INDIAN INSTITUTE OF INFORMATION TECHNOLOGY BHAGALPUR

DIGITAL SIGNAL PROCESSING LABORATORY REPORT (EC311)

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SUBJECT : EC311

INDIAN INSTITUE OF INFORMATION TECHNOLOGY

SHASHI CHAURASIA 2001028 CSE

EXPERIMENT 1

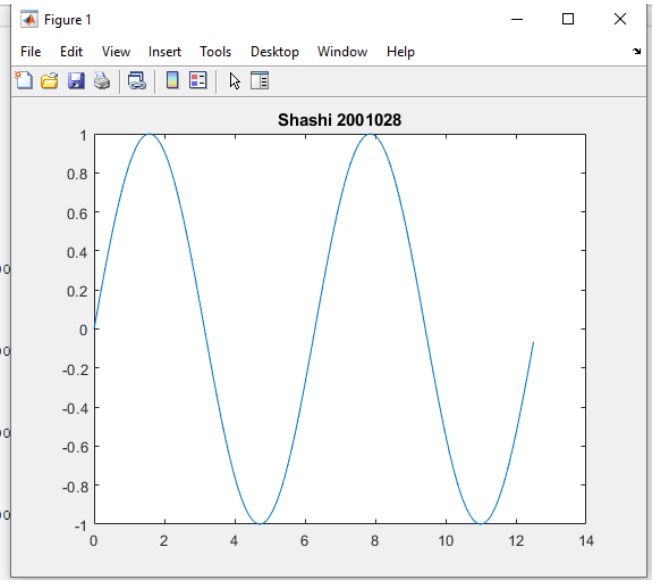
Aim: Write MATLAB Code to solve/plot:

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

```
Command Window
>> a=1;
b=2;
c=4;
x="Shashi 2001028";
f=(a+b+c);
f3=(a+b+c)^3;
f2=(a-b-c)^2;
f4=f*f2*f3;
display(x);
display(f4);

x =

    "Shashi 2001028"


f4 =

        60025

fx >>
```

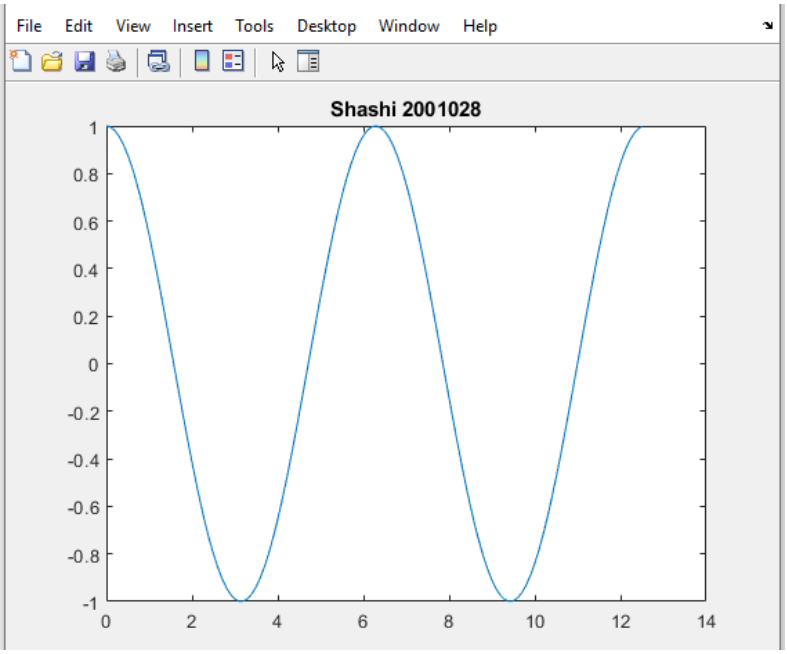
b) Sine Wave

```
Command Window
>> %sine wave
t = [0:0.1:4*pi]
a = sin(t);
plot(t,a)
a = sin(2*pi*60*t)
title('Shashi 2001028');

t =

  Columns 1 through 14

         0    0.1000    0.2000    0.3000    0.4000

  Columns 15 through 28

    1.4000    1.5000    1.6000    1.7000    1.8000

  Columns 29 through 42

    2.8000    2.9000    3.0000    3.1000    3.2000

  Columns 43 through 56

    4.2000    4.3000    4.4000    4.5000    4.6000

  Columns 57 through 70
```



