



# SVR ENGINEERING COLLEGE

Approved by AICTE & Permanently Affiliated to JNTUA

Ayyalurmetta, Nandyal – 518503. Website: [www.svrec.ac.in](http://www.svrec.ac.in)

Department of Electronics and Communication Engineering



## **SIMULATION LAB (20A04301P) R- 20**

II B. Tech (ECE) I Semester 2021-2022



<b>STUDENT NAME</b>	
<b>ROLL NUMBER</b>	
<b>SECTION</b>	





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## DEPARTMENT OF

## ELECTRONICS AND COMMUNICATION ENGINEERING

### CERTIFICATE

ACADEMIC YEAR: 2021-2022

*This \_\_\_\_\_ is to certify  
that the bonafide record work done by*

*Mr./Ms. \_\_\_\_\_ bearing  
H.T.NO. \_\_\_\_\_ of II B. Tech I Semester in the*

**SIMULATION LAB.**

**Faculty In-Charge**

**Head of the Department**

## Electronics & Communication Engineering

Course Code	SIMULATION LAB		L	T	P	C
20A04301P			0	0	3	1.5
<b>Pre-requisite</b>	<b>Linear Algebra</b>	<b>Semester</b>	<b>III</b>			
<b>Course Objectives:</b>						
<ul style="list-style-type: none"> <li>• To realize the concepts studied in theory</li> <li>• To simulate various Signals and Systems through MATLAB</li> <li>• To apply the concepts of signals to determine their energy, power, psd etc.</li> <li>• To analyze the output of a system when it is excited by different types of deterministic and random signals.</li> <li>• To generate random signals for the given specifications</li> </ul>						
<b>Course Outcomes (CO):</b>						
CO1: Learn how to use the MATLAB software and know syntax of MATLAB programming. CO2: Understand how to simulate different types of signals and system response. CO3: Find the Fourier Transform of a given signal and plot amplitude and phase characteristics. CO4: Analyze the response of different systems when they are excited by different signals and plot power spectral density of signals. CO5: Generate/Simulate different random signals for the given specifications						
<b>List of Experiments:</b>						
<ol style="list-style-type: none"> <li>1. Write a program to generate various Signals and Sequences: Periodic and Aperiodic, Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc function.</li> <li>2. Perform operations on Signals and Sequences: Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy and Average Power.</li> <li>3. Write a program to find the trigonometric &amp; exponential Fourier series coefficients of a rectangular periodic signal. Reconstruct the signal by combining the Fourier series coefficients with appropriate weightings- Plot the discrete spectrum of the signal.</li> <li>4. Write a program to find Fourier transform of a given signal. Plot its amplitude and phase spectrum.</li> <li>5. Write a program to convolve two discrete time sequences. Plot all the sequences.</li> <li>6. Write a program to find autocorrelation and cross correlation of given sequences.</li> <li>7. Write a program to verify Linearity and Time Invariance properties of a given Continuous/Discrete System.</li> <li>8. Write a program to generate discrete time sequence by sampling a continuous time signal. Show that with sampling rates less than Nyquist rate, aliasing occurs while reconstructing the signal.</li> <li>9. Write a program to find magnitude and phase response of first order low pass and high pass filter. Plot the responses in logarithmic scale.</li> <li>10. Write a program to find response of a low pass filter and high pass filter, when a speech signal is passed through these filters.</li> <li>11. Write a program to generate Complex Gaussian noise and find its mean, variance, Probability Density Function (PDF) and Power Spectral Density (PSD).</li> <li>12. Generate a Random data (with bipolar) for a given data rate (say 10kbps). Plot the same for a time period of 0.2 sec.</li> <li>13. To plot pole-zero diagram in S-plane of given signal/sequence and verify its stability.</li> </ol>						
<p>Note: All the experiments are to be simulated using MATLAB or equivalent software.</p>						
<b>References:</b>						
Stephen J. Chapman, "MATLAB Programming for Engineers", Cengage, November 2012.						
Online Learning Resources/Virtual Labs:						
<a href="https://www.vlab.co.in/">https://www.vlab.co.in/</a>						

# **ECE DEPT VISION & MISSION PEOs and PSOs**

## **Vision**

To produce highly skilled, creative and competitive Electronics and Communication Engineers to meet the emerging needs of the society.

## **Mission**

- Impart core knowledge and necessary skills in Electronics and Communication Engineering Through innovative teaching and learning.
- Inculcate critical thinking, ethics, lifelong learning and creativity needed for industry and society
- Cultivate the students with all-round competencies, for career, higher education and self-employability

## **I. PROGRAMME EDUCATIONAL OBJECTIVES (PEOS)**

- PEO1: Graduates apply their knowledge of mathematics and science to identify, analyze and solve problems in the field of Electronics and develop sophisticated communication systems.
- PEO2: Graduates embody a commitment to professional ethics, diversity and social awareness in their professional career.
- PEO3: Graduates exhibit a desire for life-long learning through technical training and professional activities.

## **II. PROGRAM SPECIFIC OUTCOMES (PSOS)**

- PSO1: Apply the fundamental concepts of electronics and communication engineering to design a variety of components and systems for applications including signal processing, image processing, communication, networking, embedded systems, VLSI and control system
- PSO2: Select and apply cutting-edge engineering hardware and software tools to solve complex Electronics and Communication Engineering problems.

### III. PROGRAMME OUTCOMES (PO'S)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

### IV. COURSE OBJECTIVES:

- To introduce MATLAB and use it as a computation and visualization tool in the study of Signals & Systems. □
- Students will then be exposed to the applications of MATLAB to signal analysis and system design.
- Synthesize Laplace transform and able to locate poles and zeros of a system.
- Compute various statistical properties of a random noise and verify whether it is stationary.
- Apply convolution and correlation operations on different signals.

## V. COURSE OUTCOMES:

After the completion of the course students will be able to

Course Outcomes	Course Outcome statements	BTL
CO1	To study about signals and systems	L1
CO2	To do analysis of signals & systems (continuous and discrete) using time domain & frequency domain methods	L2
CO3	Students able to learn Various signals and Sequences (Periodic and Aperiodic).	L3
CO4	Students able to learn Various Operations on Signals, Auto correlation and Cross correlation	L4
CO5	Students able to learn Fourier Transform, Laplace Transform, Sampling Theorem, Removal of Noise by Auto Correlation	L5

## VI. COURSE MAPPING WITH PO'S AND PEO'S:

CourseTitle	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
SIMULATION LAB	3	3	2	3	3	2	2		2	2		2	3	2

## VII. MAPPING OF COURSE OUTCOMES WITH PEO'S AND PO'S:

Course Title	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	2	3	1	2	3	2	2	1	3	2	3	3	3	3
CO2	1	1	3	2	2	1		2	1	1	3	2	2	3
CO3	2	3	2	2	2	3	2	1	2	1	1	2	2	2
CO4	3	2		2		1		1		2		2	3	2
CO5	2		2	3	3	2	1	2	1	1	2			2

**LABORATORY INSTRUCTIONS**

1. While entering the Laboratory, the students should follow the dress code. (Wear shoes and White apron, Female Students should tie their hair back).
2. The students should bring their observation book, record, calculator, necessary stationery items and graph sheets if any for the lab classes without which the students will not be allowed for doing the experiment.
3. All the Equipment and components should be handled with utmost care. Any breakage or damage will be charged.
4. If any damage or breakage is noticed, it should be reported to the concerned in charge immediately.
5. The theoretical calculations and the updated register values should be noted down in the observation book and should be corrected by the lab in-charge on the same day of the laboratory session.
6. Each experiment should be written in the record note book only after getting signature from the lab in-charge in the observation notebook.
7. Record book must be submitted in the successive lab session after completion of experiment.
8. 100% attendance should be maintained for the laboratory classes.

**Precautions.**

1. Check the connections before giving the supply.
2. Observations should be done carefully.

## **Objective of Laboratory**

The main objective of this lab is to learn MATLAB and know why it is an indispensable tool, especially for electronics and communication engineer. MATLAB is a software package for carrying out numerical computations and analyses. It uses blocks of data called matrices (MATLAB stands for matrix laboratory). MATLAB is probably the most commonly used scientific and engineering numerical software.

### **Evaluation Procedure for Internal Laboratory Examinations**

#### **Day-to-day evaluation:**

The concerned teacher have to do necessary corrections with explanations and evaluate each lab experiment.

Concerned Lab Incharge should also enter the marks in index page of the record and observation book & also at the end of each experiment with signature.

#### **Internal Laboratory examination:**

5 marks will be awarded for internal Lab exam, the division of the marks as given below:

- |                               |           |
|-------------------------------|-----------|
| 1. Matlab program & Execution | : 2Marks  |
| 2. Observations and Graphs    | : 1 Marks |
| 3. Result                     | : 1 Marks |
| 4. Viva voce                  | : 1 Marks |

Internal lab exam will be conducted by the in-charge Faculty member along with Associate Faculty members

**Evaluation Procedure for External Laboratory Examinations**

- This examination will be conducted by the faculty in-charge of the lab and another faculty member of the same department (who have more knowledge in the concern lab), recommended by Head of the Department with the approval of Principal.
- The maximum marks for this examination is 70.
- The distribution of marks for the evaluation is as follows.

1. Matlab program	: 20 Marks
2. Execution	: 20 Marks
3. Observations and Graphs	: 10 Marks
4. Result	: 10 Marks
5. Viva voce	: 10 Marks

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## MATLAB INTRODUCTION

MATLAB, which stands for Matrix Laboratory, is a state-of-the-art mathematical software package, which is used extensively in both academia and industry. It is an interactive program for numerical computation and data visualization, which along with its programming capabilities provides a very useful tool for almost all areas of science and engineering. Unlike other mathematical packages, such as MAPLE or MATHEMATICA, MATLAB cannot perform symbolic manipulations without the use of additional Toolboxes. It remains however, one of the leading software packages for numerical computation.

As you might guess from its name, MATLAB deals mainly with matrices. A scalar is a 1-by-1 matrix and a row vector of length say 5, is a 1-by-5 matrix.. One of the many advantages of MATLAB is the natural notation used. It looks a lot like the notation that you encounter in a linear algebra. This makes the use of the program especially easy and it is what makes MATLAB a natural choice for numerical computations. The purpose of this experiment is to familiarize MATLAB, by introducing the basic features and commands of the program.

MATLAB is case-sensitive, which means that  $a + B$  is not the same as  $a + b$ . The MATLAB prompt ( $\gg$ ) in command window is where the commands are entered.

### **Operators:**

1. + addition
2. -subtraction
3. \* multiplication
4. ^ power
5. ' transpose
6. \ left division
7. / right division

Remember that the multiplication, power and division operators can be used in conjunction with a period to specify an element-wise operation.

**Built in Functions:**1. Scalar Functions:

Certain MATLAB functions are essentially used on scalars, but operate element-wise when applied to a matrix (or vector). They are summarized below.

1. sin -trigonometric sine
2. cos -trigonometric cosine
3. tan -trigonometric tangent
4. asin -trigonometric inverse sine (arcsine)
5. acos -trigonometric inverse cosine (arccosine)
6. atan -trigonometric inverse tangent (arctangent)
7. exp -exponential
8. log -natural logarithm
9. abs -absolute value
10. sqrt -square root
11. rem -remainder
12. round -round towards nearest integer
13. floor -round towards negative infinity
14. ceil -round towards positive infinity

2. Vector Functions:

Other MATLAB functions operate essentially on vectors returning a scalar value. Some of these functions are given below.

1. max largest component : get the row in which the maximum element lies
2. min smallest component
3. length length of a vector
4. sort sort in ascending order
5. sum sum of elements
6. prod product of elements
7. median median value

8. mean mean value std standard deviation

### 3. Matrix Functions:

Much of MATLAB's power comes from its matrix functions. These can be further separated into two sub-categories. The first one consists of convenient matrix building functions, some of which are given below.

1. eye -identity matrix
2. zeros -matrix of zeros
3. ones -matrix of ones
4. diag -extract diagonal of a matrix or create diagonal matrices
5. triu -upper triangular part of a matrix
6. tril -lower triangular part of a matrix
7. rand -randomly generated matrix

eg: `diag([0.9092;0.5163;0.2661])`

ans =

0.9092 0 0

0 0.5163 0

0 0 0.2661

Commands in the second sub-category of matrix functions are

1. size size of a matrix
2. det determinant of a square matrix
3. inv inverse of a matrix
4. rank rank of a matrix
5. rref reduced row echelon form
6. eig eigenvalues and eigenvectors

## 1. Write a program to generate various Signals and Sequences: Periodic and Aperiodic, Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc function.

**Aim:** Generate various signals and sequences (Periodic and aperiodic ), such as Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc.

**Software Required:** Matlab software 7.0 version and above

**Theory:** If the amplitude of the signal is defined at every instant of time then it is called continuous time signal. If the amplitude of the signal is defined at only at some instants of time then it is called discrete time signal. If the signal repeats itself at regular intervals then it is called periodic signal. Otherwise they are called aperiodic signals.

