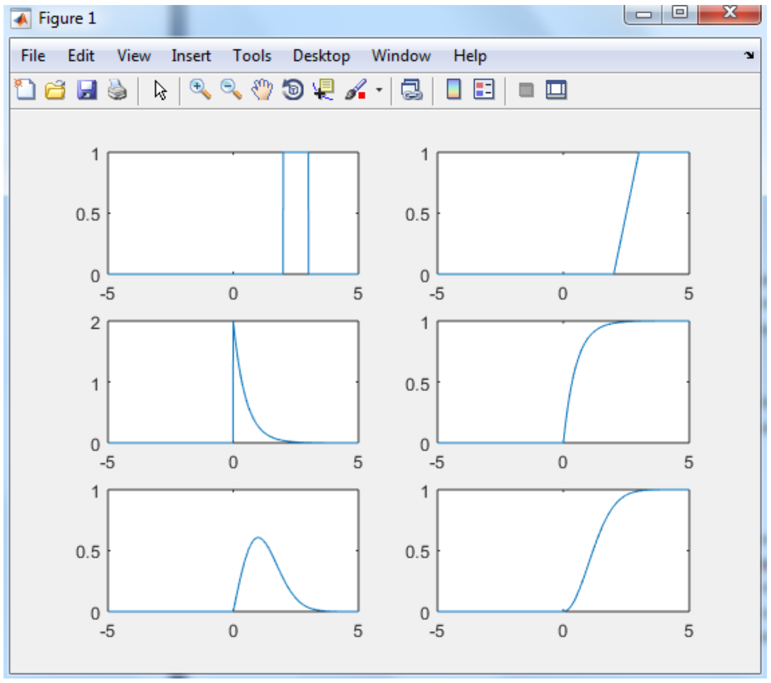
For $x \in [0, \infty)$.

PROGRAM:

%Distribution and density functions of standard random variables

```
clc;
clear all;
close all;
x=-5:0.01:5;
% uniform random variable
a=2;b=3;
%PDF
f=(1/(b-a)).*(x>=a).*(x<=b);
subplot(3,2,1);
plot(x,f);
%CDF
F=(0*(x<a))+(((x-a)/(b-a)).*(x>=a).*(x<=b))+(1*(x>b));
subplot(3,2,2);
plot(x,F);

% exponential random variable
f=(a.*(exp(-a*x)).*(x>=0))+(0*(x<0));
subplot(3,2,3);
plot(x,f);
%CDF
F=((1-exp(-a*x)).*(x>=0))+(0*(x<0));
subplot(3,2,4);
plot(x,F);

% rayleigh random variable
f=(x.*(exp(-0.5*x.^2)).*(x>=0))+(0*(x<0));
subplot(3,2,5);
plot(x,f);
%CDF
F=((1-exp(-0.5*x.^2)).*(x>=0))+(0*(x<0));
subplot(3,2,6);
plot(x,F);
```

OUTPUT:



RESULT:

VIVA QUESTIONS:

1. Define Probability density function with examples?
2. Define Cumulative density function with examples?

14. CHECKING A RANDOM PROCESS FOR STATIONARITY IN WIDE SENSE.

AIM: Checking a random process for stationarity in wide sense.

EQUIPMENTS:

PC with windows (95/98/XP/NT/2000).

MATLAB Software

THEORY:

A **stationary process** (or **strict(ly) stationary process** or **strong(ly) stationary process**) is a stochastic process whose joint probability distribution does not change when shifted in time or space. As a result, parameters such as the mean and variance, if they exist, also do not change over time or position..

Definition

Formally, let *Xt* be a stochastic process and letrepresent the cumulative distribution function of the joint distribution of *Xt* at times t1…..tk. Then, *Xt* is said to be stationary if, for all *k*, for all τ, and for all t1…..tk

$$F_{X_{t_1},\ldots,X_{t_k}}(x_{t_1},\ldots,x_{t_k}) = F_{X_{t_1+\tau},\ldots,X_{t_k+\tau}}(x_{t_1},\ldots,x_{t_k}).$$

Weak or wide-sense stationarity

A weaker form of stationarity commonly employed in signal processing is known as **weak-sense stationarity**, **wide-sense stationarity** (WSS) or **covariance stationarity**. WSS random processes only require that 1st and 2nd moments do not vary with respect to time. Any strictly stationary process which has a mean and a covariance is also WSS.

