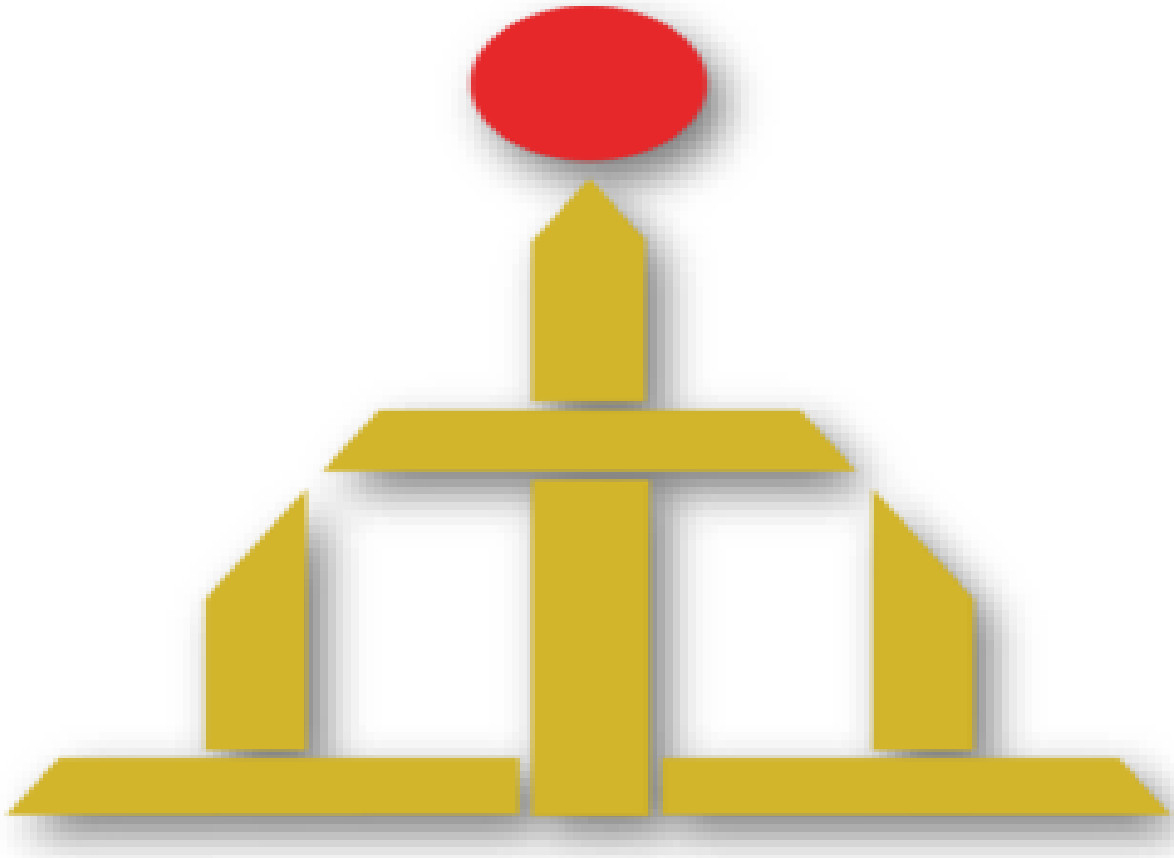
INDIAN INSTITUTE OF INFORMATION TECHNOLOGY BHAGALPUR



भारतीय सूचना प्रौद्योगिकी संस्थान भागलपुर
Indian Institute of Information Technology
Bhagalpur

DIGITAL SIGNAL PROCESSING LABORATORY REPORT

(EC311)

NAME : SAGAR SONI **BRANCH :** ECE **ROLL NUMBER :** 2001092

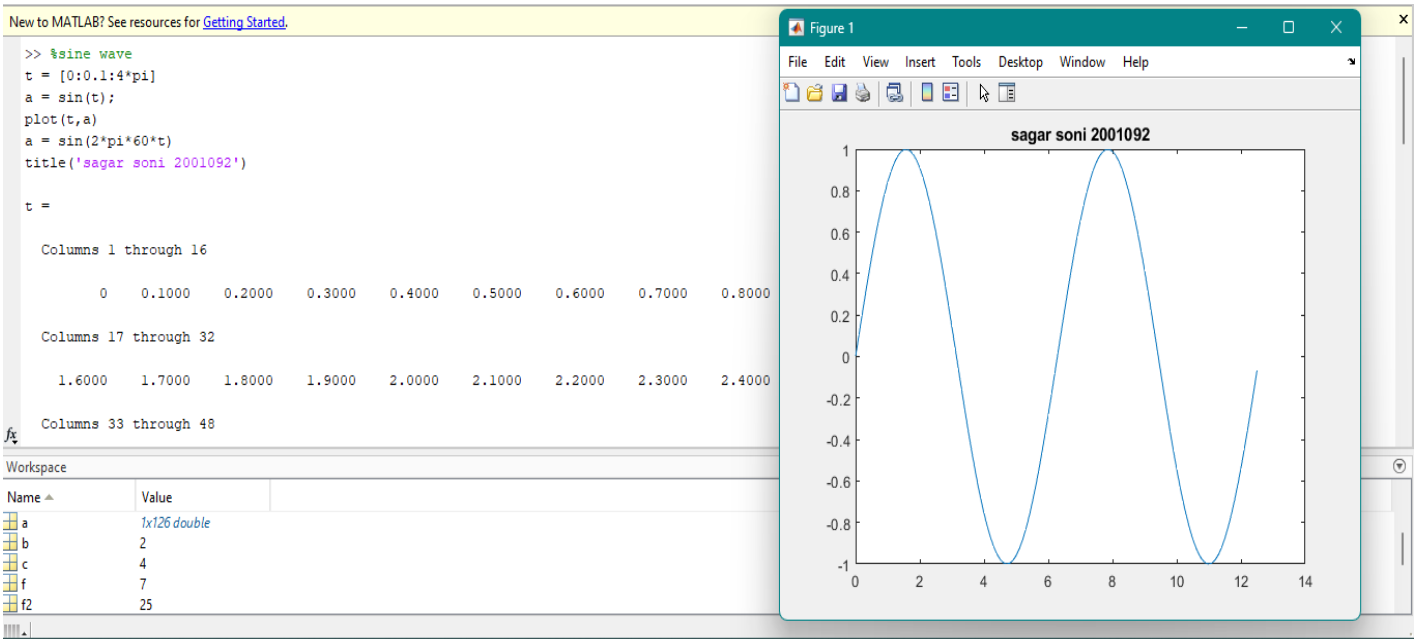
EXPERIMENT 1

Aim: Write MATLAB Code to solve/plot:

a)Y= (a+b-c) (a-b-c) 2 (a+b+c) 3, where a=1, b=2, c=4

```
>> a=1;
b=2;
c=4;
x="sagar soni";
f=(a+b+c);
f3=(a+b+c)^3;
f2=(a-b-c)^2;
f4=f*f2*f3;
display(x);
display(f4)

x =

     "sagar soni"


f4 =

        60025
```

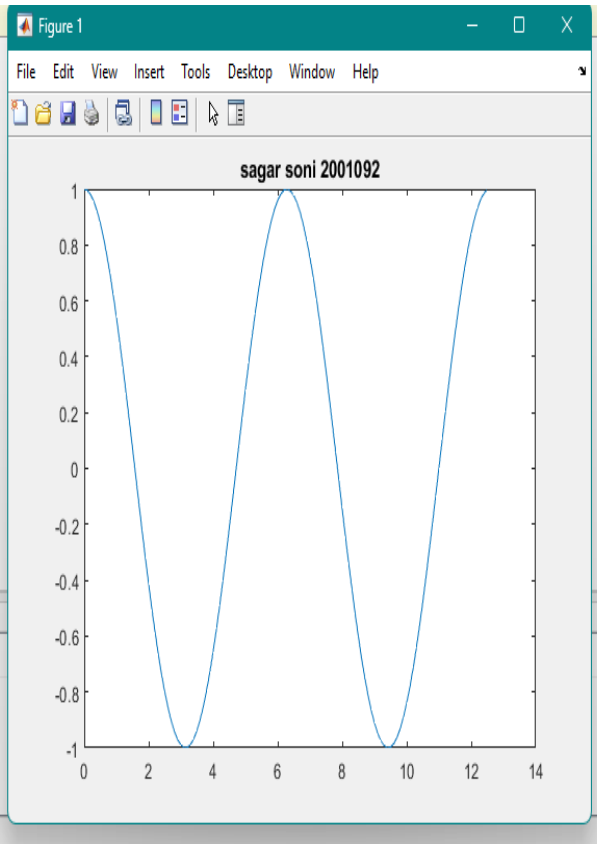
b) Sine Wave



NAME : SAGAR SONI **BRANCH : ECE** **ROLL NUMBER : 2001092**

c) Cosine Wave

```
>> %cosine wave
t = [0:0.1:4*pi]
a = cos(t);
plot(t,a)
a = cos(2*pi*60*t)
title('sagar soni 2001092')

t =

  Columns 1 through 16

         0    0.1000    0.2000    0.3000    0.4000    0.5000    0.6000    0.7000    0.8000

  Columns 17 through 32

    1.6000    1.7000    1.8000    1.9000    2.0000    2.1000    2.2000    2.3000    2.4000

  Columns 33 through 48
```