EX: ramp, Impulse, unit step, sinc- Aperiodic signals square, sawtooth, triangular sinusoidal – periodic signals.

```
» plot(x,y)
```

It is good practice to label the axis on a graph and if applicable indicate what each axis represents. This can be done with the xlabel and ylabel commands.

```
» xlabel('x')
```

```
» ylabel('y=cos(x)')
```

Inside parentheses, and enclosed within single quotes, we type the text that we wish to be displayed along the x and y axis, respectively. We could even put a title on top using

```
» title('Graph of cosine from -pi to pi')
```

```
» plot (x,y,'g')
```

Where the third argument indicating the color, appears within single quotes. We could get a dashed line instead of a solid one by typing

```
» plot (x,y,'--')
```

or even a combination of line type and color, say a blue dotted line by typing

```
» plot (x,y,'b:')
```

We can get both graphs on the same axis, distinguished by their line type, using

```
» plot(x,y,'r--',x,z,'b:')
```

When multiple curves appear on the same axis, it is a good idea to create a legend to label and distinguish them. The command `legend` does exactly this.

```
» legend ('cos(x)','sin(x)')
```

The text that appears within single quotes as input to this command, represents the legend labels. We must be consistent with the ordering of the two curves, so since in the plot command we asked for cosine to be plotted before sine, we must do the same here.

At any point during a MATLAB session, you can obtain a hard copy of the current plot by either issuing the command `print` at the MATLAB prompt, or by using the command menus on the plot window. In addition, MATLAB plots can be copied and pasted (as pictures) in your favorite word processor (such as Microsoft Word). This can be achieved using the Edit menu on the figure window. Another nice feature that can be used in conjunction with plot is the command `grid`, which places grid lines to the current axis (just like you have on graphing paper). Type `help grid` for more information.

### The 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  $2\pi$  and height

The sinc function has a value of 1 when  $x$  is equal to zero, and a value of  $\frac{\sin(x)}{x}$  for all other elements of  $x$ .

```
% Generation of signals and sequences
clc;
clear all;
close all;
%~~~~~
%generation of unit impulse signal
t1=-1:0.01:1
y1=(t1==0);
subplot(2,2,1);
plot(t1,y1);
xlabel('time');
ylabel('amplitude');
title('unit impulse signal');
%generation of impulse sequence
subplot(2,2,2);
```

```

stem(t1,y1);
xlabel('n');
ylabel('amplitude');
title('unit impulse sequence');
%~~~~~
%generation of unit step signal
t2=-10:1:10;
y2=(t2>=0);
subplot(2,2,3);
plot(t2,y2);
xlabel('time');
ylabel('amplitude');
title('unit step signal');
%generation of unit step sequence
subplot(2,2,4);
stem(t2,y2);
xlabel('n');
ylabel('amplitude');
title('unit step sequence');
%~~~~~
%generation of square wave signal
t=0:0.002:0.1;
y3=square(2*pi*50*t);
figure;
subplot(2,2,1);
plot(t,y3);
axis([0 0.1 -2 2]);
xlabel('time');
ylabel('amplitude');
title('square wave signal');
%generation of square wave sequence
subplot(2,2,2);
stem(t,y3);
axis([0 0.1 -2 2]);
xlabel('n');
ylabel('amplitude');
title('square wave sequence');
%~~~~~
%generation of sawtooth signal
y4=sawtooth(2*pi*50*t);
subplot(2,2,3);
plot(t,y4);
axis([0 0.1 -2 2]);
xlabel('time');
ylabel('amplitude');
title('sawtooth wave signal');
%generation of sawtooth sequence

```

```

subplot(2,2,4);
stem(t,y4);
axis([0 0.1 -2 2]);
xlabel('n');
ylabel('amplitude');
title('sawtooth wave sequence');
%~~~~~
%generation of triangular wave signal
y5=sawtooth(2*pi*50*t,.5);
figure;
subplot(2,2,1);
plot(t,y5);
axis([0 0.1 -2 2]);
xlabel('time');
ylabel('amplitude');
title(' triangular wave signal');
%generation of triangular wave sequence
subplot(2,2,2);
stem(t,y5);
axis([0 0.1 -2 2]);
xlabel('n');
ylabel('amplitude');
title('triangular wave sequence');
%generation of sinsoidal wave signal
y6=sin(2*pi*40*t);
subplot(2,2,3);
plot(t,y6);
axis([0 0.1 -2 2]);
xlabel('time');
ylabel('amplitude');
title(' sinsoidal wave signal');
%generation of sin wave sequence
subplot(2,2,4);
stem(t,y6);
axis([0 0.1 -2 2]);
xlabel('n');
ylabel('amplitude');
title('sin wave sequence');
%~~~~~
%generation of ramp signal
y7=t;
figure;
subplot(2,2,1);
plot(t,y7);
xlabel('time');
ylabel('amplitude');
title('ramp signal');

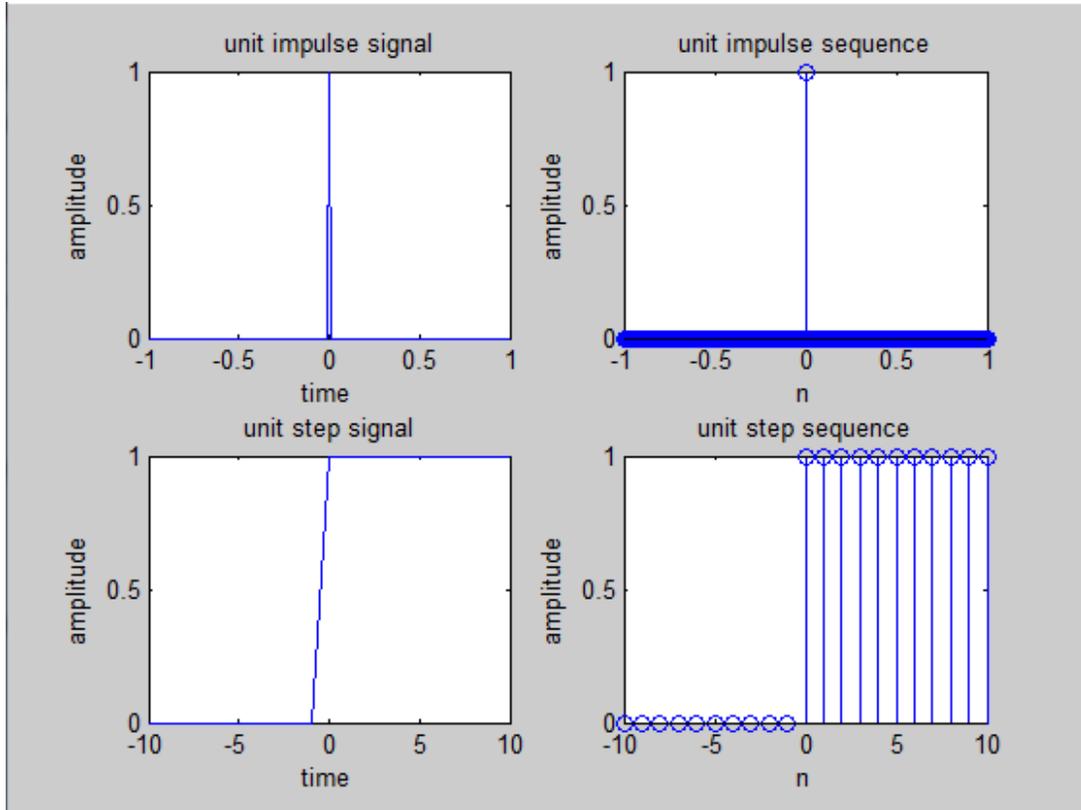
```

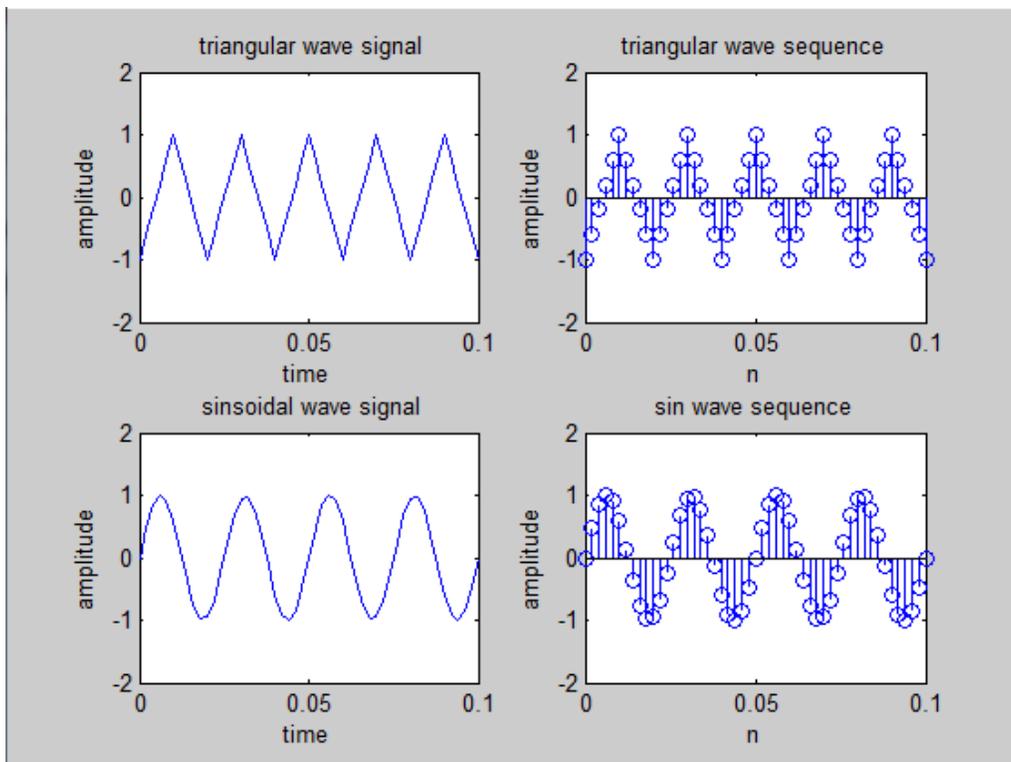
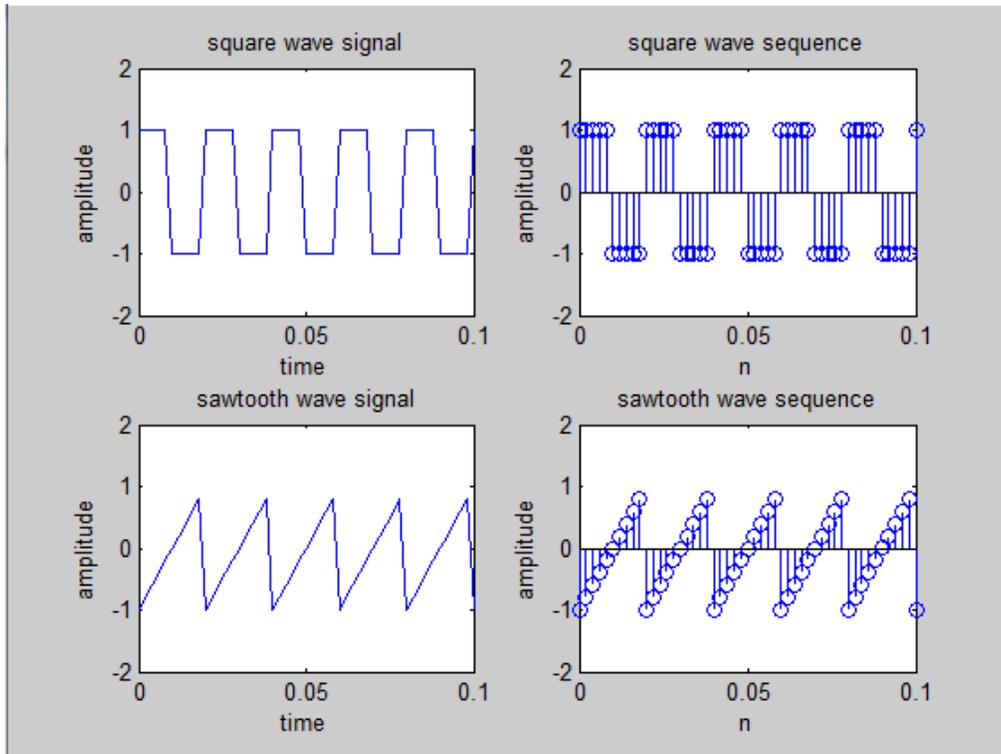
```

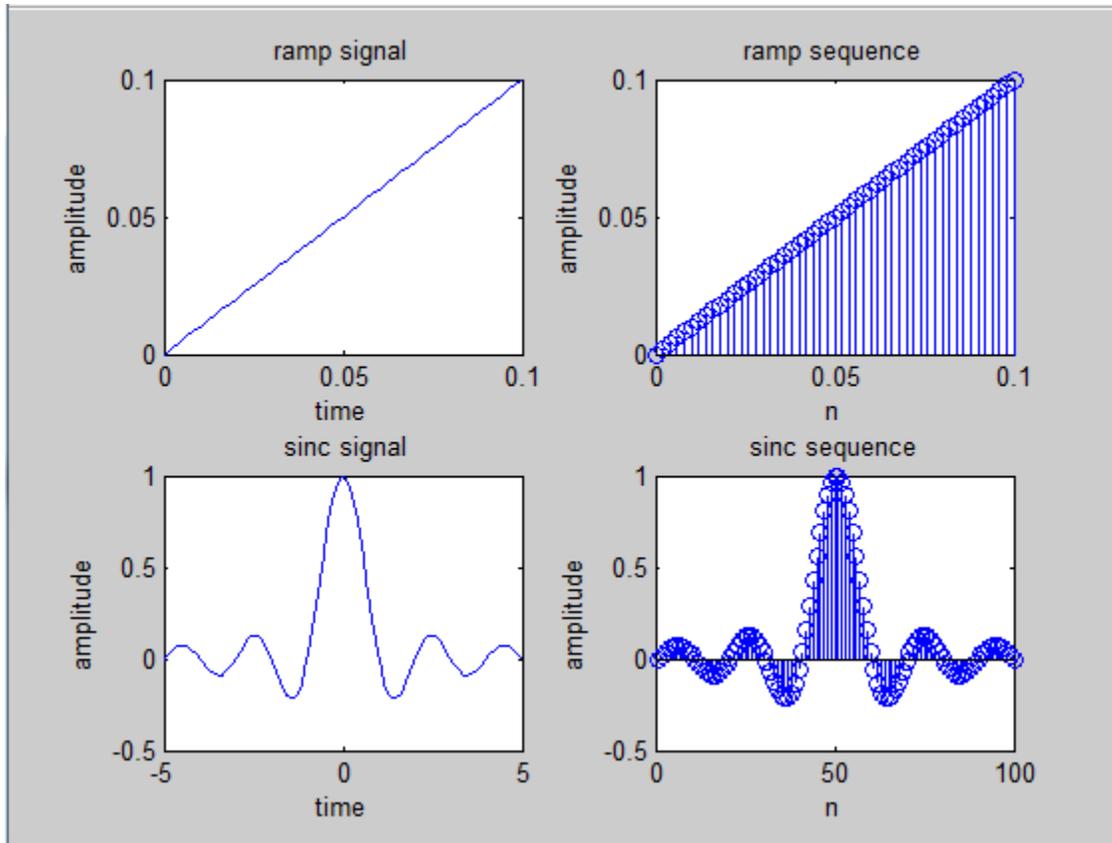
%generation of ramp sequence
subplot(2,2,2);
stem(t,y7);
xlabel('n');
ylabel('amplitude');
title('ramp sequence');
%~~~~~
%generation of sinc signal
t3=linspace(-5,5);
y8=sinc(t3);
subplot(2,2,3);
plot(t3,y8);
xlabel('time');
ylabel('amplitude');
title(' sinc signal');
%generation of sinc sequence
subplot(2,2,4);
stem(y8);
xlabel('n');
ylabel('amplitude');
title('sinc sequence');