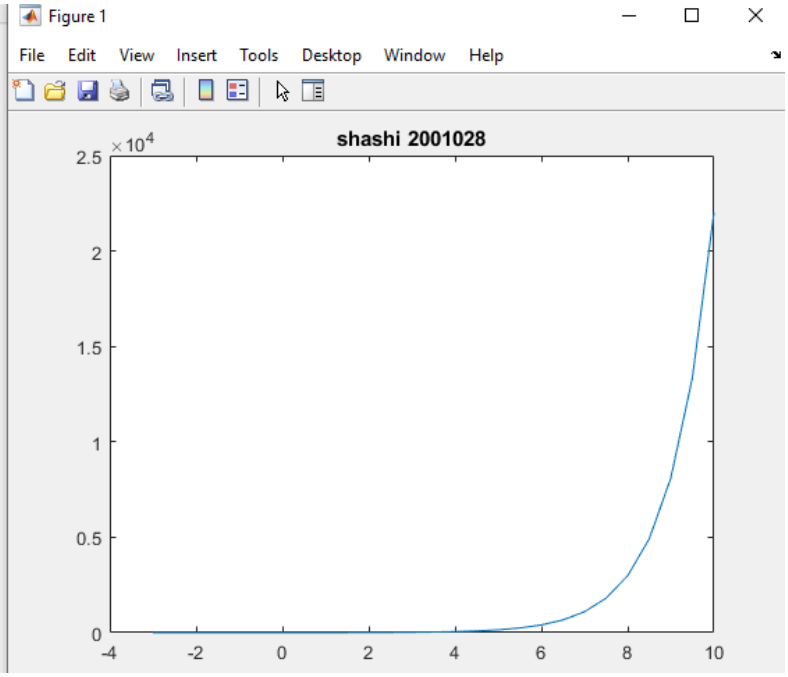
c.) Cosine Wave

```
>>
%cosine wave
t = [0:0.1:4*pi]
a = cos(t);
plot(t,a)
a = cos(2*pi*60*t)
title('Shashi 2001028');

t =

  Columns 1 through 14

         0    0.1000    0.2000    0.3000

  Columns 15 through 28

    1.4000    1.5000    1.6000    1.7000

  Columns 29 through 42

    2.8000    2.9000    3.0000    3.1000

  Columns 43 through 56

    4.2000    4.3000    4.4000    4.5000
```