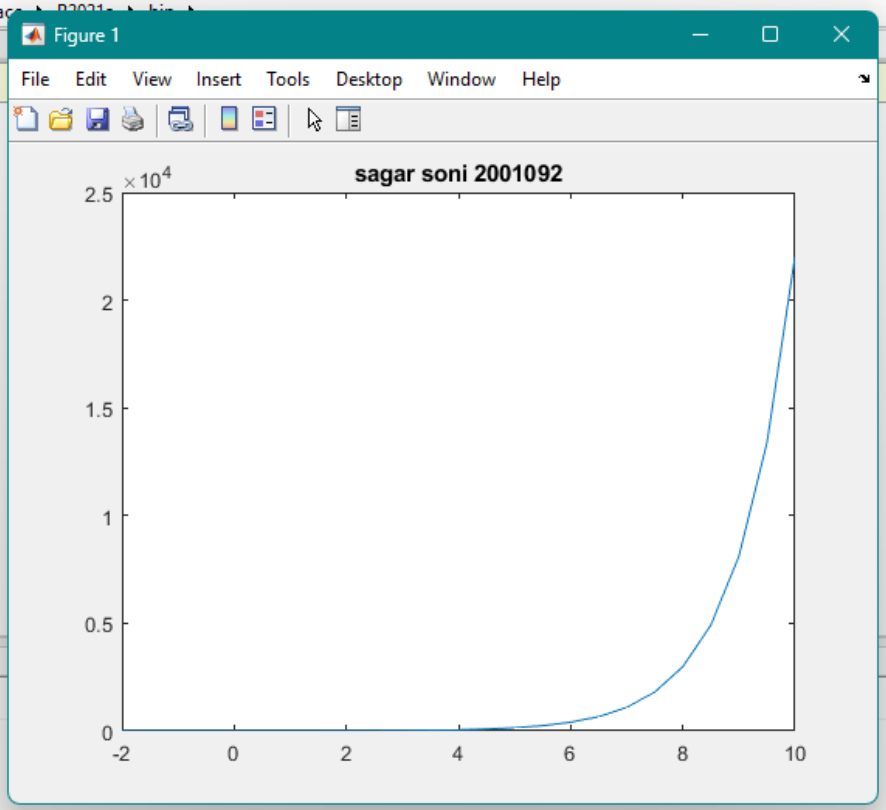


Workspace

Name	Value
a	1x126 double
b	2
c	4
f	7
f2	25

d) e^x

```
>> X = -2:0.5:10;
Y = exp(X);
plot(X,Y)
title('sagar soni 2001092')
>>
>>
```



Workspace

Name	Value
a	1x126 double
b	2
c	4
f	7

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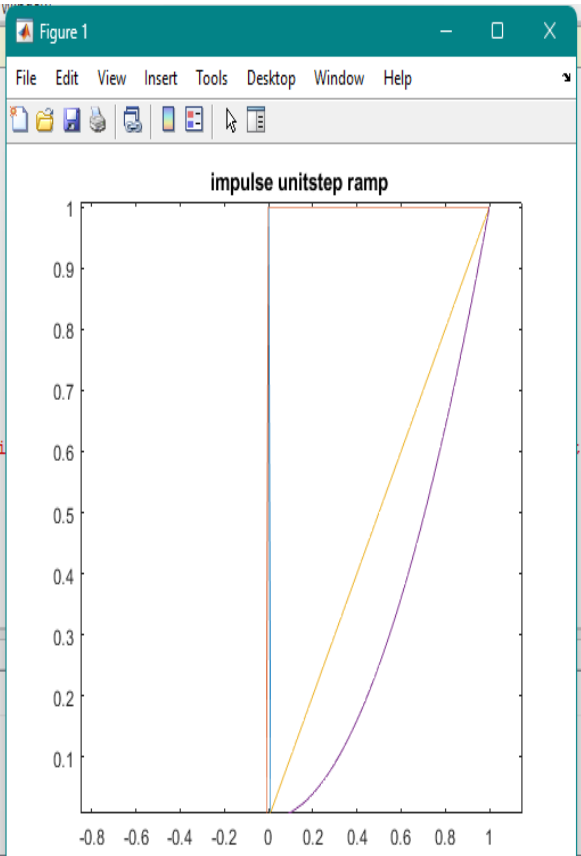
e)Unit Step, Unit Impulse, Ramp function

```
>> t = (-1:0.01:1)';
impulse = t==0;
unitstep = t>=0;
ramp = t.*unitstep;
quad = t.^2.*unitstep;
plot(t,[impulse unitstep ramp quad])
title('impulse unitstep ramp ')
set(gcf, 'Color', [1 1 1], 'Position', [1 1 1280 1024])
annotation(gcf,'textbox', 'Position',[0.38 0.96 0.45 0.026]'EdgeColor',[1 1 1],...
    'String', '\bf sagar soni 2001092', 'FitBoxToText','on');
 annotation(gcf,'textbox', 'Position',[0.38 0.96 0.45 0.026]'EdgeColor',[1 1 1],...
                                                          ↑
Invalid expression. Check for missing multiplication operator, missing or unbalanced delimi
parentheses.

>>
```



Workspace

Name	Value
a	1x126 double
b	2
c	4
f	7
f2	25

NAME : SAGAR SONI **BRANCH : ECE** **ROLL NUMBER : 2001092**

EXPERIMENT 2

Aim: Write MATLAB Function to solve/plot:

a)Y= $(a-b-c)^3$, where a=2, b=3, c=4

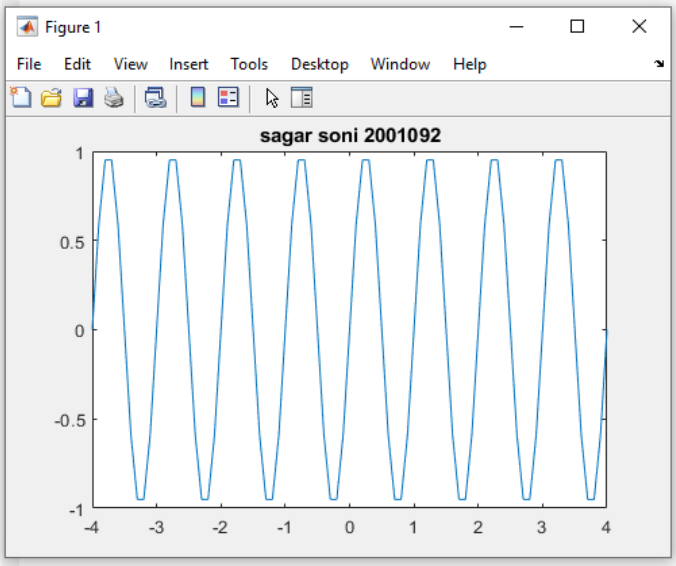
```
Command Window
>> a =2;b=3;c=4;
>> z = equation(a,b,c)

x =

    "sagar soni 2001092"


z =

   729

fx >>
```

```
1  function [y]=equation(a,b,c)
2      y=(a+b+c)^3;
3      x="sagar soni 2001092";
4      display(x);
5  end
```

b)Sine Wave

```
C: ▸ Program Files ▸
Command Window
>> t = -4:0.1:4;
>> z = sine_wave(t);
fx >>
```

```
untitled.mlx | dual_tone_multi_frequency.m | sine_wave.m | ramp_func.m
1  function [y]= sine_wave(t)
2      y = sin(2*pi*t);
3      plot(t,y);
4      title("sagar soni 2001092");
5  end
```