```

Result: Various signals & sequences generated using Matlab software.







**Results and discussion :** Periodic and Aperiodic, Unit Impulse, Unit Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc function are generated and plotted.

## 2. Perform operations on Signals and Sequences: Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy and Average Power.

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

**Software Required:** Matlab software 7.0 version and above

### Theory:Signal Addition

Any two signals can be added to form a third signal,

$$z(t) = x(t) + y(t)$$

### Multiplication:

Multiplication of two signals can be obtained by multiplying their values at every instant. z

$$z(t) = x(t) y(t)$$

### Time reversal/Folding:

Time reversal of a signal  $x(t)$  can be obtained by folding the signal about  $t=0$ .

$$Y(t)=y(-t)$$

**Signal Amplification/Scaling :**  $Y(n)=ax(n)$  if  $a < 1$  attenuation

$a > 1$  amplification

**Time shifting:** The time shifting of  $x(n)$  obtained by delay or advance the signal in time by using  $y(n)=x(n+k)$

If  $k$  is a positive number,  $y(n)$  shifted to the right i e the shifting delays the signal

If  $k$  is a negative number,  $y(n)$  it gets shifted left. Signal Shifting advances the signal

### Program :

```
clc;
clear all;
close all;
% generating two input signals
t=0:.01:1;
x1=sin(2*pi*4*t);
x2=sin(2*pi*8*t);
subplot(2,2,1);
plot(t,x1);
```

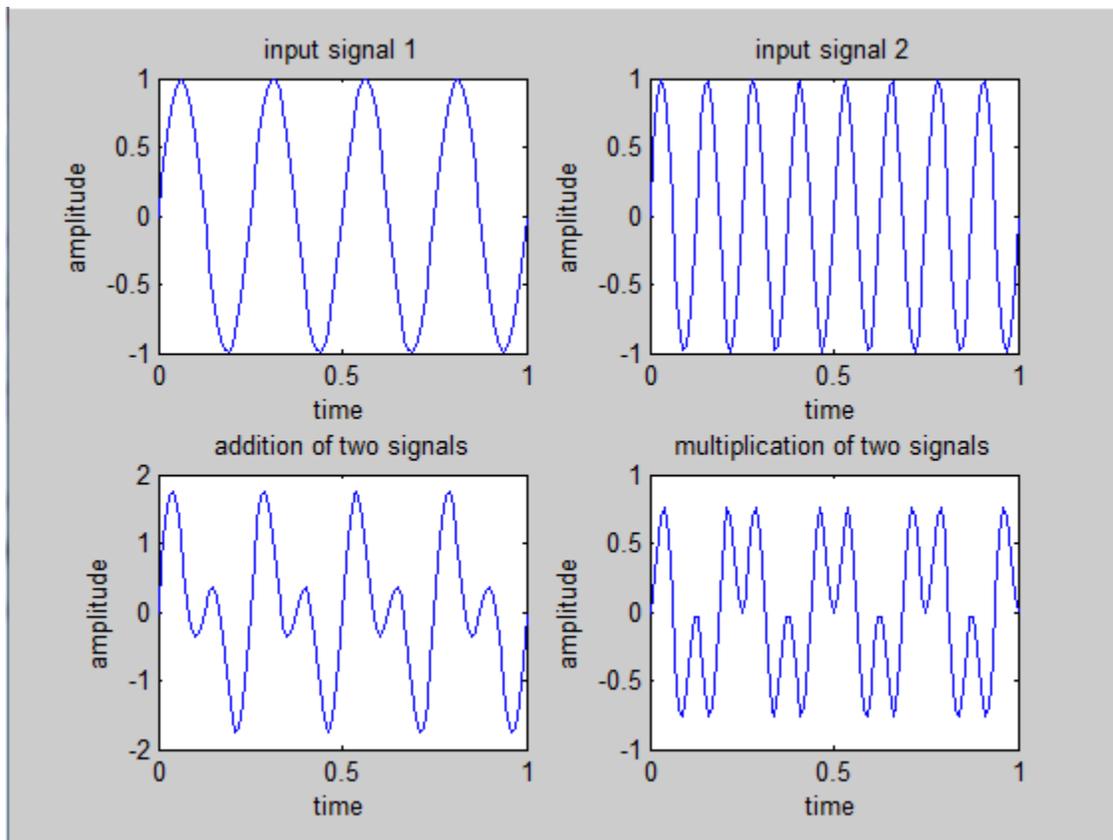
```
xlabel('time');
ylabel('amplitude');
title('input signal 1');
subplot(2,2,2);
plot(t,x2);
xlabel('time');
ylabel('amplitude');
title('input signal 2');
% addition of signals
y1=x1+x2;
subplot(2,2,3);
plot(t,y1);
xlabel('time');
ylabel('amplitude');
title('addition of two signals');
% multiplication of signals
y2=x1.*x2;
subplot(2,2,4);
plot(t,y2);
xlabel('time');
ylabel('amplitude');
title('multiplication of two signals');
% scaling of a signal1
A=2;
y3=A*x1;
figure;
subplot(2,2,1);
plot(t,x1);
xlabel('time');
ylabel('amplitude');
title('input signal')
subplot(2,2,2);
plot(t,y3);
xlabel('time');
ylabel('amplitude');
title('amplified input signal');
% folding of a signal1
h=length(x1);
nx=0:h-1;
subplot(2,2,3);
plot(nx,x1);
xlabel('nx');
ylabel('amplitude');
title('input signal')
y4=fliplr(x1);
nf=-fliplr(nx);
subplot(2,2,4);
```

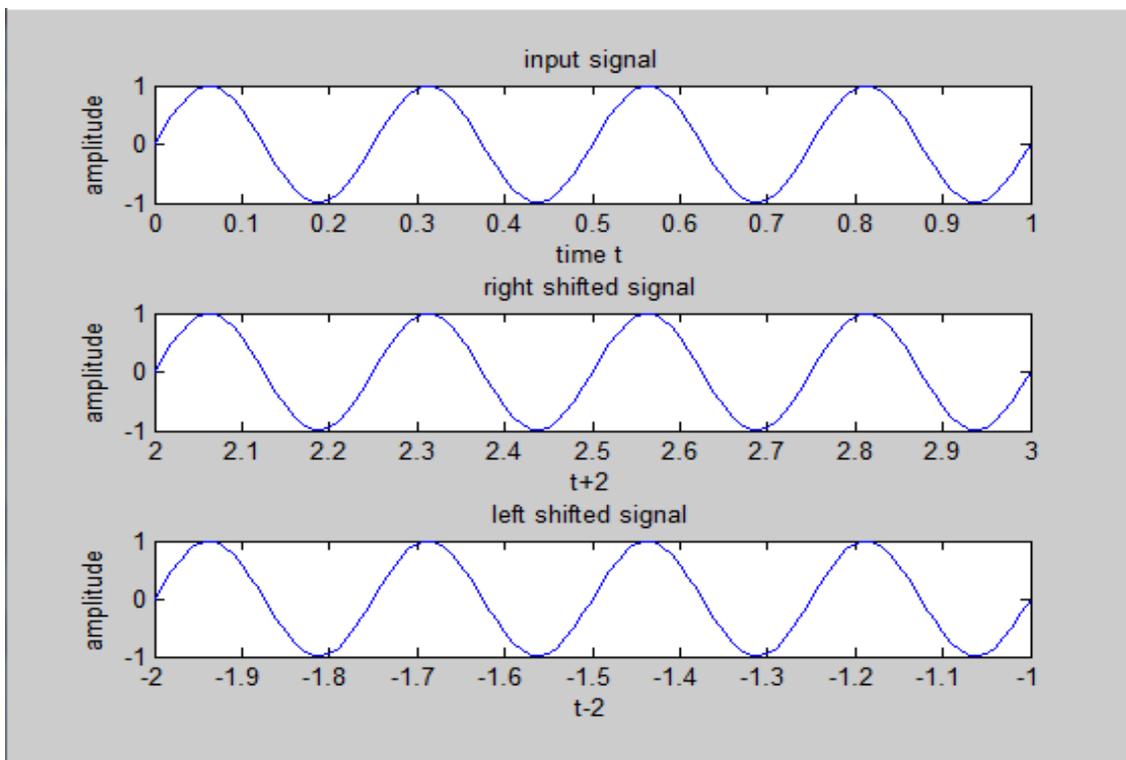
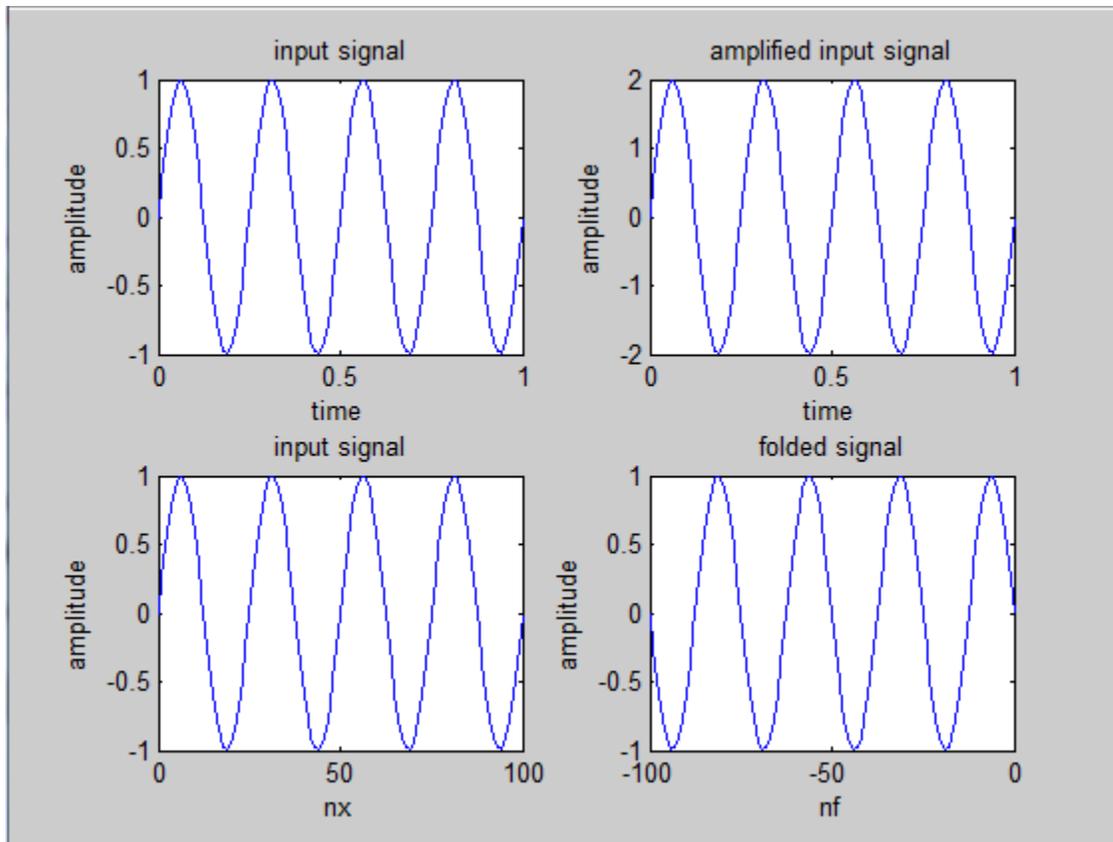
```
plot(nf,y4);
xlabel('nf');
ylabel('amplitude');
title('folded signal');
%shifting of a signal 1
figure;
subplot(3,1,1);
plot(t,x1);
xlabel('time t');
ylabel('amplitude');
title('input signal');
subplot(3,1,2);
plot(t+2,x1);
xlabel('t+2');
ylabel('amplitude');
title('right shifted signal');
subplot(3,1,3);
plot(t-2,x1);
xlabel('t-2');
ylabel('amplitude');
title('left shifted signal');
%operations on sequences
n1=1:1:9;
s1=[1 2 3 0 5 8 0 2 4];
figure;
subplot(2,2,1);
stem(n1,s1);
xlabel('n1');
ylabel('amplitude');
title('input sequence 1');
s2=[1 1 2 4 6 0 5 3 6];
subplot(2,2,2);
stem(n1,s2);
xlabel('n2');
ylabel('amplitude');
title('input sequence 2 ');
% addition of sequences
s3=s1+s2;
subplot(2,2,3);
stem(n1,s3);
xlabel('n1');
ylabel('amplitude');
title('sum of two sequences');
% multiplication of sequences
s4=s1.*s2;
subplot(2,2,4);
stem(n1,s4);
```