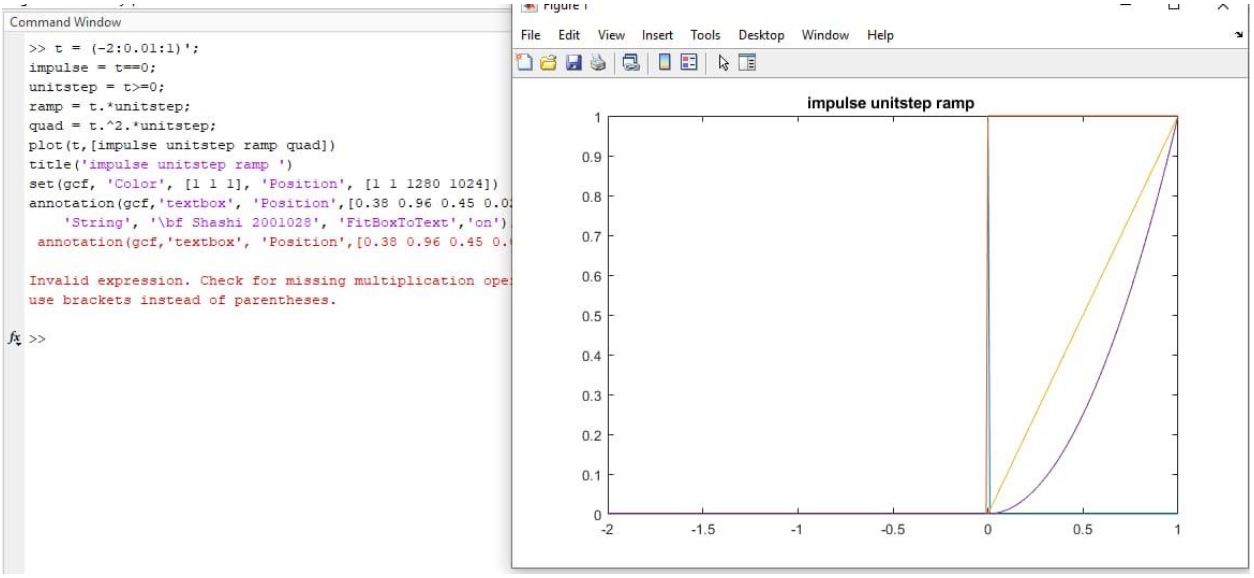


D.) e^x

```
Command Window
>> X = -3:0.5:10;
Y = exp(X);
plot(X,Y)
title('shashi 2001028')
>>
```



E.) Unit Step ,Unit impulse, Ramp function



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AIM: Write MATLAB Function to solve/plot

EXPERIMENT 2

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

e_power_x.m | equation.m | impulse_func.m | sine_wave.m

```
function [y]=equation(a,b,c)
    y=(a+b+c)^3;
    x="shashi 2001028";
    display(x);
end
```

Command Window

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

x =

    "shashi 2001028"


z =

   729

>>
```

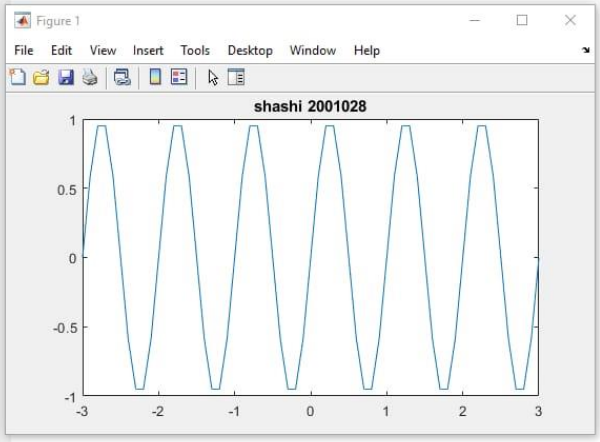
b) Sine wave

Command Window

```
  -0.6000   -0.5000   -0.4000   -0.3000   -0.2000   -0.1000

Columns 31 through 36

         0    0.1000    0.2000    0.3000    0.4000    0.5000

Columns 37 through 42

    0.6000    0.7000    0.8000    0.9000    1.0000    1.1000

Columns 43 through 48

    1.2000    1.3000    1.4000    1.5000    1.6000    1.7000

Columns 49 through 54

    1.8000    1.9000    2.0000    2.1000    2.2000    2.3000

Columns 55 through 60

    2.4000    2.5000    2.6000    2.7000    2.8000    2.9000

Column 61

    3.0000

>> z = sine_wave(t);
>>
```

untitled.mlx | dual_tone_multi_frequency.m | sine_wave.m | ramp_func.m