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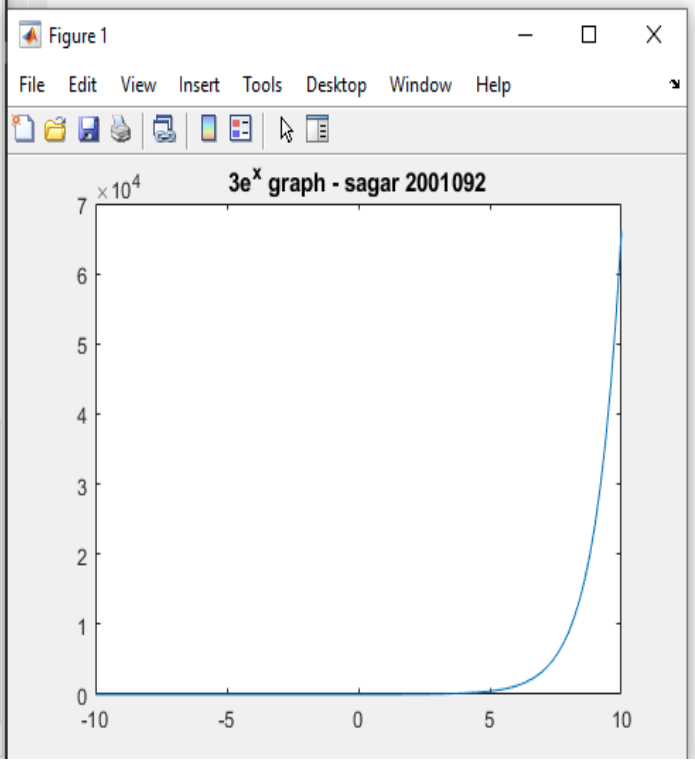
c) $3e^x$

```
C: ▸ Program Files ▸
Command Window
    2.0000    2.2000    2.4000    2.6000    2.8000    3.0000

  Columns 67 through 72

    3.2000    3.4000    3.6000    3.8000    4.0000    4.2000

  Columns 73 through 78

    4.4000    4.6000    4.8000    5.0000    5.2000    5.4000

  Columns 79 through 84

    5.6000    5.8000    6.0000    6.2000    6.4000    6.6000

  Columns 85 through 90

    6.8000    7.0000    7.2000    7.4000    7.6000    7.8000

  Columns 91 through 96

    8.0000    8.2000    8.4000    8.6000    8.8000    9.0000

  Columns 97 through 101

    9.2000    9.4000    9.6000    9.8000   10.0000

>> y=e_power_x(t);
fx >>
```

e_power_x.m

```
1  function [y]=e_power_x(t)
2      y=3.*exp(t);
3      plot(t,y);
4      title("3e^x graph - sagar 2001092");
5  end
```

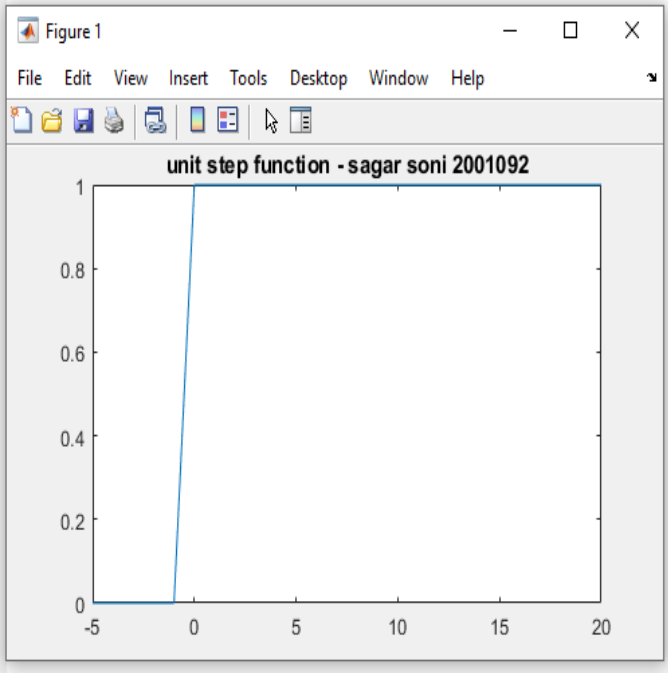


d) Unit Step

```
C: ▸ Program Files ▸
Command Window
  Columns 1 through 11

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

  Columns 12 through 22

     6     7     8     9    10    11    12    13    14    15    16

  Columns 23 through 26

    17    18    19    20

>> z = unitstep_func(t)

z =

  1×26 logical array

  Columns 1 through 17

   0   0   0   0   0   1   1   1   1   1   1   1   1   1   1   1   1

  Columns 18 through 26

   1   1   1   1   1   1   1   1   1

fx >>
```

equation.m | unitstep_func.m

```
1  function [y]= unitstep_func(t)
2      unitstep=t>=0;
3      y=unitstep;
4      plot(t,y);
5       title("unit step function - sagar soni 2001092");
6  end
```



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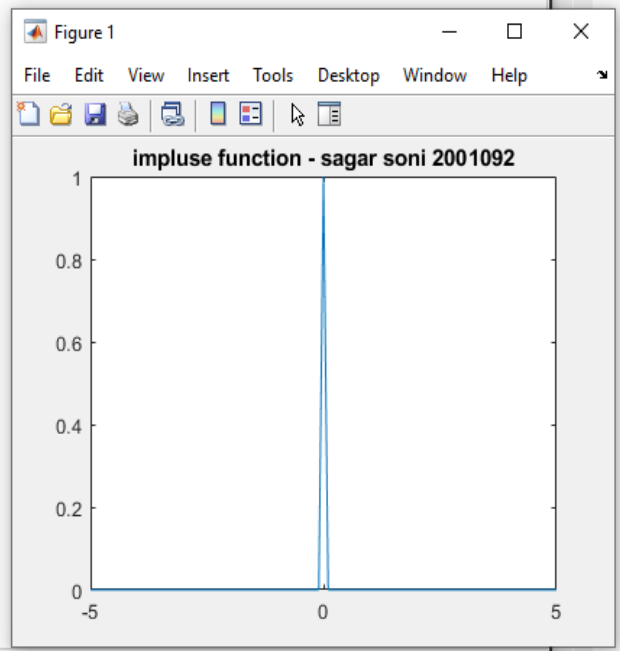
e)Unit Impulse

```
>> t = -5:0.1:5;
>> y = impulse_func(t);
>>
```

```
function [y]=impulse_func(t)

    y=t==0;
    plot(t,y);
    title("impluse function - sagar soni 2001092");
end
```

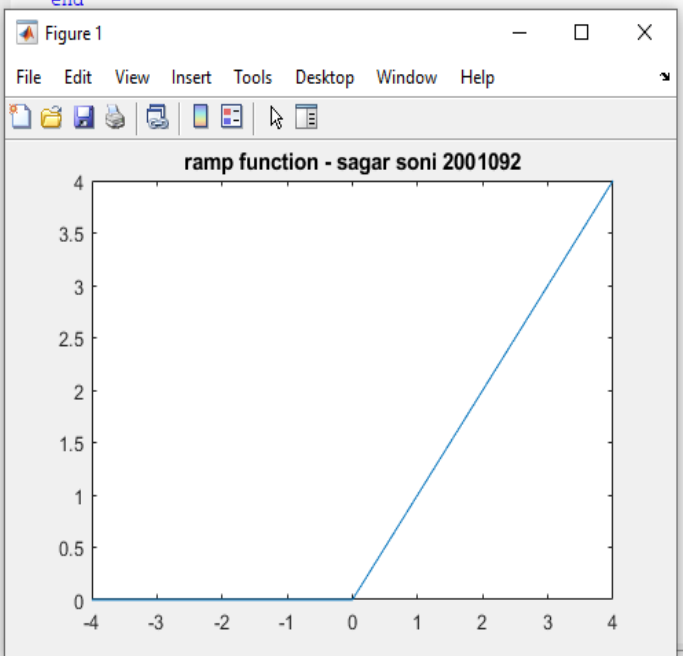


f) Ramp function

```
>> t = -4:0.1:4;
>> y = ramp_func(t);
>>
```

```
function [y]=ramp_func(t)

    y=t>=0;
    y=y.*t;
    plot(t,y);
    title("ramp function - sagar soni 2001092");
end
```



NAME : SAGAR SONI **BRANCH : ECE** **ROLL NUMBER : 2001092**

EXPERIMENT 3

Aim: Verify Sampling theorem through MATLAB coding.