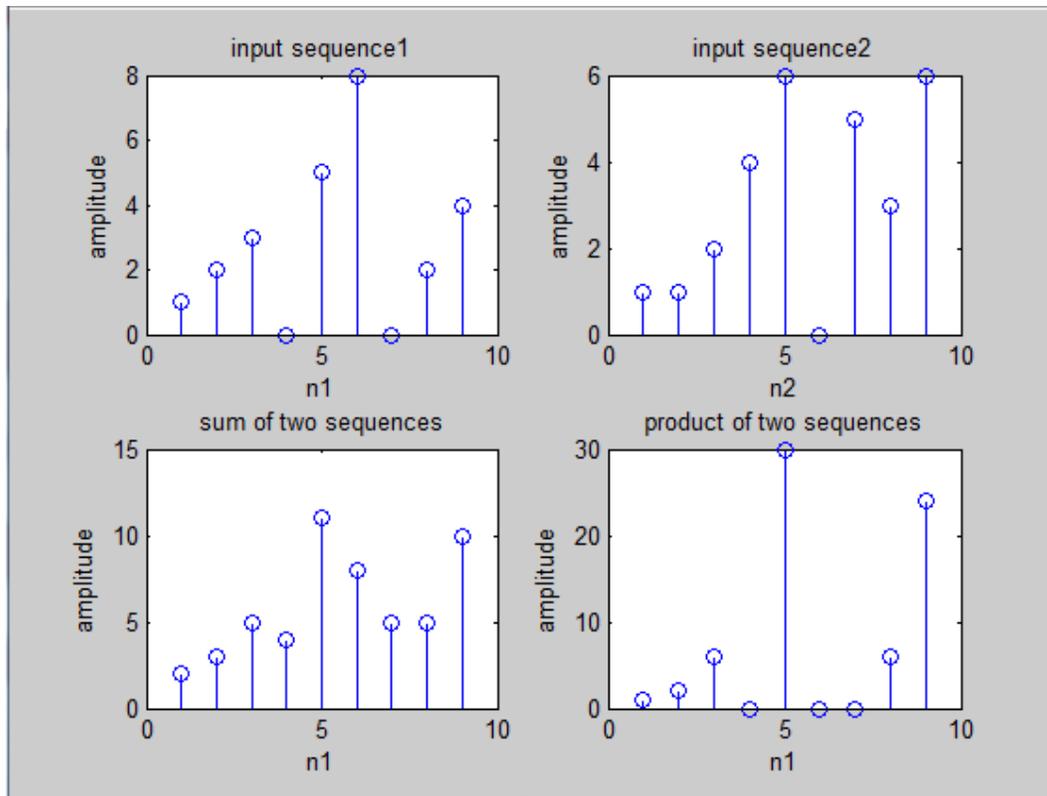
```

xlabel('n1');
ylabel('amplitude');
title('product of two sequences');
%~~~~~
% program for energy of a sequence
z1=input('enter the input sequence');
e1=sum(abs(z1).^2);
disp('energy of given sequence is');e1
% program for energy of a signal
t=0:pi:10*pi;
z2=cos(2*pi*50*t).^2;
e2=sum(abs(z2).^2);
disp('energy of given signal is');e2
% program for power of a sequence
p1= (sum(abs(z1).^2))/length(z1);
disp('power of given sequence is');p1
% program for power of a signal
p2=(sum(abs(z2).^2))/length(z2);
disp('power of given signal is');

```







## Results and discussions

### Output:

enter the input sequence[1 3 2 4 1]

energy of given sequence is

$$e1 = 31$$

energy of given signal is

$$e2 = 4.0388$$

power of given sequence is

$$p1 = 6.2000$$

power of given signal is

$$p2 = 0.3672$$

**Result:** Various operations on signals and sequences are performed.

**3. Write a program to find the trigonometric & exponential Fourier series coefficients of a rectangular periodic signal. Reconstruct the signal by combining the Fourier series coefficients with appropriate weightages - Plot the discrete spectrum of the signal.**

**Aim:** To find the trigonometric & exponential Fourier series coefficients of a rectangular periodic signal. Reconstruct the signal by combining the Fourier series coefficients with appropriate weightages - Plot the discrete spectrum of the signal.

**Software Required:** Matlab software 7.0 version and above

**Theory:** to compute the trigonometric fourier series coefficients of a periodic square wave time signal that has a value of 2 from time 0 to 3 and a value of -12 from time 3 to 6. It then repeats itself. I am trying to calculate in MATLAB the fourier series coefficients of this time signal and am having trouble on where to begin.

The equation is  $x(t) = a_0 + \sum(b_k \cos(2\pi f_k t) + c_k \sin(2\pi f_k t))$

The sum is obviously from  $k=1$  to  $k=\infty$ .  $a_0$ ,  $b_k$ , and  $c_k$  are the coefficients

**Program:**

```
% Description: This M-file plots the truncated Fourier Series
%             representation of a square wave as well as its
%             amplitude and phase spectrum.

clear;                % clear all variables
clf;                  % clear all figures

N = 11;               % summation limit (use N odd)
wo = pi;              % fundamental frequency (rad/s)
c0 = 0;               % dc bias
t = -3:0.01:3;        % declare time values

figure(1)             % put first two plots on figure 1

% Compute yce, the Fourier Series in complex exponential form

yce = c0*ones(size(t)); % initialize yce to c0

for n = -N:2:N,       % loop over series index n (odd)
    cn = 2/(j*n*wo);  % Fourier Series Coefficient
    yce = yce + real(cn*exp(j*n*wo*t)); % Fourier Series computation
end

subplot(2,1,1)
plot([-3 -2 -2 -1 -1 0 0 1 1 2 2 3],... % plot original y(t)
```

```

        [-1 -1  1  1 -1 -1  1  1 -1 -1  1  1], ':');
hold;
plot(t,yce);           % plot truncated exponential FS
xlabel('t (seconds)'); ylabel('y(t)');
title = ['EE341.01: Truncated Exponential Fourier Series with N = ',...
        num2str(N)];
title(title);
hold;

% Compute yt, the Fourier Series in trigonometric form

yt = c0*ones(size(t));           % initialize yt to c0

for n = 1:2:N,                   % loop over series index n (odd)
    cn = 2/(j*n*wo);             % Fourier Series Coefficient
    yt = yt + 2*abs(cn)*cos(n*wo*t+angle(cn)); % Fourier Series computation
end

subplot(2,1,2)
plot([-3 -2 -2 -1 -1  0 0 1  1  2 2 3],... % plot original y(t)
     [-1 -1  1  1 -1 -1  1  1 -1 -1  1  1], ':');
hold;                               % plot truncated trigonometric FS
plot(t,yt);
xlabel('t (seconds)'); ylabel('y(t)');
title = ['EE341.01: Truncated Trigonometric Fourier Series with N = ',...
        num2str(N)];
title(title);
hold;

% Draw the amplitude spectrum from exponential Fourier Series

figure(2)                            % put next plots on figure 2

subplot(2,1,1)
stem(0,c0);                           % plot c0 at nwo = 0

hold;
for n = -N:2:N,                       % loop over series index n
    cn = 2/(j*n*wo);                 % Fourier Series Coefficient
    stem(n*wo,abs(cn))               % plot |cn| vs nwo
end
for n = -N+1:2:N-1,                  % loop over even series index n
    cn = 0;                           % Fourier Series Coefficient
    stem(n*wo,abs(cn));               % plot |cn| vs nwo
end

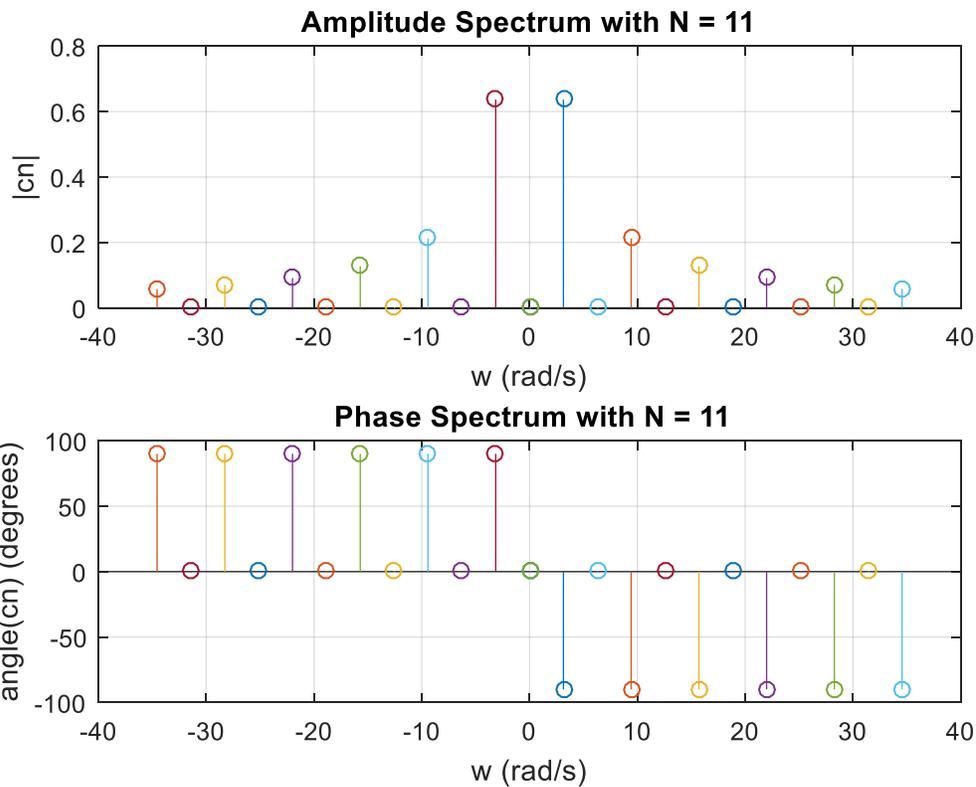
xlabel('w (rad/s)')
ylabel('|cn|')
title = ['EE341.01: Amplitude Spectrum with N = ',num2str(N)];
title(title);
grid;
hold;

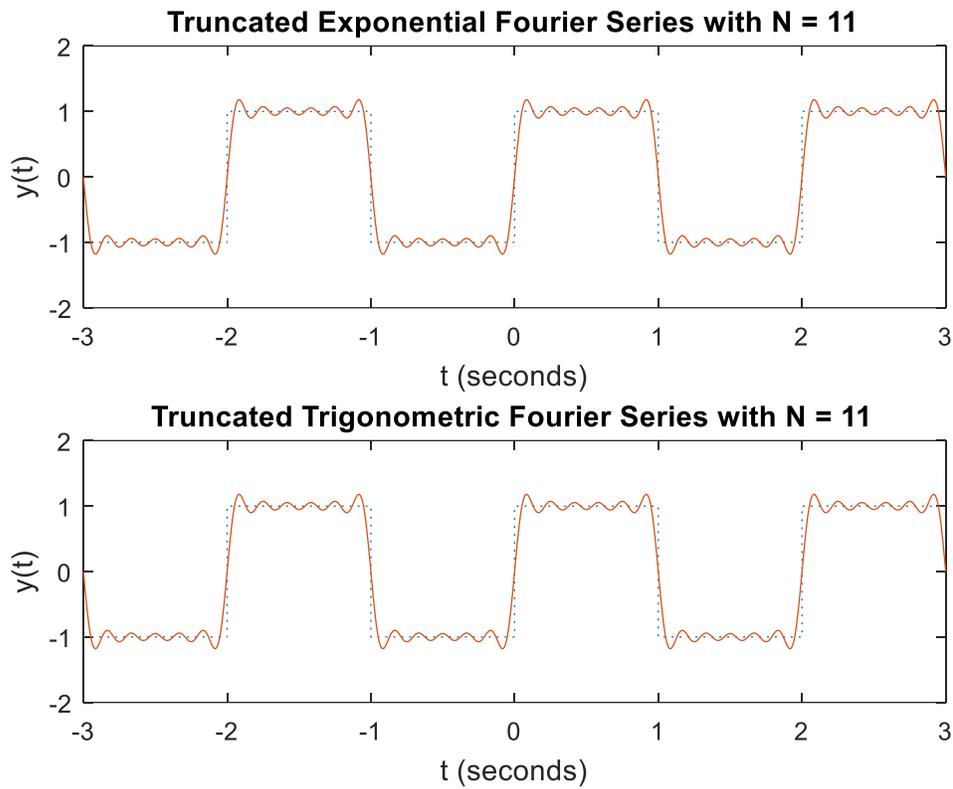
```

```
% Draw the phase spectrum from exponential Fourier Series
```

```
subplot(2,1,2)
stem(0,angle(c0)*180/pi);           % plot angle of c0 at nwo = 0

hold;
for n = -N:2:N,                   % loop over odd series index n
    cn = 2/(j*n*wo);              % Fourier Series Coefficient
    stem(n*wo,angle(cn)*180/pi);  % plot |cn| vs nwo
end
for n = -N+1:2:N-1,              % loop over even series index n
    cn = 0;                       % Fourier Series Coefficient
    stem(n*wo,angle(cn)*180/pi);  % plot |cn| vs nwo
end
xlabel('w (rad/s)')
ylabel('angle(cn) (degrees)')
title(['EE341.01: Phase Spectrum with N = ',num2str(N)]);
title(ttle);
grid;
hold;
```





---

### Results and discussions

**Result:** Trigonometric & exponential Fourier series coefficients of a rectangular periodic signals are plotted.

#### 4. Write a program to find Fourier transform of a given signal. Plot its amplitude and phase spectrum.

**Aim:** To find the Fourier Transform of a given signal and plotting its magnitude and phase spectrum.

**Software Required:** Matlab software 7.0 version and above

**Theory:**

**Fourier Transform:**

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  $T \geq L$  we may expand  $f$  in a Fourier series on the interval  $[-T/2, T/2]$ , where the "amount" of the wave  $e^{2\pi i n x/T}$  in the Fourier series of  $f$  is given by By definition Fourier Transform of signal  $f(t)$  is defined as

$$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$$

**Programs with symbolic matlab tool**

Compute the Fourier transform of common inputs. By default, the transform is in terms of  $w$ .