```
function [y]= sine_wave(t)
    y = sin(2*pi*t);
    plot(t,y);
    title("shashi 2001028");
end
```



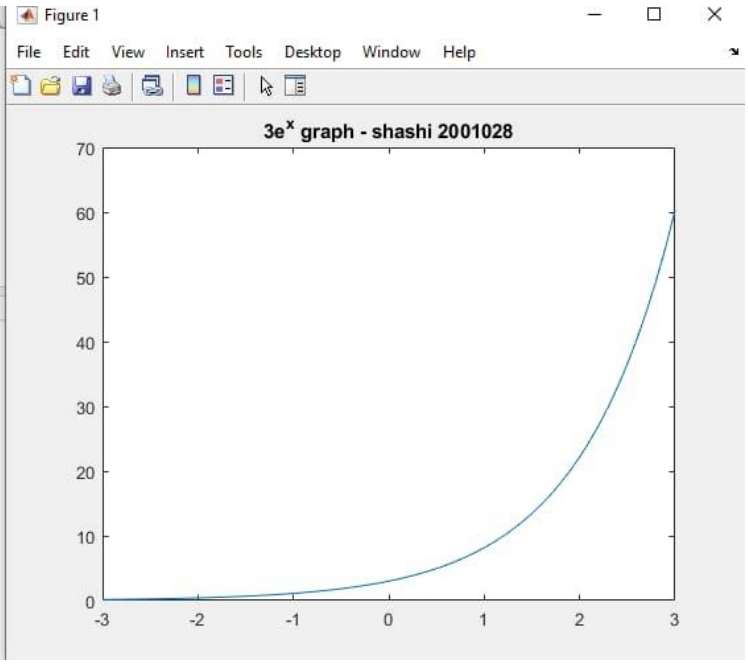
c) 3e^x

e_power_x.m | impulse_func.m | sine_wave.m

```
function [y]=e_power_x(t)
    y=3.*exp(t);
    plot(t,y);
    title("3e^x graph - shashi 2001028");
end
```

Command Window

```
>> x= -3:0.1:3;
>> e_power_x(x);
>>
```



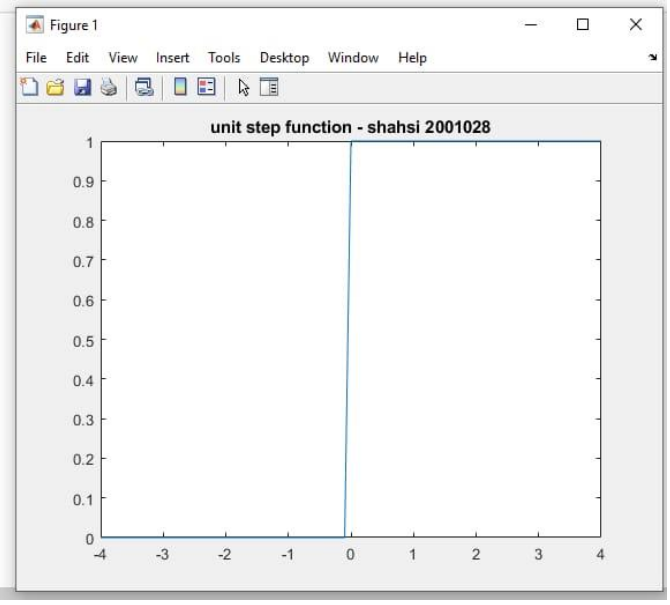
d) Unit step

untitled.mlx | dual_tone_multi_frequency.m | sine_wave.m | unitste

```
function [y]= unitstep_func(t)
    unitstep=t>=0;
    y=unitstep;
    plot(t,y);
     title("unit step function - shahsi 2001028");
end
```

Command Window

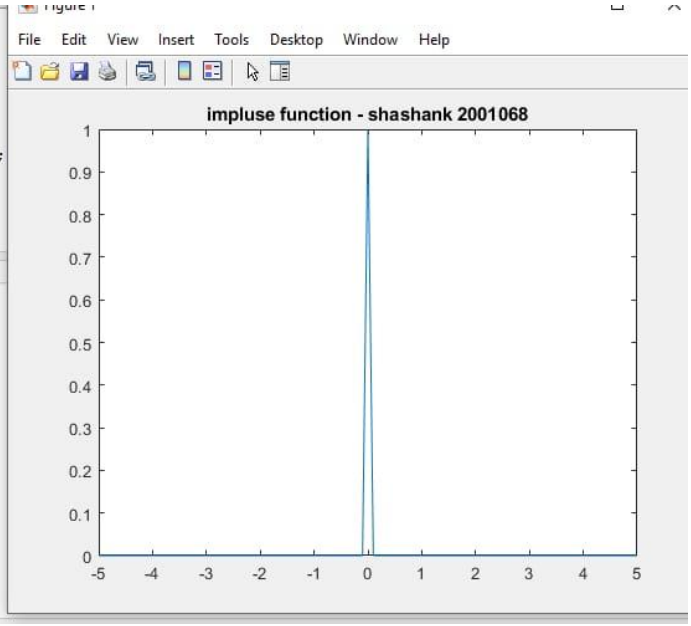
```
>> -5:1:20