Sampling Theorem: *The sampling theorem specifies the minimum sampling rate at which a continuous-time signal needs to be uniformly sampled so that the original signal can be completely recovered or reconstructed by these samples alone. This is usually referred to as Shannon's sampling theorem in the literature.*

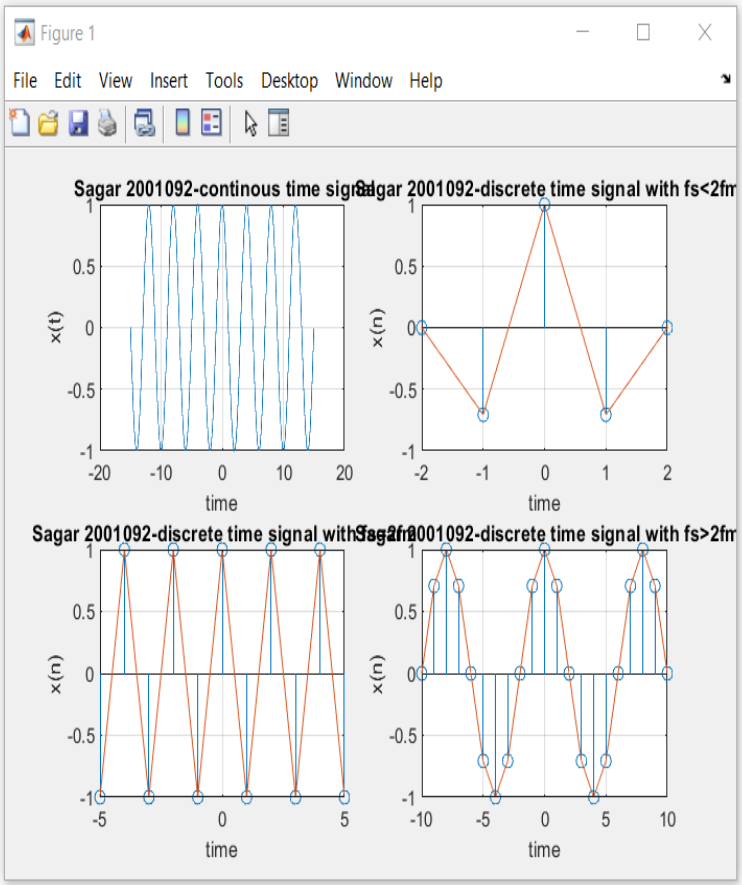
Command Window

New to MATLAB? See resources for Getting Started.

```
title(' Sagar 2001092-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(' Sagar 2001092-discrete time signal with fs=2fm')
hold on
subplot(2,2,3);
plot(n2,x2)
grid;
n3=-10:1:10;
x3=cos(2*pi*fm/fs3*n3);
subplot(2,2,4);
stem(n3,x3);
xlabel('time');ylabel('x(n)')
title(' Sagar 2001092-discrete time signal with fs>2fm')
hold on
subplot(2,2,4);
plot(n3,x3)
grid;

n1 =

    -2    -1     0     1     2
```

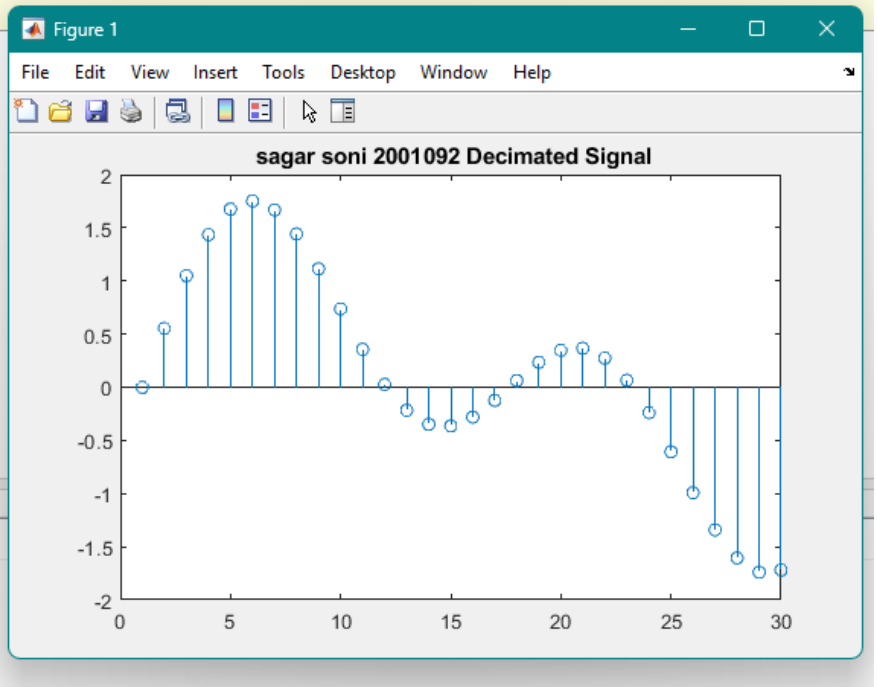


NAME : SAGAR SONI **BRANCH : ECE** **ROLL NUMBER : 2001092**

EXPERIMENT 4

Aim: Perform Interpolation and Decimation of any wave and verify any deformation in wave after performing both actions by same factor by using MATLAB.

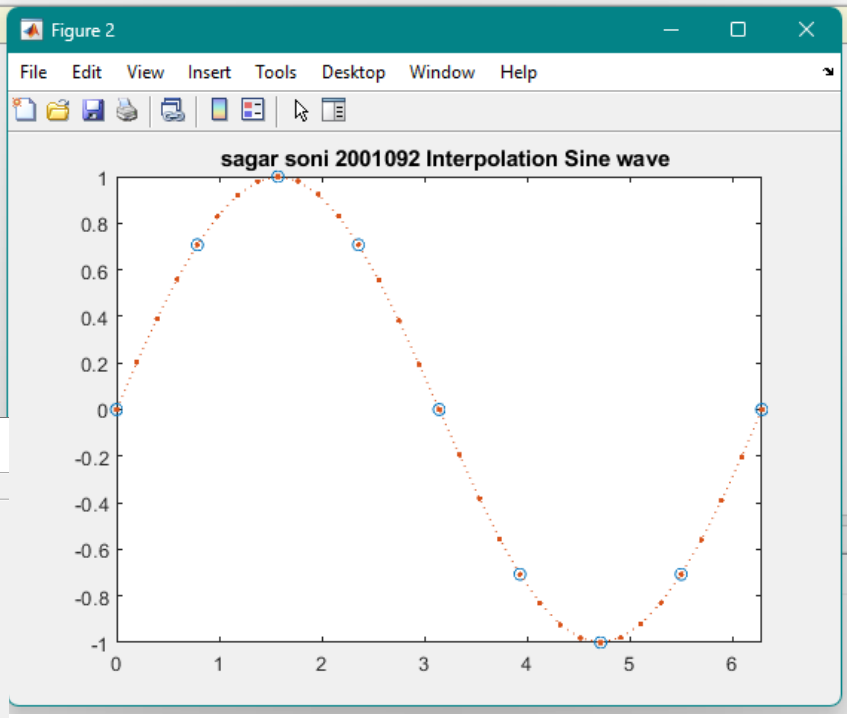
```
>> t = 0:.00025:1;                          % Time vector
x = sin(2*pi*30*t) + sin(2*pi*60*t);
y = decimate(x,4);
stem(x(1:120)), axis([0 120 -2 2])    % Original signal
title(' sagar soni 2001092 Original Signal')
figure
stem(y(1:30))                            % Decimated signal
title(' sagar soni 2001092 Decimated Signal')
>>
>>
```

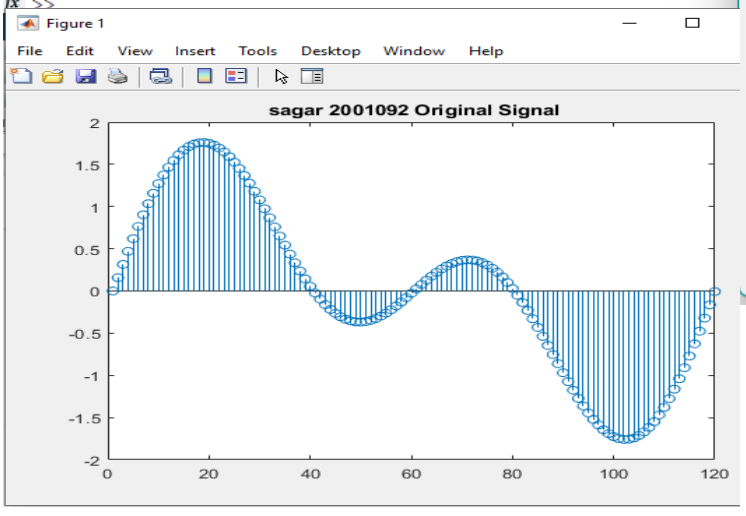


Workspace

Name	Value
a	1x126 double
b	2
c	4
f	7
f2	25

```
>> x = 0:pi/4:2*pi;
v = sin(x);
xq = 0:pi/16:2*pi;
%figure
%vq1 = interp1(x,v,xq);
%plot(x,v,'o',xq,vq1,':.');
%xlim([0 2*pi]);
%title('(Default) Linear Interpolation');
figure
vq2 = interp1(x,v,xq,'spline');
plot(x,v,'o',xq,vq2,':.');
xlim([0 2*pi]);
title('  sagar soni 2001092 Interpolation Sine wave');
>>
```