Function	Input and Output
Rectangular pulse	<pre>syms a b t f = rectangularPulse(a,b,t); f_FT = fourier(f) f_FT = - (sin(a*w) + cos(a*w)*1i)/w + (sin(b*w) + cos(b*w)*1i)/w</pre>
Unit impulse (Dirac delta)	<pre>f = dirac(t); f_FT = fourier(f) f_FT = 1</pre>
Absolute value	<pre>f = a*abs(t);</pre>

Function	Input and Output
	$f_{FT} = \text{fourier}(f)$ $f_{FT} =$ $-(2*a)/w^2$
Step (Heaviside)	$f = \text{heaviside}(t);$ $f_{FT} = \text{fourier}(f)$ $f_{FT} =$ $\pi * \text{dirac}(w) - 1i/w$
Constant	$f = a;$ $f_{FT} = \text{fourier}(a)$ $f_{FT} =$ $\pi * \text{dirac}(1, w) * 2i$
Cosine	$f = a * \cos(b * t);$ $f_{FT} = \text{fourier}(f)$ $f_{FT} =$ $\pi * a * (\text{dirac}(b + w) + \text{dirac}(b - w))$
Sine	$f = a * \sin(b * t);$ $f_{FT} = \text{fourier}(f)$ $f_{FT} =$ $\pi * a * (\text{dirac}(b + w) - \text{dirac}(b - w)) * 1i$
Sign	$f = \text{sign}(t);$ $f_{FT} = \text{fourier}(f)$ $f_{FT} =$ $-2i/w$
Triangle	$\text{syms } c$ $f = \text{triangularPulse}(a, b, c, t);$ $f_{FT} = \text{fourier}(f)$ $f_{FT} =$

Function	Input and Output
	$-(a \exp(-b w i) - b \exp(-a w i) - a \exp(-c w i) + \dots$ $c \exp(-a w i) + b \exp(-c w i) - c \exp(-b w i)) / \dots$ $(w^2 (a - b)(b - c))$
Right-sided exponential	<p>Also calculate transform with condition <math>a &gt; 0</math>. Clear assumptions.</p> <pre>f = exp(-t*abs(a))*heaviside(t); f_FT = fourier(f)  assume(a &gt; 0) f_FT_condition = fourier(f) assume(a,'clear') f_FT = 1/(abs(a) + w*i) - (sign(abs(a))/2 - 1/2)*fourier(exp(-t*abs(a)),t,w)  f_FT_condition = 1/(a + w*i)</pre>
Double-sided exponential	<p>Assume <math>a &gt; 0</math>. Clear assumptions.</p> <pre>assume(a &gt; 0) f = exp(-a*t^2); f_FT = fourier(f) assume(a,'clear') f_FT = (pi^(1/2)*exp(-w^2/(4*a)))/a^(1/2)</pre>
Gaussian	<p>Assume <math>b</math> and <math>c</math> are real. Simplify result and clear assumptions.</p> <pre>assume([b c],'real') f = a*exp(-(t-b)^2/(2*c^2)); f_FT = fourier(f)  f_FT_simplify = simplify(f_FT) assume([b c],'clear')</pre>

Function	Input and Output
	<pre>f_FT = (a*pi^(1/2)*exp(-(c^2*(w + (b*1i)/c^2)^2/2 - b^2/(2*c^2)))/ ... (1/(2*c^2))^(1/2)  f_FT_simplify = 2^(1/2)*a*pi^(1/2)*exp(-(w*(w*c^2 + b*2i))/2)*abs(c)</pre>
Bessel of first kind with nu = 1	<pre>Simplify the result. syms x f = besselj(1,x); f_FT = fourier(f); f_FT = simplify(f_FT) f_FT = (2*w*(heaviside(w - 1)*1i - heaviside(w + 1)*1i))/(1 - w^2)^(1/2)</pre>

### Specify Independent Variable and Transformation Variable

Compute the Fourier transform of  $\exp(-t^2-x^2)$ . By default, symvar determines the independent variable, and w is the transformation variable. Here, symvar chooses x.

```
syms t x
```

```
f = exp(-t^2-x^2);
```

```
fourier(f)
```

```
ans =
```

```
pi^(1/2)*exp(- t^2 - w^2/4)
```

Specify the transformation variable as y. If you specify only one variable, that variable is the transformation variable. symvar still determines the independent variable.

```
syms y
```

```
fourier(f,y)
```

```
ans =
```

$$\pi^{1/2} \exp(-t^2 - y^2/4)$$

Specify both the independent and transformation variables as t and y in the second and third arguments, respectively.

```
fourier(f,t,y)
```

```
ans =
```

$$\pi^{1/2} \exp(-x^2 - y^2/4)$$

### Fourier Transforms Involving Dirac and Heaviside Functions

Compute the following Fourier transforms. The results are in terms of the Dirac and Heaviside functions.

```
syms t w
```

```
fourier(t^3, t, w)
```

```
ans =
```

$$-\pi \operatorname{dirac}(3, w) * 2i$$

```
syms t0
```

```
fourier(heaviside(t - t0),t,w)
```

```
ans =
```

$$\exp(-t_0 * w * 1i) * (\pi * \operatorname{dirac}(w) - 1i/w)$$

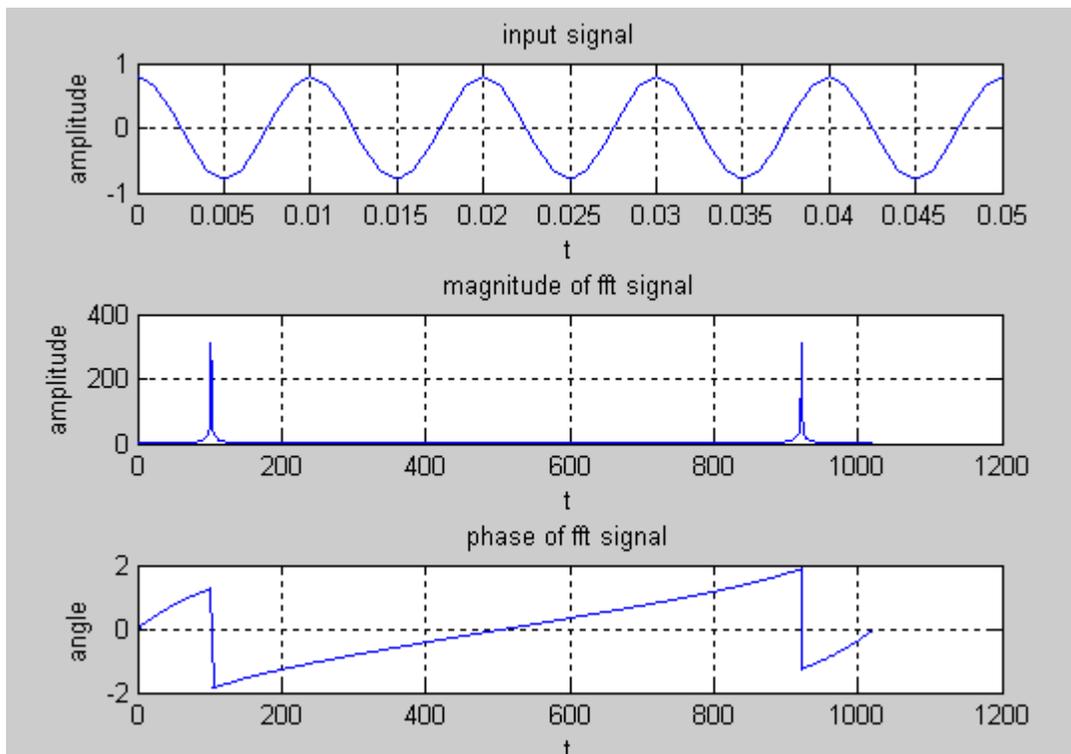
### Program:

```
clc;
clear all;
close all;
fs=1000;
N=1024; % length of fft sequence
t=[0:N-1]*(1/fs);
% input signal
x=0.8*cos(2*pi*100*t);
subplot(3,1,1);
plot(t,x);
axis([0 0.05 -1 1]);
grid;
xlabel('t');
ylabel('amplitude');
title('input signal');
% Fourier transform of given signal
x1=fft(x);
% magnitude spectrum
k=0:N-1;
Xmag=abs(x1);
subplot(3,1,2);
plot(k,Xmag);
grid;
```

```

xlabel('t');
ylabel('amplitude');
title('magnitude of fft signal')
%phase spectrum
Xphase=angle(x1);
subplot(3,1,3);
plot(k,Xphase);
grid;
xlabel('t');
ylabel('angle');
title('phase of fft signal');

```



**Result:** Magnitude and phase spectrum of FFT of a given signal is plotted.

## 5. Write a program to convolution two discrete time sequences. Plot all the sequences

**Aim:** Write the program for convolution between two signals and also between two sequences.

**Software Required:** Matlab software 7.0 version and above

### Theory:

Convolution involves the following operations.

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

Convolution is an integral concatenation of two signals. It is used for the determination of the output signal of a linear time-invariant system by convolving the input signal with the impulse response of the system. Note that convolving two signals is equivalent to multiplying the Fourier transform of the two signals.

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

$x[n]$  = Input signal Samples

$h[n-k]$  = Impulse response co-efficient.