ans =

  Columns 1 through 23

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

  Columns 24 through 26

    18    19    20

>> z = unitstep_func(t)

z =

  1×81 logical array

  Columns 1 through 34

   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0

  Columns 35 through 68

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

  Columns 69 through 81
```



e) Unit Impulse

```
function [y]=impulse_func(t)
    if t~=0
        then y=0;
    else if t==0
            then y=1;
    plot(t,y);
    title("unitstep function - shashi 2001028");
end
```

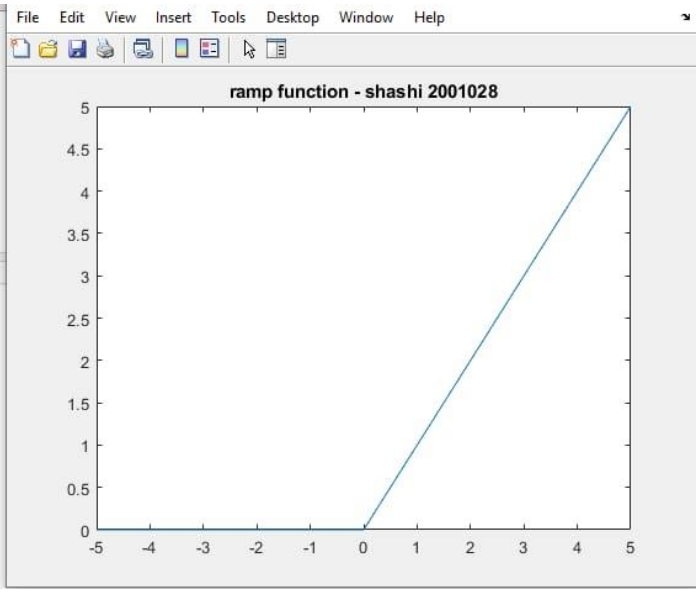
```
>> x = -5:0.1:5;
>> y = impulse_func(x);
>>
```



f) Ramp Function

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

    y=t>=0;
    y=y.*t;
    plot(t,y);
    title("ramp function - shashi 2001028");
end
```

```
>> x = -5:0.1:5;
>> y = ramp_func(x);
>>
```



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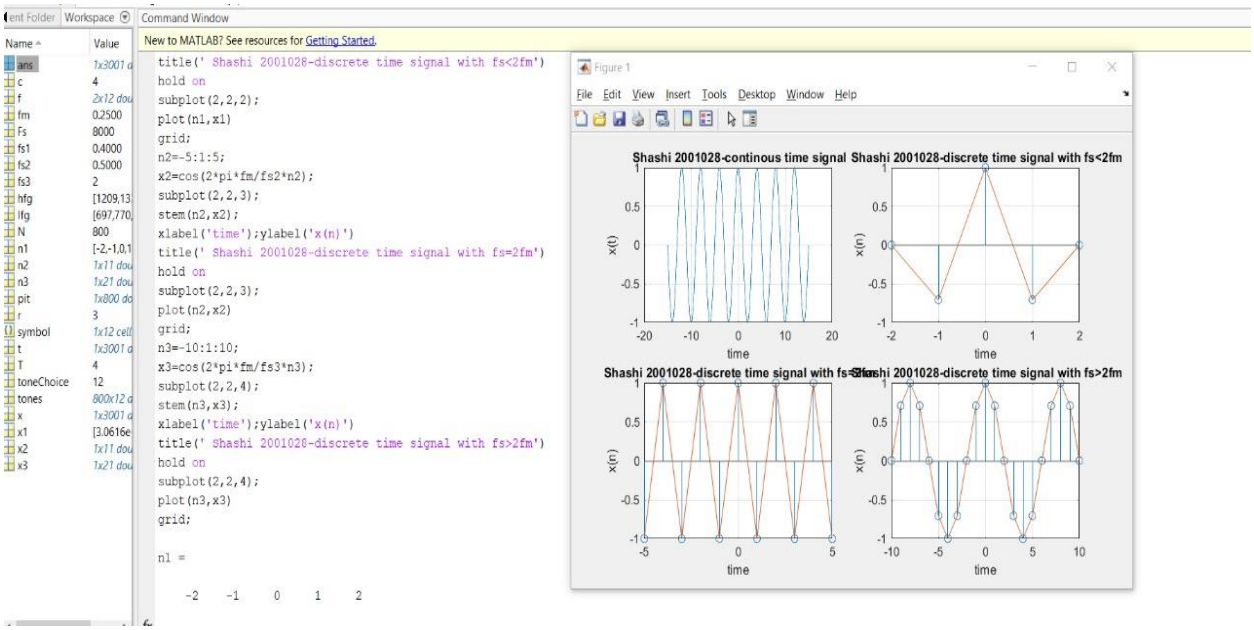
EXPERIMENT 3