So, a continuous-time random process *x*(*t*) which is WSS has the following restrictions on its mean function

$$\mathbb{E}\{x(t)\} = m_x(t) = m_x(t+\tau)\ \forall\,\tau \in \mathbb{R}$$

and autocorrelation function

$$\mathbb{E}\{x(t_1)x(t_2)\} = R_x(t_1,t_2) = R_x(t_1+\tau, t_2+\tau) = R_x(t_1-t_2, 0)\ \forall\,\tau \in \mathbb{R}.$$

The first property implies that the mean function *mx*(*t*) must be constant. The second property implies that the correlation function depends only on the *difference* between *t*1 and *t*2 and only needs to be indexed by one variable rather than two variables. Thus, instead of writing,

$$R_x(t_1 - t_2, 0)$$

we usually abbreviate the notation and write

$$R_x(\tau) \text{ where } \tau = t_1 - t_2.$$

This also implies that the autocovariance depends only on $\tau = t_1 - t_2$, since

$$C_x(t_1, t_2) = C_x(t_1 - t_2, 0) = C_x(\tau).$$

When processing WSS random signals with linear, time-invariant (LTI) filters, it is helpful to think of the correlation function as a linear operator. Since it is a circulant
operator (depends only on the difference between the two arguments), its eigenfunctions are the Fourier complex exponentials. Additionally, since the eigenfunctions of LTI operators are also complex exponentials, LTI processing of WSS random signals is highly tractable—all computations can be performed in the frequency domain. Thus, the WSS assumption is widely employed in signal processing algorithms.

Applicatons:

Stationarity is used as a tool in time series analysis, where the raw data are often transformed to become stationary, for example, economic data are often seasonal and/or dependent on the price level. Processes are described as *trend stationary* if they are a linear combination of a stationary process and one or more processes exhibiting a trend. Transforming these data to leave a stationary data set for analysis is referred to as **de-trending**

Stationary and Non Stationary Random Process:

A random X(t) is stationary if its statistical properties are unchanged by a time shift in the time origin.When the auto-Correlation function Rx(t,t+T) of the random X(t) varies with time difference T and the mean value of the random variable X(t1) is independent of the choice of t1,then X(t) is said to be stationary in the wide-sense or wide-sense stationary . So a continous- Time random process X(t) which is WSS has the following properties

1) E[X(t)]=μX(t)= μX(t+T)

2) The Autocorrelation function is written as a function of T that is

3) RX(t,t+T)=Rx(T)

If the statistical properties like mean value or moments depends on time then the random process is said to be non-stationary.

When dealing wih two random process X(t) and Y(t), we say that they are jointly wide-sense stationary if each pocess is stationary in the wide-sense.

Rxy(t,t+T)=E[X(t)Y(t+T)]=Rxy(T).

PROGRAM:

```
clear all
clc
y = randn([1 40])
my=round(mean(y));
z=randn([1 40])
mz=round(mean(z));
vy=round(var(y));
vz=round(var(z));
t = sym('t','real');
h0=3;
x=y.*sin(h0*t)+z.*cos(h0*t);
mx=round(mean(x));
k=2;
xk=y.*sin(h0*(t+k))+z.*cos(h0*(t+k));
x1=sin(h0*t)*sin(h0*(t+k));
x2=cos(h0*t)*cos(h0*(t+k));
c=vy*x1+vz*x1;
%if we solve "c=2*sin(3*t)*sin(3*t+6)" we get c=2cos(6)
%which is a costant does not depent on variable 't'
% so it is wide sence stationary
```

RESULT:

VIVA QUESTIONS:

1. What is the condition for WSS random process?
2. Define random variable with examples?
3. Define random process with examples?