$y[n]$  = 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:

```

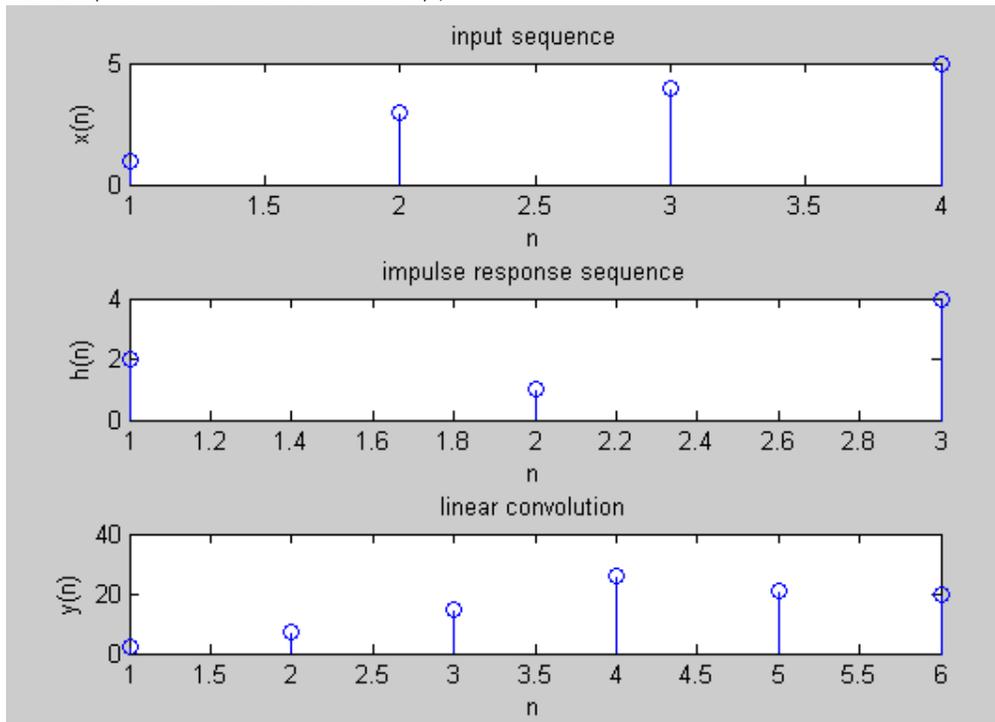
clc;
close all;
clear all;
%program for convolution of two sequences
x=input('enter input sequence: ');
h=input('enter impulse response: ');
y=conv(x,h);
subplot(3,1,1);
stem(x);
xlabel('n');
ylabel('x(n)');
title('input sequence')

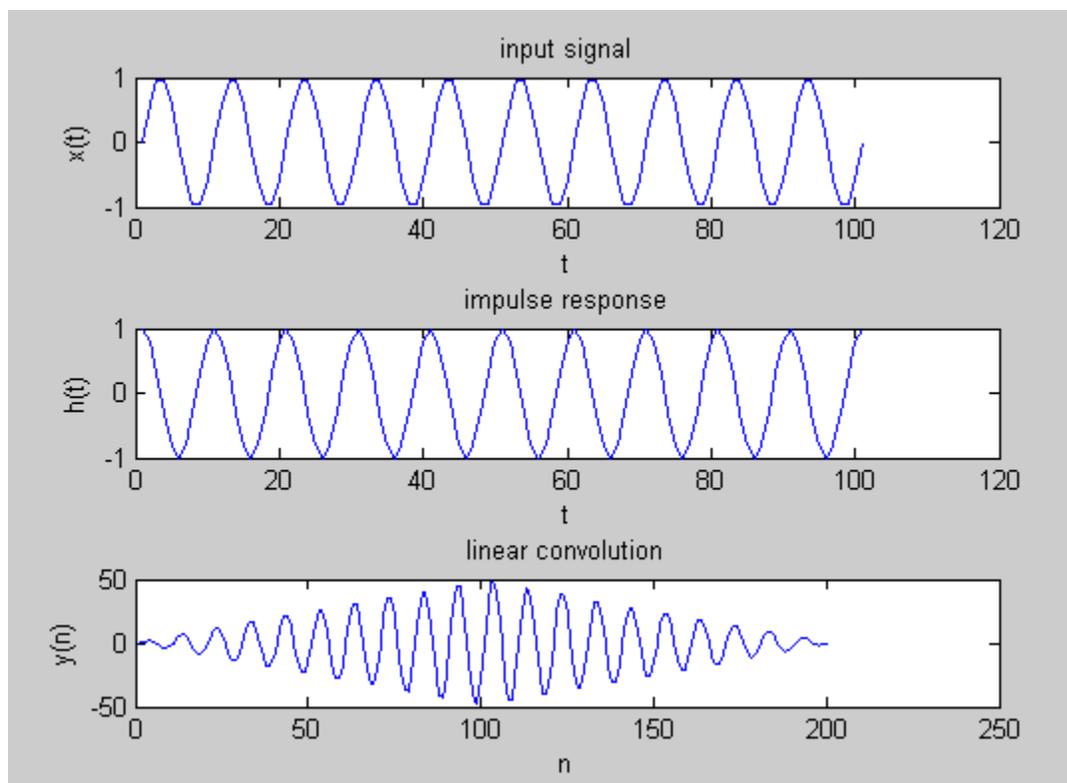
```

```

subplot(3,1,2);
stem(h);
xlabel('n');
ylabel('h(n)');
title('impulse response sequence')
subplot(3,1,3);
stem(y);
xlabel('n');
ylabel('y(n)');
title('linear convolution')
disp('linear convolution y=');
disp(y)
%program for signal convolution
t=0:0.1:10;
x1=sin(2*pi*t);
h1=cos(2*pi*t);
y1=conv(x1,h1);
figure;
subplot(3,1,1);
plot(x1);
xlabel('t');
ylabel('x(t)');
title('input signal')
subplot(3,1,2);
plot(h1);
xlabel('t');
ylabel('h(t)');
title('impulse response')
subplot(3,1,3);
plot(y1);
xlabel('n');
ylabel('y(n)');
title('linear convolution');

```





## Results and discussions

### Output:

enter input sequence: [1 3 4 5]

enter impulse response: [2 1 4]

linear convolution  $y = \{2\ 7\ 15\ 26\ 21\ 20\}$

**Result:** convolution between signals and sequences is computed.

## 6. Write a program to find auto correlation and cross correlation of given sequences.

**Aim:** To compute Auto correlation and Cross correlation between signals and sequences.

**Software Required:** Matlab software 7.0 version and above

### 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

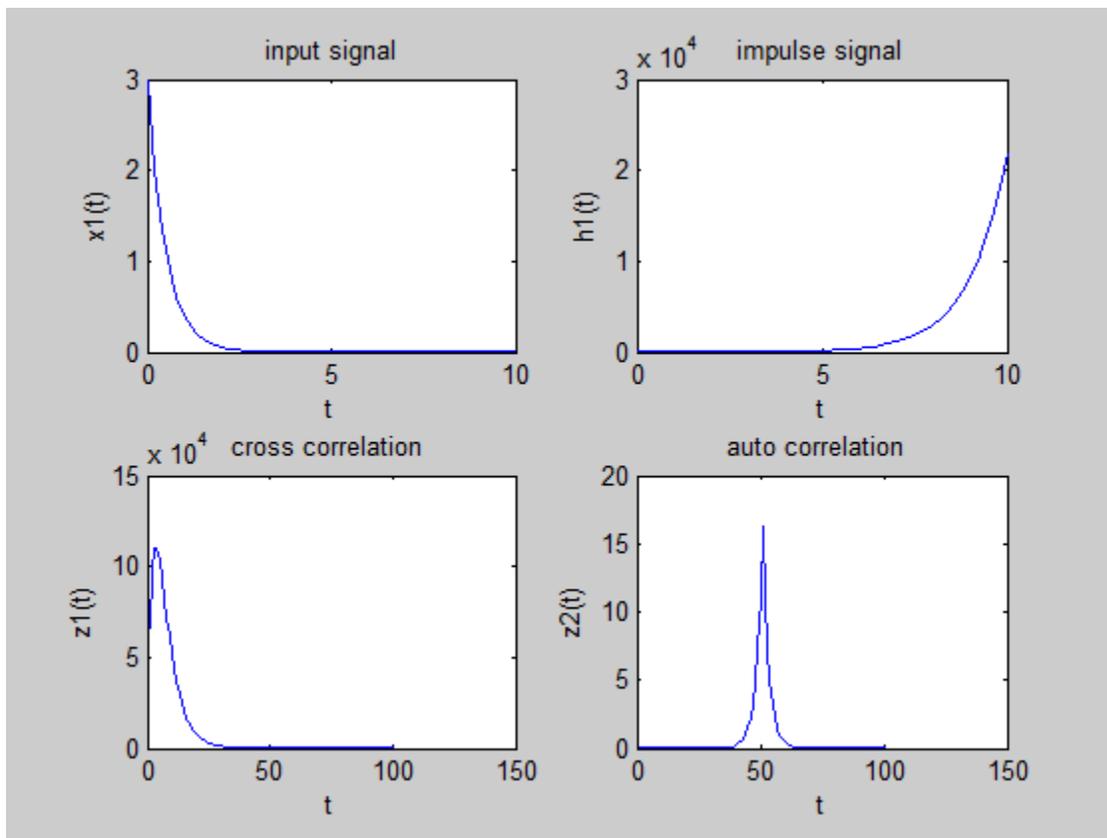
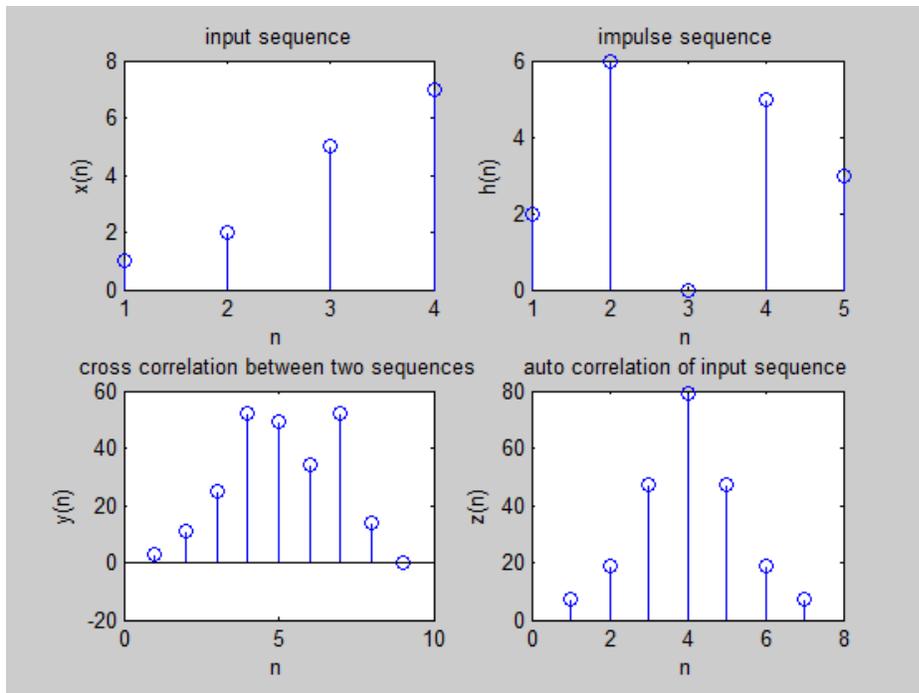
### Program:

```

clc;
close all;
clear all;
% two input sequences
x=input('enter input sequence');
h=input('enter the impulse suquence');
subplot(2,2,1);
stem(x);
xlabel('n');
ylabel('x(n)');
title('input sequence');
subplot(2,2,2);
stem(h);
xlabel('n');
ylabel('h(n)');
title('impulse sequence');
% cross correlation between two
y=xcorr(x,h);
subplot(2,2,3);
stem(y);
xlabel('n');
ylabel('y(n)');
title(' cross correlation between two sequences ');
% auto correlation of input sequence
z=xcorr(x,x);
subplot(2,2,4);
stem(z);
xlabel('n');
ylabel('z(n)');
title('auto correlation of input sequence');
% cross correlation between two signals

```

```
% generating two input signals
t=0:0.2:10;
x1=3*exp(-2*t);
h1=exp(t);
figure;
subplot(2,2,1);
plot(t,x1);
xlabel('t');
ylabel('x1(t)');
title('input signal');
subplot(2,2,2);
plot(t,h1);
xlabel('t');
ylabel('h1(t)');
title('impulse signal');
% cross correlation
subplot(2,2,3);
z1=xcorr(x1,h1);
plot(z1);
xlabel('t');
ylabel('z1(t)');
title('cross correlation ');
% auto correlation
subplot(2,2,4);
z2=xcorr(x1,x1);
plot(z2);
xlabel('t');
ylabel('z2(t)');
title('auto correlation ');
```



**Results and discussions**

**Output:** enter input sequence [1 2 5 7]  
enter the impulse sequence [2 6 0 5 3]

Result: Auto correlation and Cross correlation between signals and sequences is computed.

## 7 Write a program to verify Linearity and Time Invariant properties of a given Continuous/Discrete System.

**Aim:** Verify the Linearity of a given Discrete System.

**Software Required:** Matlab software 7.0 version and above

### Theory:

Any system is said to be linear if it satisfies the superposition principal. Superposition principal state that Response to a weighted sum of input signal equal to the corresponding weighted sum of the outputs of the system to each of the individual input signals. If  $x(n)$  is a input signal and  $y(n)$  is a output signal then  $y(n)=T[x(n)]$

$$y_1(n)=T[x_1(n)] \text{ and } y_2(n)=T[x_2(n)]$$

$$x_3=[a*x_1(n) +b *x_2(n) ]$$

$$Y_3(n)= T [x_3(n)]$$

$$T [a*x_1(n)+b*x_2(n) ] = a y_1(n)+ b y_2(n)$$

### Program (A) :

```
% Verification of Linearity of a given System.
% a) y(n)=nx(n) b) y=x^2(n)
clc;
clear all;
close all;
n=0:40;
a1=input('enter the scaling factor a1=');
a2=input('enter the scaling factor a2=');
```

```

x1=cos(2*pi*0.1*n);
x2=cos(2*pi*0.4*n);
x3=a1*x1+a2*x2;
%y(n)=n.x(n);
y1=n.*x1;
y2=n.*x2;
y3=n.*x3;
yt=a1*y1+a2*y2;
yt=round(yt);
y3=round(y3);
if y3==yt
disp('given system [y(n)=n.x(n)]is Linear');
else
disp('given system [y(n)=n.x(n)]is non Linear');
end
%y(n)=x(n).^2
x1=[1 2 3 4 5];
x2=[1 4 7 6 4];
x3=a1*x1+a2*x2;
y1=x1.^2;
y2=x2.^2;
y3=x3.^2;
yt=a1*y1+a2*y2;
if y3==yt
disp('given system [y(n)=x(n).^2 ]is Linear');
else
disp('given system is [y(n)=x(n).^2 ]non Linear');
end

```

Result: The Linearity of a given Discrete System is verified.