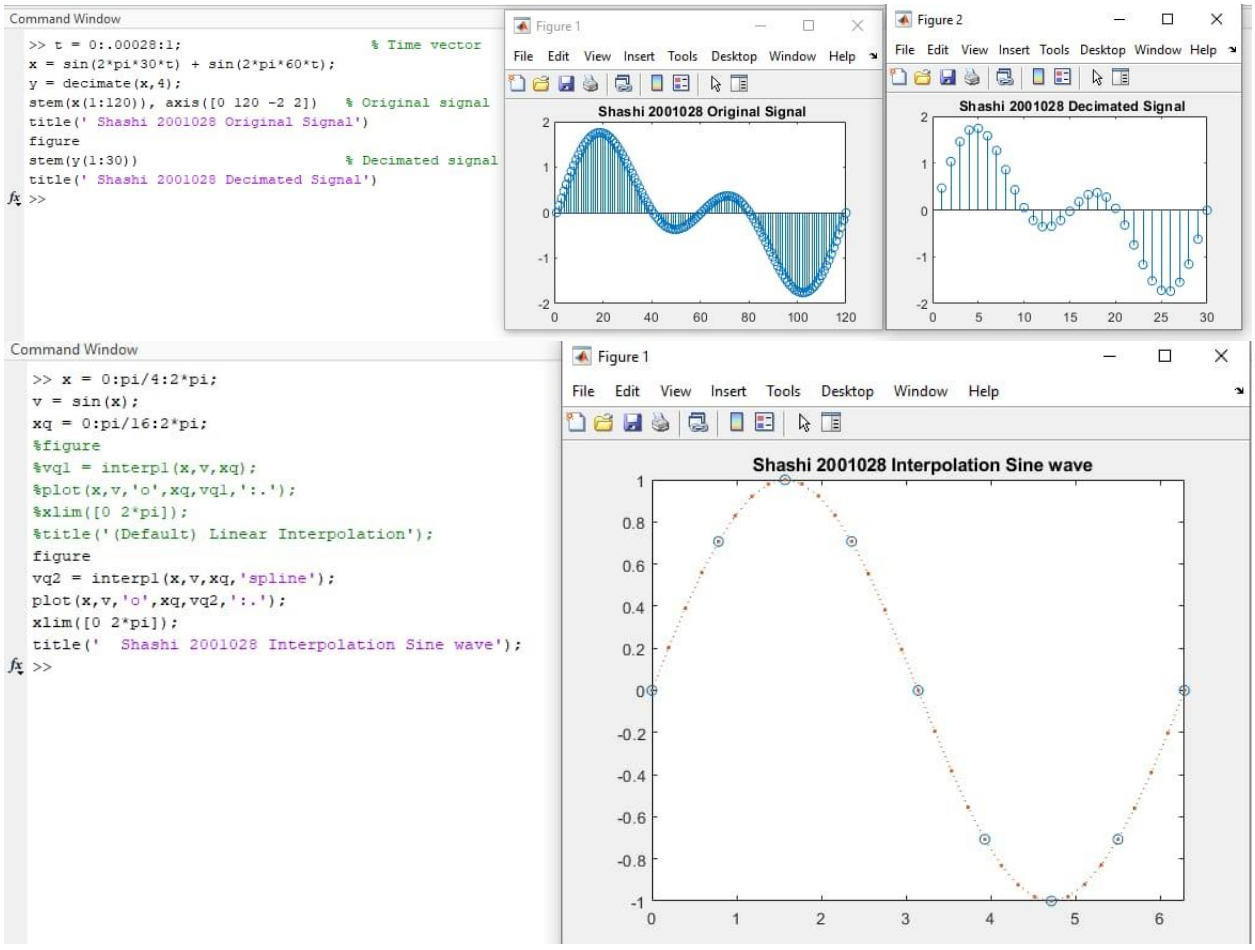
Aim: Verify Sampling theorem through MATLAB coding.