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EXPERIMENT 5

Aim: Write MATLAB code to plot graph for Dual Tone Multi Frequency for: 1, 2,3,4,5,6,7,8,9,0, *, #

```
symbol = {'1','2','3','4','5','6','7','8','9','*','0','#'};
lfg = [697 770 852 941]; % Low frequency group
hfg = [1209 1336 1477];  % High frequency group
f   = [];
for c=1:4,
    for r=1:3,
        f = [ f [lfg(c);hfg(r)] ];
    end
end
Fs  = 8000;        % Sampling frequency 8 kHz
N = 800;           % Tones of 100 ms
t   = (0:N-1)/Fs; % 800 samples at Fs
pit = 2*pi*t;
tones = zeros(N,size(f,2));
for toneChoice=1:12,
    % Generate tone
    tones(:,toneChoice) = sum(sin(f(:,toneChoice)*pit))';
    % Plot tone
    subplot(4,3,toneChoice),plot(t*1e3,tones(:,toneChoice));
    title(['Symbol "', symbol{toneChoice},'": [',num2str(f(1,toneChoice)),',',num2str(f(2,toneChoice)),']'])
    set(gca, 'Xlim', [0 25]);
    ylabel('Amplitude');
    if toneChoice>9, xlabel('Time (ms)'); end
end
set(gcf, 'Color', [1 1 1], 'Position', [1 1 1280 1024])
annotation(gcf,'textbox', 'Position',[0.38 0.96 0.45 0.026],...
    'EdgeColor',[1 1 1],...
```

```
    'EdgeColor',[1 1 1],...
    'String', '\bf sagar 2001092 Time response of each tone of the telephone pad', ...
    'FitBoxToText','on');
symbol = {'1','2','3','4','5','6','7','8','9','*','0','#'};
lfg = [697 770 852 941]; % Low frequency group
hfg = [1209 1336 1477];  % High frequency group
f   = [];
for c=1:4,
    for r=1:3,
        f = [ f [lfg(c);hfg(r)] ];
    end
end
Fs  = 8000;        % Sampling frequency 8 kHz
N = 800;           % Tones of 100 ms
t   = (0:N-1)/Fs; % 800 samples at Fs
pit = 2*pi*t;
tones = zeros(N,size(f,2));
for toneChoice=1:12,
    % Generate tone
    tones(:,toneChoice) = sum(sin(f(:,toneChoice)*pit))';
    % Plot tone
    subplot(4,3,toneChoice),plot(t*1e3,tones(:,toneChoice));
    title(['Symbol "', symbol{toneChoice},'": [',num2str(f(1,toneChoice)),',',num2str(f(2,toneChoice)),']'])
    set(gca, 'Xlim', [0 25]);
    ylabel('Amplitude');
    if toneChoice>9, xlabel('Time (ms)'); end
end
```

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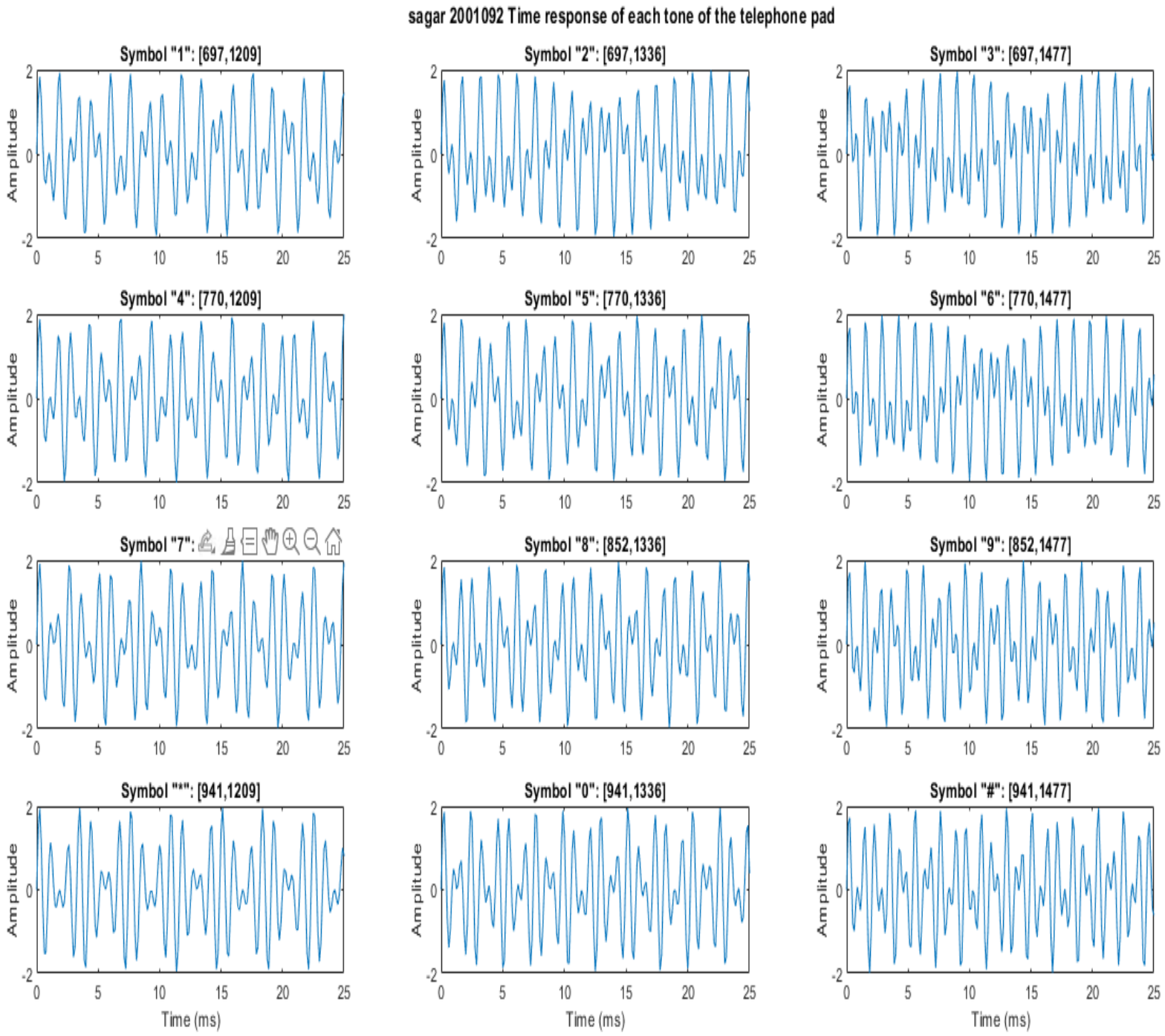


NAME : SAGAR SONI **BRANCH : ECE** **ROLL NUMBER : 2001092**

EXPERIMENT 6

(a) Write MATLAB codes to find convolution, auto and cross-correlation of a given sequence and analyze output

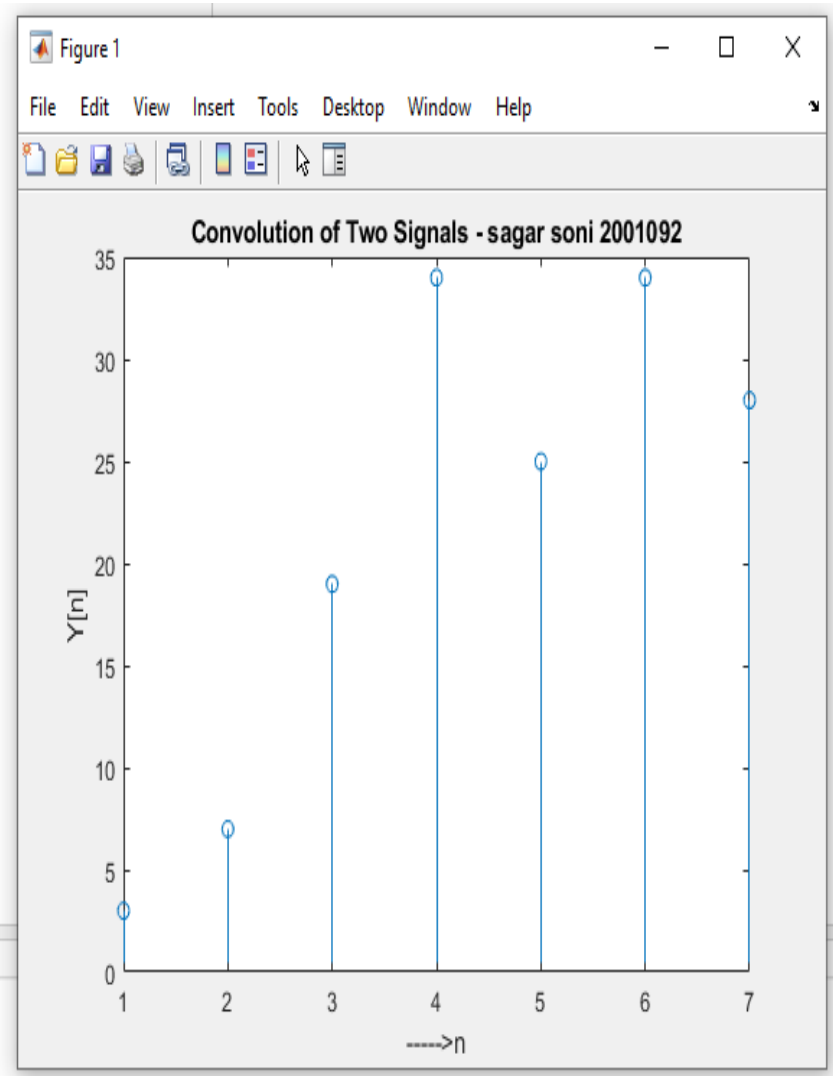
A= [1 2 5 7]