### Output:

```

enter the scaling factor a1=3
enter the scaling factor a2=5
given system [y(n)=n.x(n)]is Linear
given system is [y(n)=x(n).^2 ]non Linear

```

### Program (B) :

```

% Verification of Time Invariance of a Discrete System
% a) y=x^2(n) b) y(n)=nx(n)
clc;
clear all;
close all;
n=1:9;
x(n)=[1 2 3 4 5 6 7 8 9];
d=3; % time delay
xd=[zeros(1,d),x(n)];%x(n-k)
y(n)=x(n).^2;
yd=[zeros(1,d),y];%y(n-k)
disp('transformation of delay signal yd:');disp(yd)
dy=xd.^2; % T[x(n-k)]
disp('delay of transformation signal dy:');disp(dy)
if dy==yd
disp('given system [y(n)=x(n).^2 ]is time invariant');
else
disp('given system is [y(n)=x(n).^2 ]not time invariant');
end

```

```

y=n.*x;
yd=[zeros(1,d),y(n)];
disp('transformation of delay signal yd:');disp(yd);
n1=1:length(xd);
dy=n1.*xd;
disp('delay of transformation signal dy:');disp(dy);
if yd==dy
disp('given system [y(n)=nx(n)]is a time invariant');
else
disp('given system [y(n)=nx(n)]not a time invariant');
end

```

**Output:**

transformation of delay signal yd:

0 0 0 1 4 9 16 25 36 49 64 81

delay of transformation signal dy:

0 0 0 1 4 9 16 25 36 49 64 81

given system  $[y(n)=x(n)^2]$  is time invariant

transformation of delay signal yd:

0 0 0 1 4 9 16 25 36 49 64 81

delay of transformation signal dy:

0 0 0 4 10 18 28 40 54 70 88 108

given system  $[y(n)=n x(n)]$  not a time invariant

**Result:** The Time Invariance of a given Discrete System is verified.

**8. Write a program to generate discrete time sequence by sampling a continuous time signal. Show that with sampling rates less than Nyquist rate, aliasing occurs while reconstructing the signal.**

**Aim:** Verify the sampling theorem.

**Software Required:** Matlab software 7.0 version and above

**Theory:** Sampling Theorem:

"A band limited signal can be reconstructed exactly if it is sampled at a rate atleast twice the maximum frequency component in it."

The maximum frequency component of  $g(t)$  is  $f_m$ . To recover the signal  $g(t)$  exactly from its samples it has to be sampled at a rate  $f_s \geq 2f_m$ .

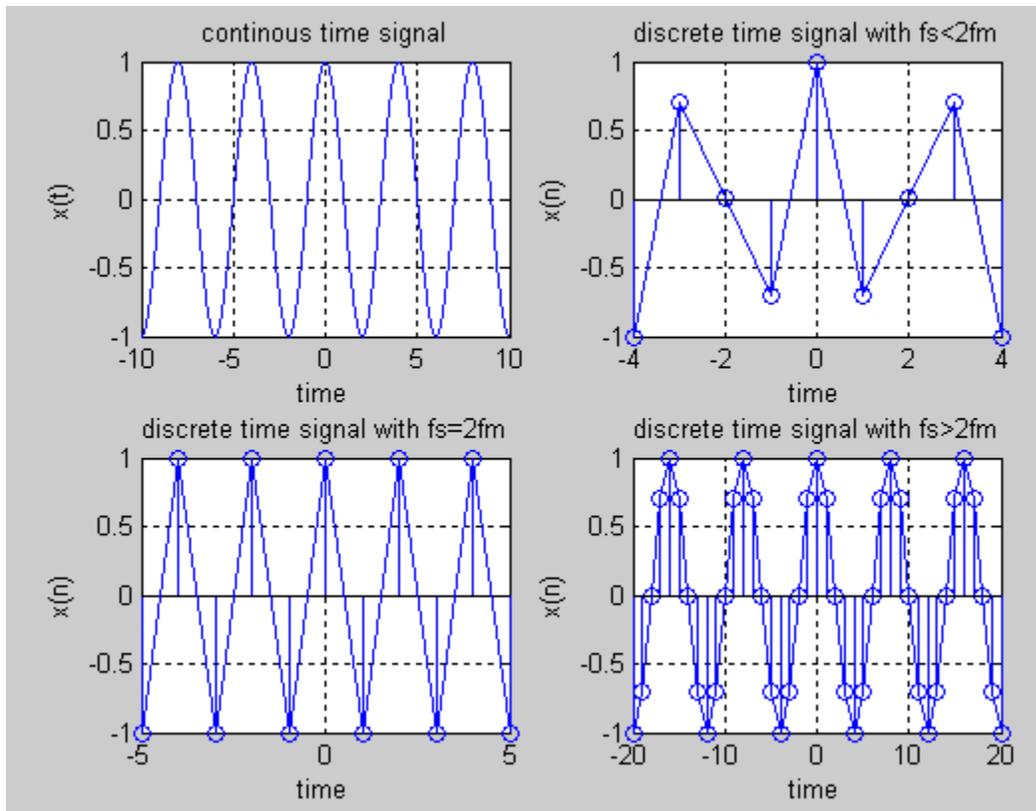
The minimum required sampling rate  $f_s = 2f_m$  is called 'Nyquist rate

**Program:**

```
clc;
clear all;
close all;
t=-10:.01:10;
T=4;
fm=1/T;
x=cos(2*pi*fm*t);
subplot(2,2,1);
plot(t,x);
xlabel('time');
ylabel('x(t)');
title('continous time signal');
grid;
n1=-4:1:4;
```

```
fs1=1.6*fm;
fs2=2*fm;
fs3=8*fm;
x1=cos(2*pi*fm/fs1*n1);
subplot(2,2,2);
stem(n1,x1);
xlabel('time');
ylabel('x(n)');
title('discrete time signal with fs<2fm');
hold on;
subplot(2,2,2);
plot(n1,x1);
grid;
n2=-5:1:5;
x2=cos(2*pi*fm/fs2*n2);
subplot(2,2,3);
stem(n2,x2);
xlabel('time');
ylabel('x(n)');
title('discrete time signal with fs=2fm');
hold on;
subplot(2,2,3);
plot(n2,x2);
grid;
n3=-20:1:20;
x3=cos(2*pi*fm/fs3*n3);
subplot(2,2,4);
stem(n3,x3);
xlabel('time');
ylabel('x(n)');
title('discrete time signal with fs>2fm');
hold on;
subplot(2,2,4);
plot(n3,x3);
grid;
```

OUTPUT :



**Result:** Sampling theorem is verified.

### 9. Write a program to find magnitude and phase response of first order low pass and high pass filter. Plot the responses in logarithmic scale.

**Aim:** To find magnitude and phase response of first order low pass and high pass filter. Plot the responses in logarithmic scale.

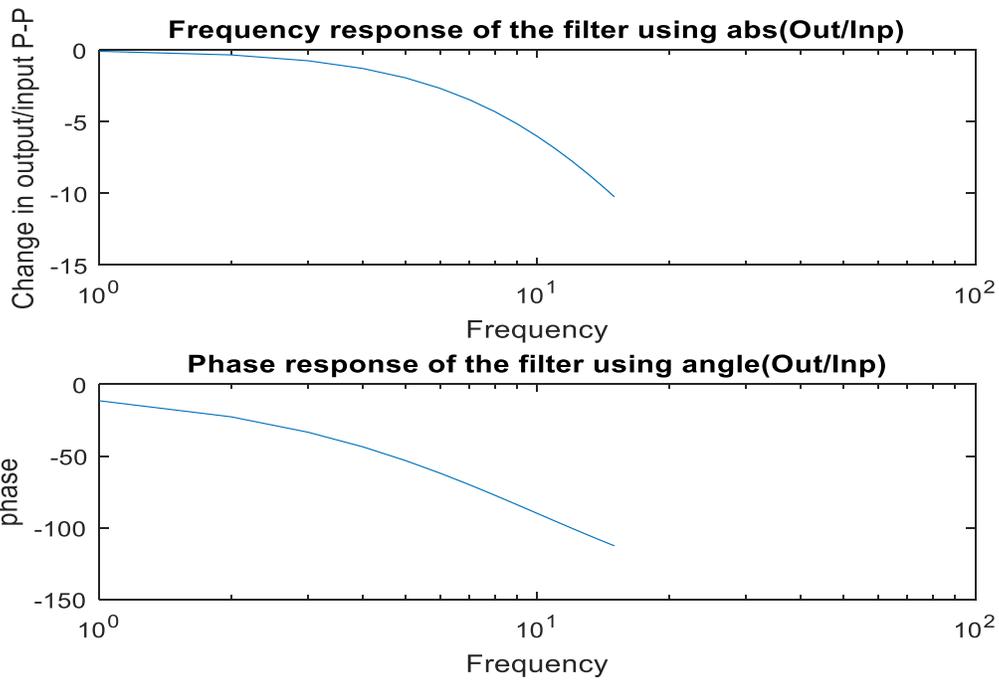
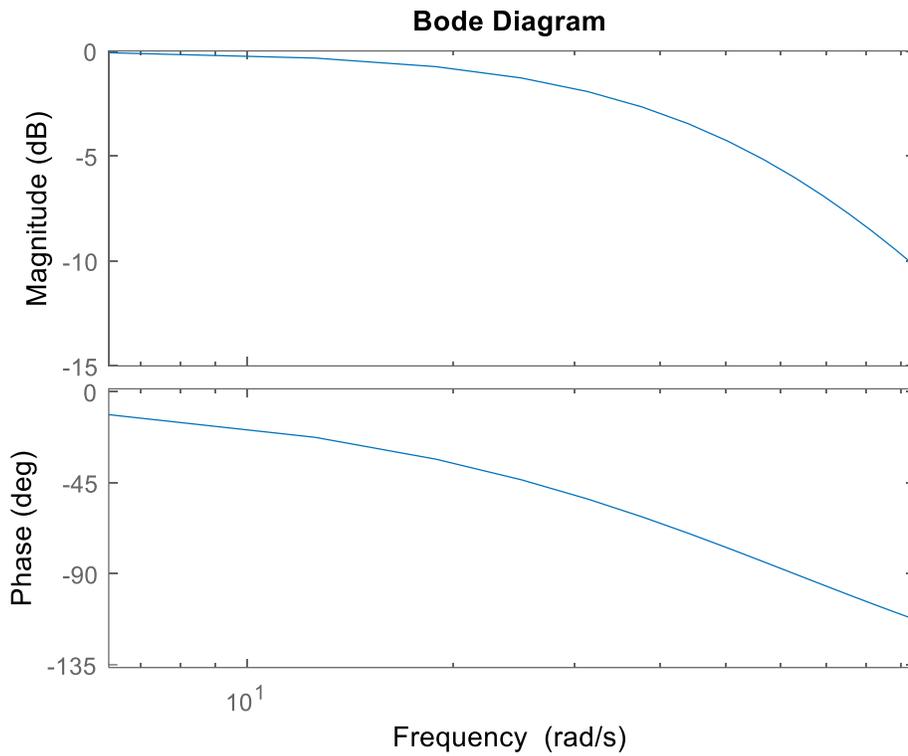
**Software Required:** Matlab software 7.0 version and above

**Theory:** To get the phase response in the time domain you need to estimate the delay between the input and the output at the test frequency and then convert to phase. For sure, taking the angle of the RMS ratio will not yield that delay. If you really want to estimate the delay in the time domain, there is a function called find delay that may be of use.

However, the alternative approach is to work in the frequency domain, i.e., use the ratio of the frequency response of the output to the frequency response of the input to directly estimate the magnitude and phase response of the system. The code that follows shows how to do that for a simple low pass filter. Keep in mind, that any approach you use may begin to suffer as you test frequency gets close to the Nyquist frequency. You can experiment with this code to see how close you can get before this simple approach begins to break down.

### Program :

```
f=1:15;
% second order filter with 10 Hz pass band
H = @(f,s) 1./(1./(2*pi*f).^2*s.^2 + 2./(2*pi*f)*s + 1);
H10 = @(s) H(10,s);
% magnitude estimation
magn = abs(H10(1j*2*pi*f));
% phase estimation
phase = rad2deg( angle(H10(1j*2*pi*f)) );
figure;
subplot(2,1,1);
semilogx(f,mag2db(magn));
title('Frequency response of the filter using abs(Out/Inp)');
xlabel('Frequency');
ylabel('Change in output/input P-P');
subplot(2,1,2);
semilogx(f,phase);
title('Phase response of the filter using angle(Out/Inp)');
xlabel('Frequency');
ylabel('phase');
% check against inbuilt functions
H_tf = @(f) tf(1,[1./(2*pi*f).^2 2./(2*pi*f) 1]);
figure;
bodeplot(H_tf(10),2*pi*f)
```



Result: The magnitude and phase response of LPF plotted.

## 10 Write a program to find response of a low pass filter and high pass filter, when a speech signal is passed through these filters.

**Aim:** To find response of a low pass filter and high pass filter, when a speech signal is passed through these filters.

**Software Required:** Matlab software 7.0 version and above

### Theory:

$y = \text{lowpass}(x, w_{\text{pass}})$  filters the input signal  $x$  using a lowpass filter with normalized passband frequency  $w_{\text{pass}}$  in units of  $\pi$  rad/sample. `lowpass` uses a minimum-order filter with a stopband attenuation of 60 dB and compensates for the delay introduced by the filter. If  $x$  is a matrix, the function filters each column independently.

$y = \text{lowpass}(x, f_{\text{pass}}, f_s)$  specifies that  $x$  has been sampled at a rate of  $f_s$  hertz.  $f_{\text{pass}}$  is the passband frequency of the filter in hertz.

$y = \text{lowpass}(xt, f_{\text{pass}})$  `lowpass`-filters the data in timetable  $xt$  using a filter with a passband frequency of  $f_{\text{pass}}$  hertz. The function independently filters all variables in the timetable and all columns inside each variable.

$y = \text{lowpass}(\_, \text{Name}, \text{Value})$  specifies additional options for any of the previous syntaxes using name-value pair arguments. You can change the stopband attenuation, the transition band steepness, and the type of impulse response of the filter.

$[y, d] = \text{lowpass}(\_)$  also returns the `digitalFilter` object  $d$  used to filter the input.