B= [3 1 2 4]

For Convolution-

```
% linear convolution
close all
x=input('Enter x: ');
h=input('Enter h: ');
m=length(x);
n=length(h);
X=[x,zeros(1,n)];
H=[h,zeros(1,m)];
for i=1:n+m-1
Y(i)=0;
for j=1:i
    Y(i)=Y(i)+X(j)*H(i-j+1);
end
Y
end
stem(Y);
ylabel('Y[n]');
xlabel('----->n');
title('Convolution of Two Signals - sagar soni 2001092')

```




```
Command Window
>> q6_a
Enter x: [1 2 5 7]
Enter h: [3 1 2 4]

Y =
```

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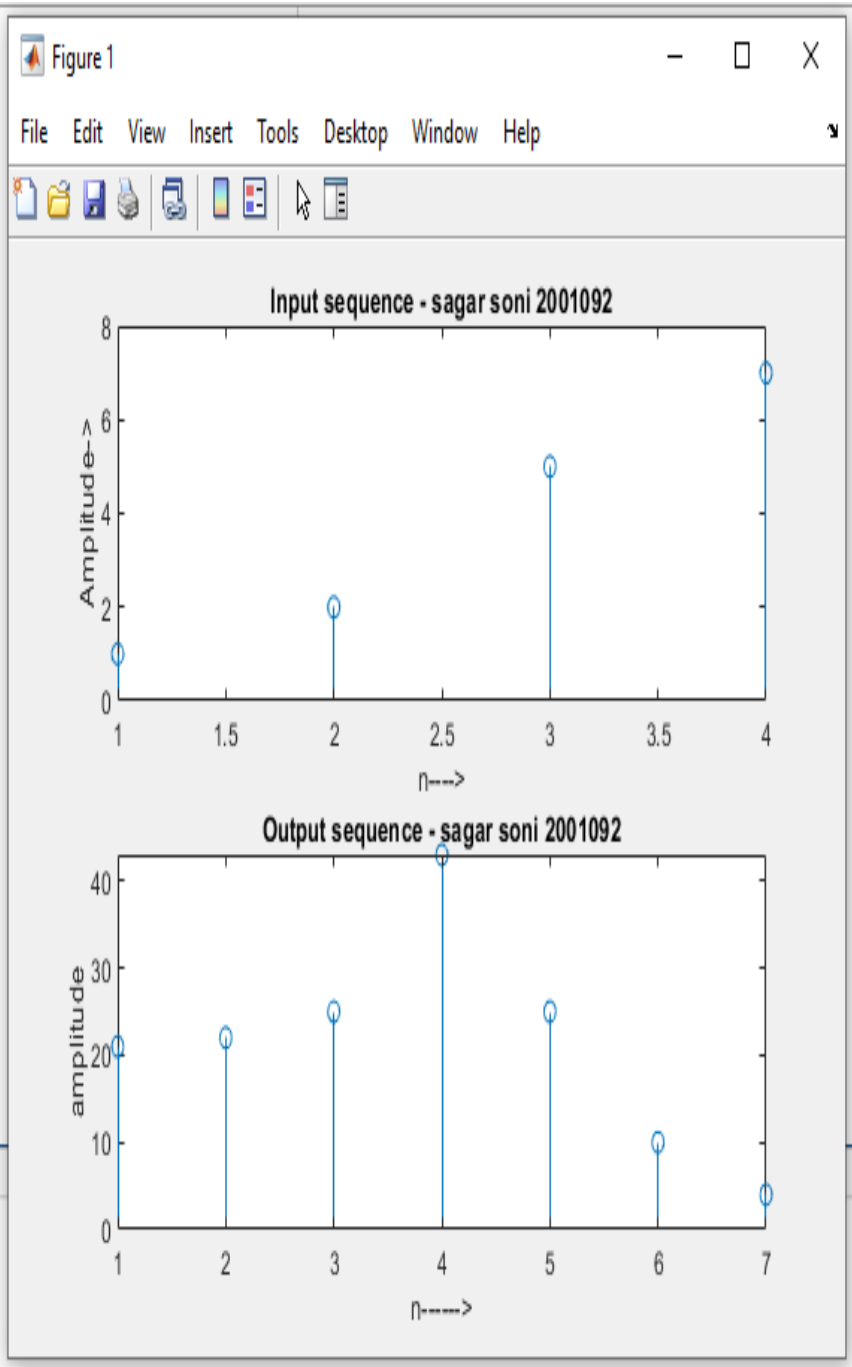
For Auto Correlation-

```
clc;
close all;
x=input('Enter the sequence 1: ');
y=input('Enter the sequence 2: ');
y=xcorr(x,y);
figure;
subplot(2,1,1);
stem(x);
title('the resultant is ');
ylabel('Amplitude->');
xlabel('n---->');
title('Input sequence - sagar soni 2001092');
subplot(2,1,2);
stem(fliplr(y));
ylabel('amplitude');
xlabel('n------>');
title('Output sequence - sagar soni 2001092');

fliplr(y);
```




```
Command Window

  Enter the sequence 1: [1 2 5 7]
  Enter the sequence 2: [3 1 2 4]
fx >>
```

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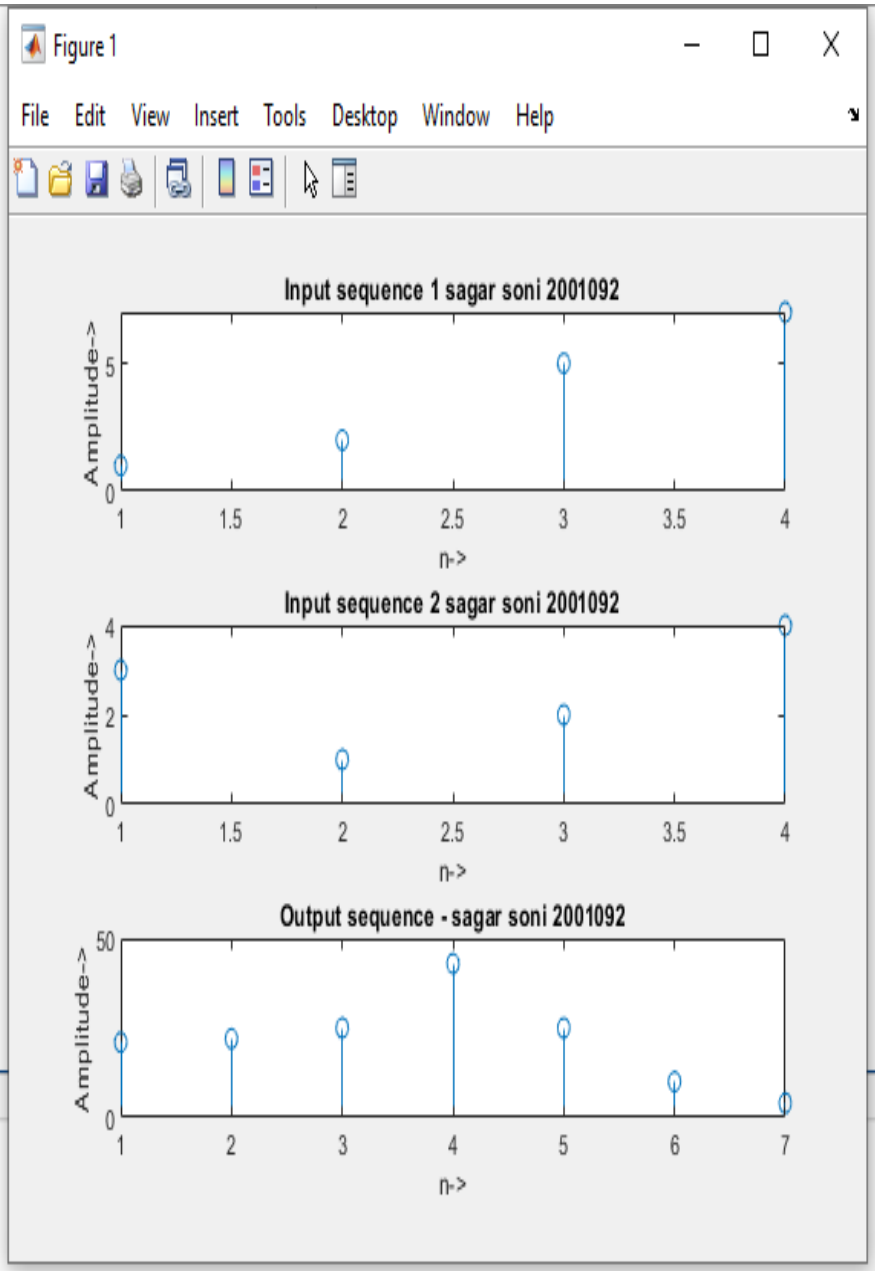
For cross-correlation-

```
x=input('Enter the sequence 1: ');
h=input('Enter the sequence 2: ');
y=xcorr(x,h);
figure;
subplot(3,1,1);
stem(x);
xlabel('n->');
ylabel('Amplitude->');
title('Input sequence 1 sagar soni 2001092');
subplot(3,1,2);
stem(fliplr(y));
stem(h);
xlabel('n->');
ylabel('Amplitude->');
title('Input sequence 2 sagar soni 2001092');
subplot(3,1,3);
stem(fliplr(y));
xlabel('n->');
ylabel('Amplitude->');
title('Output sequence - sagar soni 2001092');
disp('The resultant is');
fliplr(y);
```