`lowpass(\_)` with no output arguments plots the input signal and overlays the filtered signal.

### Program :

```
% Read standard sample tune that ships with MATLAB.
[dataIn, Fs] = audioread('guitartune.wav');
% Filter the signal
fc = 800; % Make higher to hear higher frequencies.
% Design a Butterworth filter.
[b, a] = butter(6, fc/(Fs/2));
freqz(b, a)
% Apply the Butterworth filter.
filteredSignal = filter(b, a, dataIn);
% Play the sound.
player = audioplayer(filteredSignal, Fs);
play(player);
```

**Result:** Response of a low pass filter and high pass filter, when a speech signal studied.

**11 Write a program to generate Complex Gaussian noise and find its mean, variance, Probability Density Function (PDF) and Power Spectral Density (PSD).**

**Aim:** Write the program for generation of Gaussian noise and computation of its mean, mean square value, standard deviation, variance, and skewness.

**Software Required:** Matlab software 7.0 version and above

**Theory:**

**Gaussian noise** is statistical noise that has a probability density function (abbreviated pdf) of the normal distribution (also known as Gaussian distribution). In other words, the values the noise can take on are Gaussian-distributed. It is most commonly used as additive white noise to yield additive white Gaussian noise (AWGN). Gaussian noise is properly defined as the noise with a Gaussian amplitude distribution. says nothing of the correlation of the noise in time or of the spectral density of the noise. Labeling Gaussian noise as 'white' describes the correlation of the noise. It is necessary to use the term "white Gaussian noise" to be correct. Gaussian noise is sometimes misunderstood to be white Gaussian noise, but this is not the case.

**Program:**

```

clc;
clear all;
close all;
%generates a set of 2000 samples of Gaussian distributed random numbers
x=randn(1,2000);
%plot the joint distribution of both the sets using dot.
subplot(211)
plot(x, '.');
title('scatter plot of gaussian distributed random numbers');
ymu=mean(x)
ymsq=sum(x.^2)/length(x)
ysigma=std(x)
yvar=var(x)
yskew=skewness(x)
p=normpdf(x,ymu,ysigma);
subplot(212);
stem(x,p);
title(' gaussian distribution');

```

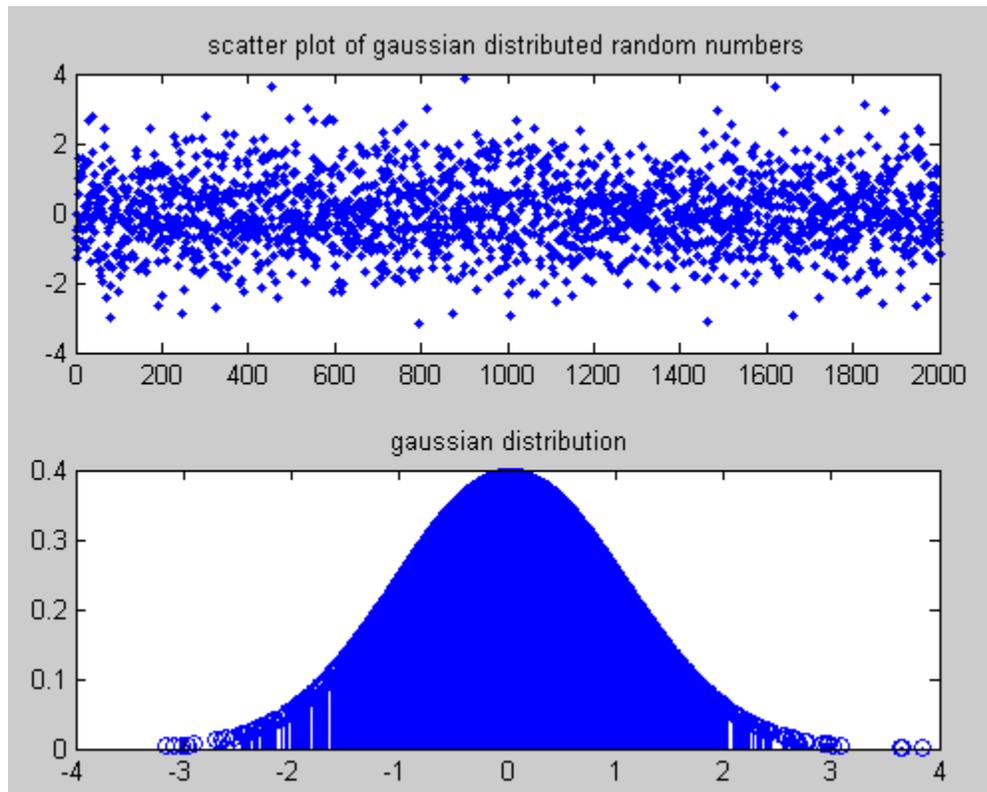
**Output:**

```

ymu = 0.0403
ymsq = 0.9727
ysigma = 0.9859
yvar = 0.9720
yskew = 0.0049

```

OUTPUT :



**Result:** Gaussian noise and its characteristics are studied.

**12. Generate a Random data (with bipolar) for a given data rate (say 10kbps). Plot the same for a time period of 0.2 sec.**

**Aim:** To Generate a Random data (with bipolar) for a given data rate (say 10kbps). Plot the same for a time period of 0.2 sec.

**Software Required:** Matlab software 7.0 version and above

**Theory:**

$X = \text{rand}$  returns a single uniformly distributed random number in the interval (0,1).

$X = \text{rand}(n)$  returns an n-by-n matrix of random numbers.

$X = \text{rand}(sz1, \dots, szN)$  returns an sz1-by-...-by-szN array of random numbers where sz1, ..., szN indicate the size of each dimension. For example,  $\text{rand}(3,4)$  returns a 3-by-4 matrix.

$X = \text{rand}(sz)$  returns an array of random numbers where size vector sz specifies size(X). For example,  $\text{rand}([3 \ 4])$  returns a 3-by-4 matrix.

$X = \text{rand}(\_, \text{typename})$  returns an array of random numbers of data type typename. The typename input can be either 'single' or 'double'. You can use any of the input arguments in the previous syntaxes.

**Program :**

```

clc;
clear all;
a=-3
b=3
x=rand
c=a+(b-a)*x
y=c^2
z=y
for i=1:1000
    x1=rand
    c1=a+(b-a)*x1
    y1=c1^2

    if y1<z
        z=y1
    else
        z;
    end
end
z

```

Result: Random data generated and studied.

### 13. To plot pole-zero diagram in S-plane/Z-plane of given signal/sequence and verify its stability

**Aim:** Write the program for locating poles and zeros and plotting pole-zero maps in s-plane and z-plane for the given transfer function.

**Software Required:** Matlab software 7.0 version and above

#### Theory: Z-transforms

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

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

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

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  $X(z)$

Example:

The zeros are:  $\{-1\}$

$$H(z) = \frac{z+1}{(z-\frac{1}{2})(z+\frac{3}{4})}$$

The poles are:  $\left\{ \frac{1}{2}, -\left(\frac{3}{4}\right) \right\}$

#### Program

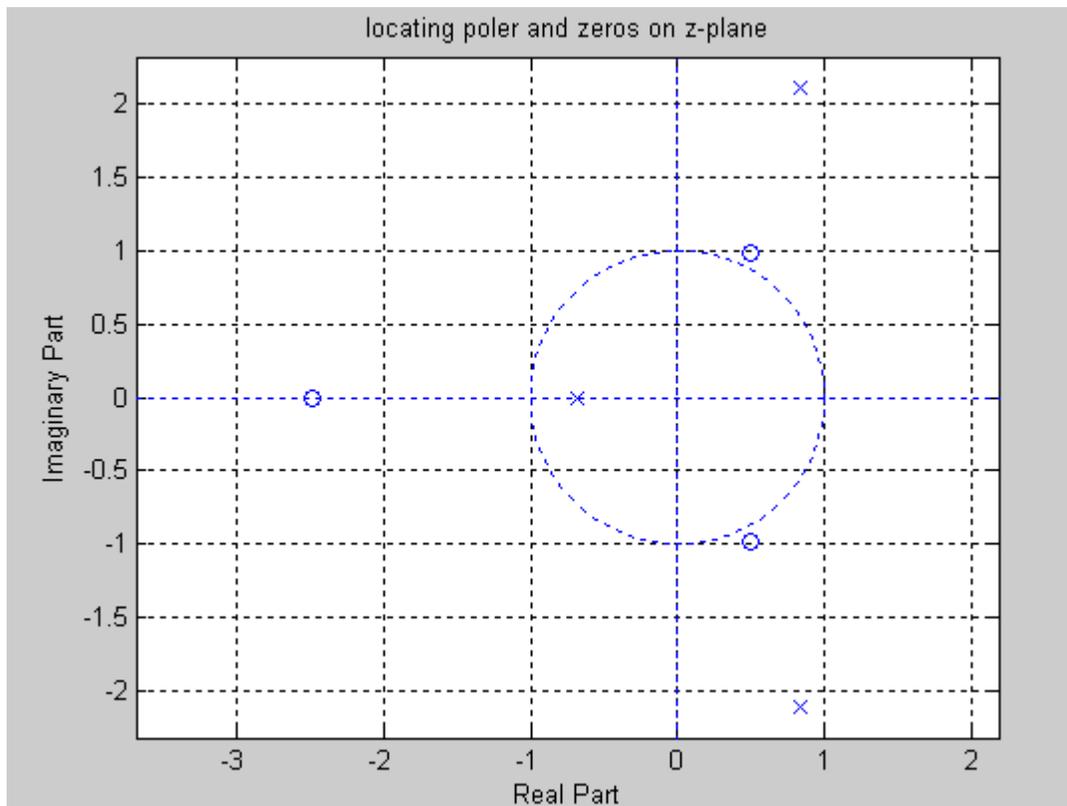
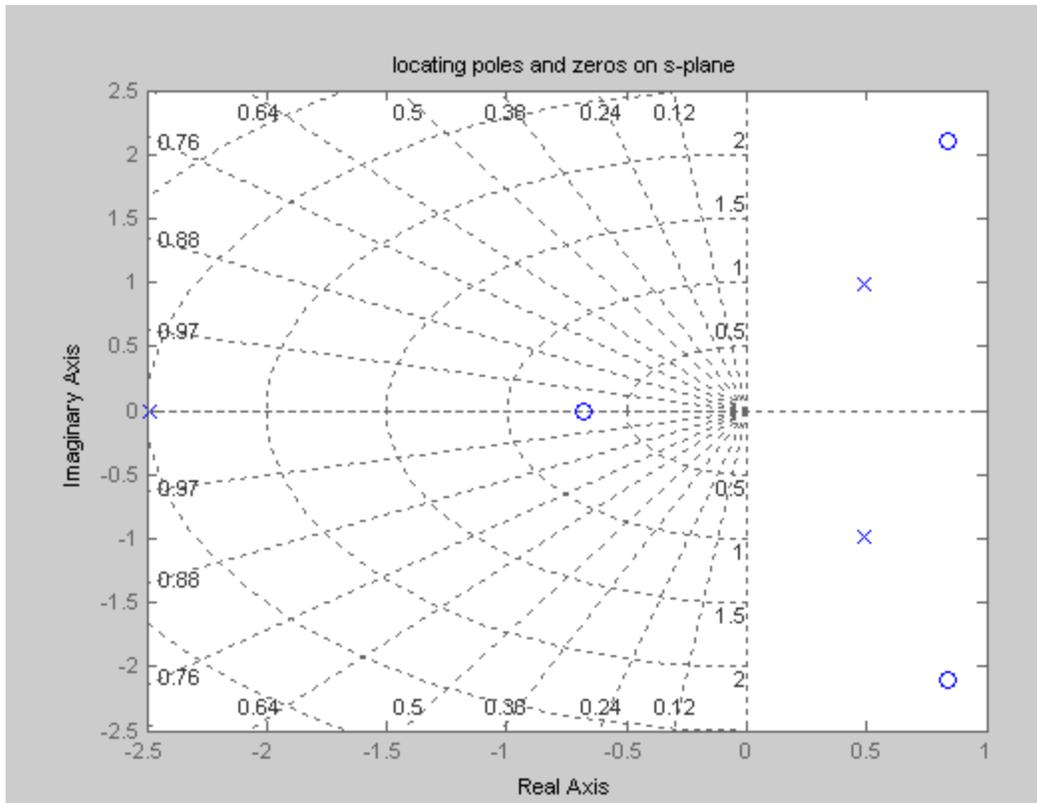
```
clc;
clear all;
close all;
%enter the numerator and denamenator coefficients in square brackets
num=input('enter numerator co-efficients');
den=input('enter denominator co-efficients');
```

```
% find poles and zeros
poles=roots(den)
zeros=roots(num)
% find transfer function H(s)
h=tf(num,den);
% plot the pole-zero map in s-plane
sgrid;
pzmap(h);
grid on;
title('locating poles and zeros on s-plane');
%plot the pole zero map in z-plane
figure
zplane(poles,zeros);
grid on;
title('locating poles and zeros on z-plane');
```

**Result:** Pole-zero maps are plotted in s-plane and z-plane for the given transfer function.

**Output:**

```
enter numerator co-efficients[1 -1 4 3.5]
enter denominator co-efficients[2 3 -2.5 6]
poles =
-2.4874
0.4937 + 0.9810i
0.4937 - 0.9810i
zeros =
0.8402 + 2.1065i
0.8402 - 2.1065i
-0.6805
```



Result: Stability test verified for given pole zero plot.