Command Window

```
>> q6_c
Enter the sequence 1: [1 2 5 7]
Enter the sequence 2: [3 1 2 4]
The resultant is
>>
```

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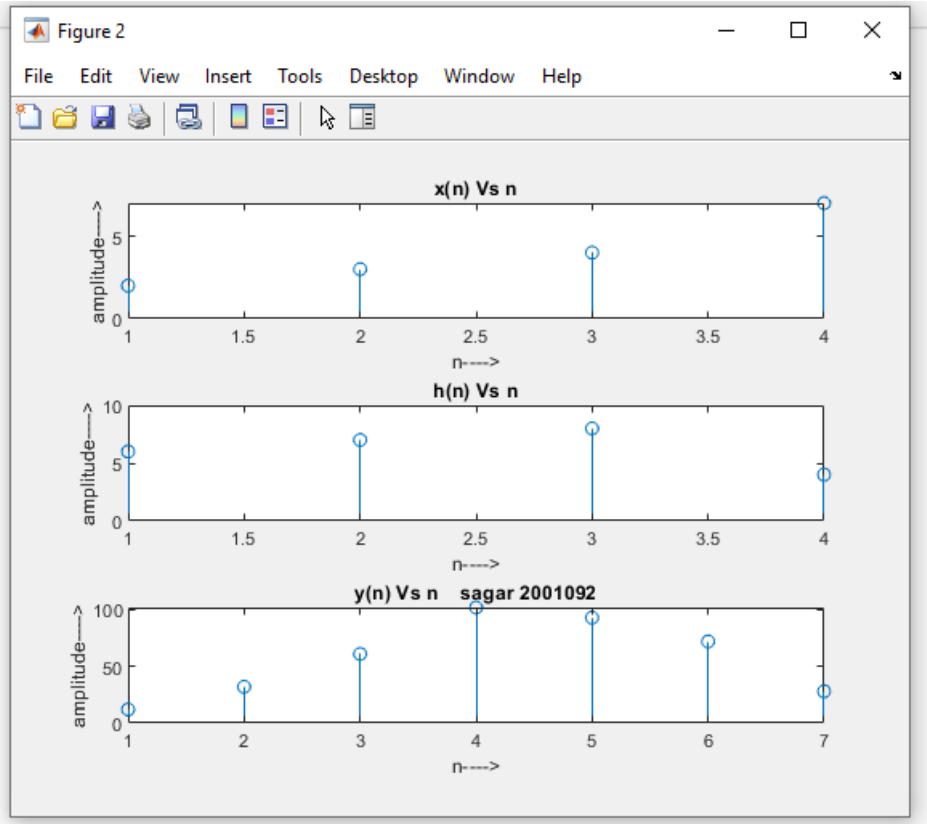
(b) Write Matlab codes to find either convolution or auto correlation or cross-correlation without using inbuilt codes.

```
clc;
close;
disp('enter the length of the first sequence m=');
m=input('');
disp('enter the first sequence x[m]=');
for i=1:m
x(i)=input('');
end
disp('enter the length of the second sequence n=');
n=input('');
disp('enter the second sequence h[n]=');
for j=1:n
h(j)=input('');
end
y=conv(x,h);
figure;
subplot(3,1,1);
stem(x);
ylabel ('amplitude---->');
xlabel('n---->');
title('x(n) Vs n');
subplot(3,1,2);
stem(h);
ylabel('amplitude---->');
xlabel('n---->');
title('h(n) Vs n');
subplot(3,1,3);
stem(y);
ylabel('amplitude---->');
xlabel('n---->');
title('y(n) Vs n    sagar 2001092');disp('linear convolution of x[m] and h[n] is y');
```

Command Window

```
enter the length of the first sequence m=
3
enter the first sequence x[m]=
2
3
4
enter the length of the second sequence n=
3
enter the second sequence h[n]=
6
7
8
linear convolution of x[m] and h[n] is y
>>
```



NAME : SAGAR SONI **BRANCH : ECE** **ROLL NUMBER : 2001092**

EXPERIMENT 7

Write a MATLAB code to design IIR Butterworth lowpass, highpass, bandpass and bandstop filter and verify its characteristics for given cutoff frequency:
lowpass- 1200 Hz , highpass-1200 Hz
bandpass- 1200 Hz to 1800Hz ,bandstop- 1200 Hz to 1800Hz

```
rp=input('enter passband ripple value');
rs=input('enter stopband ripple value');
fp=input('enter passband freq value');
fs=input('enter stopband freq value');
fsp=input('enter sampling freq value');
w1=2*fp/fsp;
w2=2*fs/fsp;
[n,wn]=buttord(w1,w2,rp,rs);
[b,a]=butter(n,wn,'low');
[h,w]=freqz(b,a,512,fsp);
mag=20*log(abs(h));
subplot(4,1,1);
plot(w,mag);
title('gain vs frequency of low pass filter  sagar 2001092');
%high pass
[b,a]=butter(n,wn,'high');
[h,w]=freqz(b,a,512,fsp);
mag=20*log(abs(h));
subplot(4,1,2);
plot(w,mag);
title('gain vs frequency of high-pass filter  sagar 2001092');
%band pass
[n]=buttord(w1,w2,rp,rs);
wn=[w1,w2];
[b,a]=butter(n,wn,'bandpass');
[h,w]=freqz(b,a,512,fsp);
mag=20*log(abs(h));
subplot(4,1,3);
plot(w,mag);
title('gain vs frequency of band-pass filter  sagar 2001092');
%band stop
[n]=buttord(w1,w2,rp,rs);
[b,a]=butter(n,wn,'stop');
[h,w]=freqz(b,a,512,fsp);
mag=20*log(abs(h));
subplot(4,1,4);
plot(w,mag);
title('gain vs frequency of band-stop filter  sagar 2001092');
```

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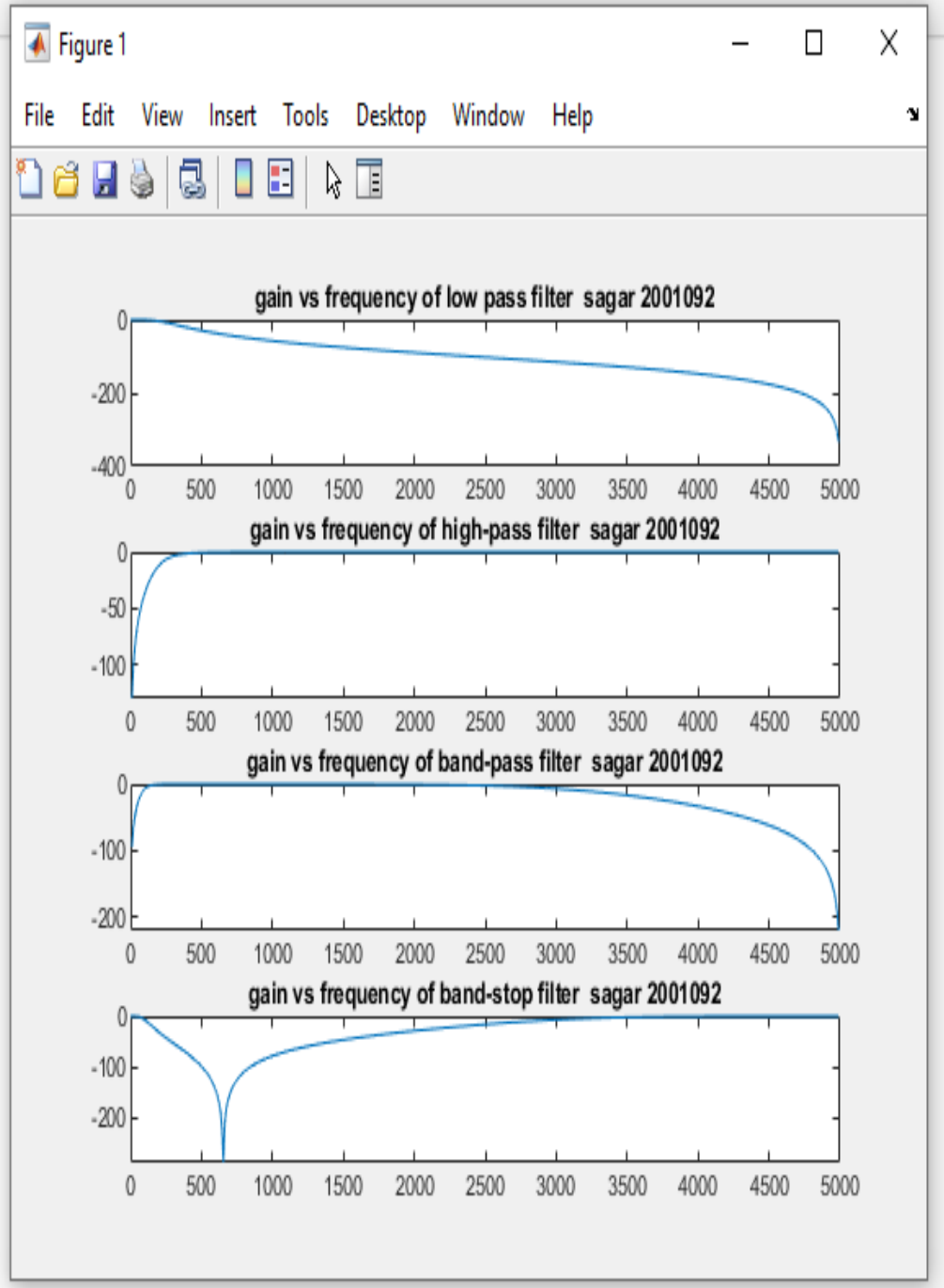
Command Window

```
>> q7
enter passband ripple value 3
enter stopband ripple value 50
enter passband freq value 100
enter stopband freq value 3000
enter sampling freq value 10000
>>
```



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EXPERIMENT 8

Write a MATLAB code to design FIR lowpass, high pass, bandpass and band stop filters and verify its characteristics for given cutoff frequency:

lowpass- 1500 Hz , highpass-1500 Hz

bandpass- 1000 Hz to 2800Hz , band stop- 1000 Hz to 2800Hz

```
fp=input('enter the passing freq:');
fstop=input('enter the stopping freq:');
fsp=input('enter the sampling freq value:');
n=input('enter the order of the filter:');
w1=2*fp/fsp;
w2=2*fstop/fsp;
%low pass filter
A=fir1(n,w1,'Low');
%freqz(A,1,512,fsp);
[h,w]=freqz(A,1,512,fsp);
mag=20*log10(abs(h));
subplot(4,1,1);
plot(w,mag);
title('Gain vs Frequency of Low-pass Filter - sagar 2001092');
%high pass filter
A=fir1(n,w2,'high');
%freqz(A,1,512,fsp);
[h,w]=freqz(A,1,512,fsp);
mag=20*log10(abs(h));
subplot(4,1,2);
plot(w,mag);
title('Gain vs Frequency of High-pass Filter - sagar 2001092');
%band pass filter
wn=[w1,w2];
A=fir1(n,wn,'bandpass');
%freqz(A,1,512,fsp);
[h,w]=freqz(A,1,512,fsp);
mag=20*log10(abs(h));
subplot(4,1,3);
plot(w,mag);
title('Gain vs Frequency of Band-pass Filter - sagar 2001092');
%band stop filter
A=fir1(n,wn,'stop');
%freqz(A,1,512,fsp);
[h,w]=freqz(A,1,512,fsp);
mag=20*log10(abs(h));
subplot(4,1,4);
plot(w,mag);
title('Gain vs Frequency of Band-stop Filter - sagar 2001092');
```

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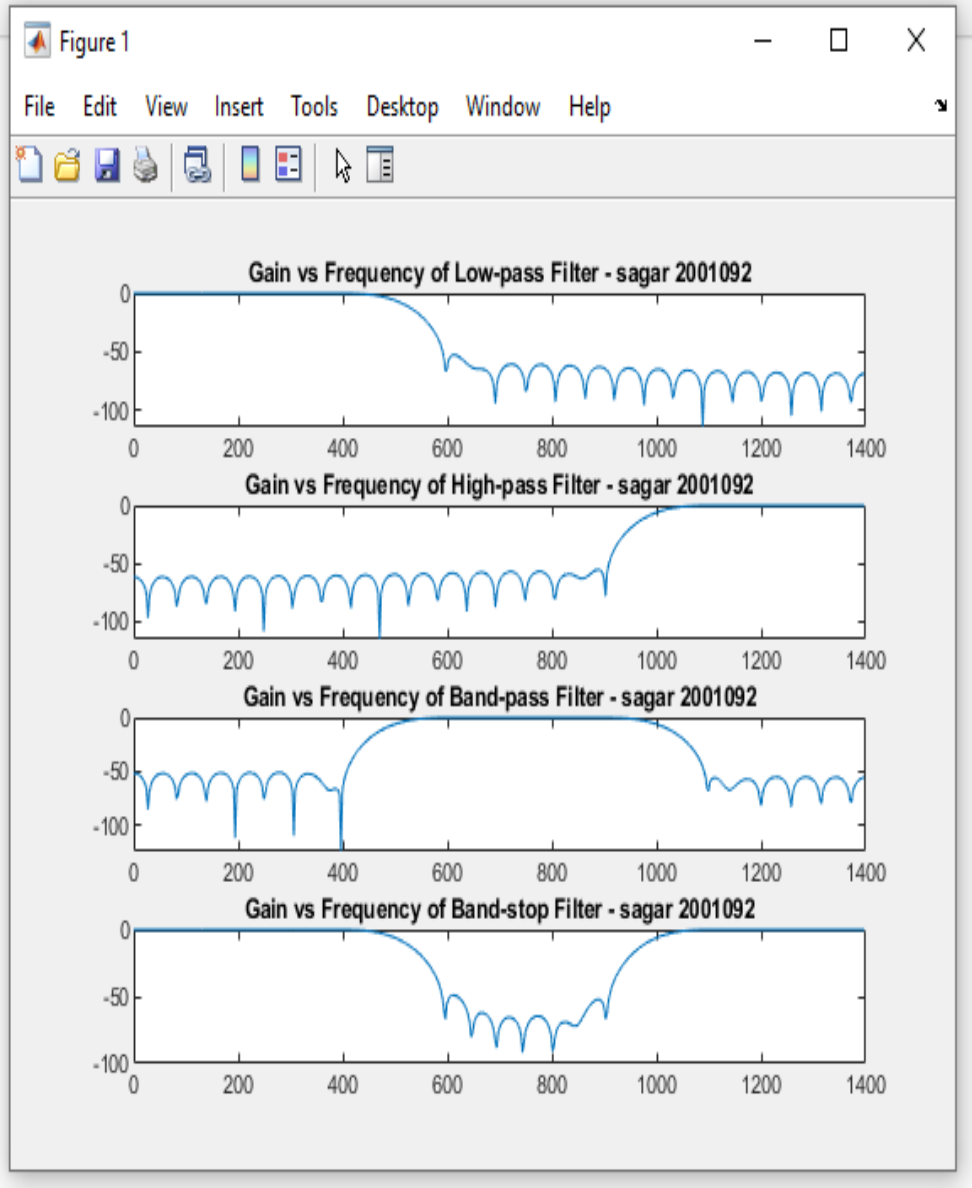
Command Window

```
>> q8
enter the passing freq: 500
enter the stopping freq: 1000
enter the sampling freq value: 2800
enter the order of the filter: 50
>>
```



NAME : SAGAR SONI **BRANCH : ECE** **ROLL NUMBER : 2001092**