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.*



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.



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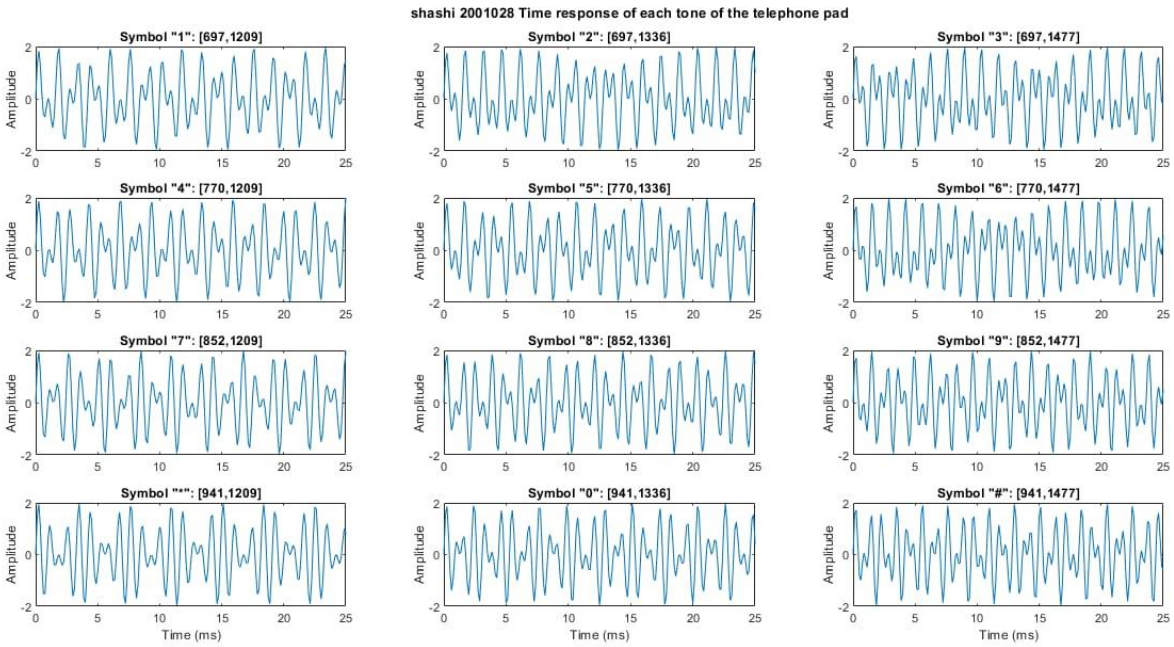
EXPERIMENT 5

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 shashi 2001028 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
```


shashi 2001028 Time response of each tone of the telephone pad
Symbol "1": [697,1209]
Symbol "2": [697,1336]
Symbol "3": [697,1477]
Symbol "4": [770,1209]
Symbol "5": [770,1336]
Symbol "6": [770,1477]
Symbol "7": [852,1209]
Symbol "8": [852,1336]
Symbol "9": [852,1477]
Symbol "*": [941,1209]
Symbol "0": [941,1336]
Symbol "#": [941,1477]
Amplitude
Time (ms)

Question 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]

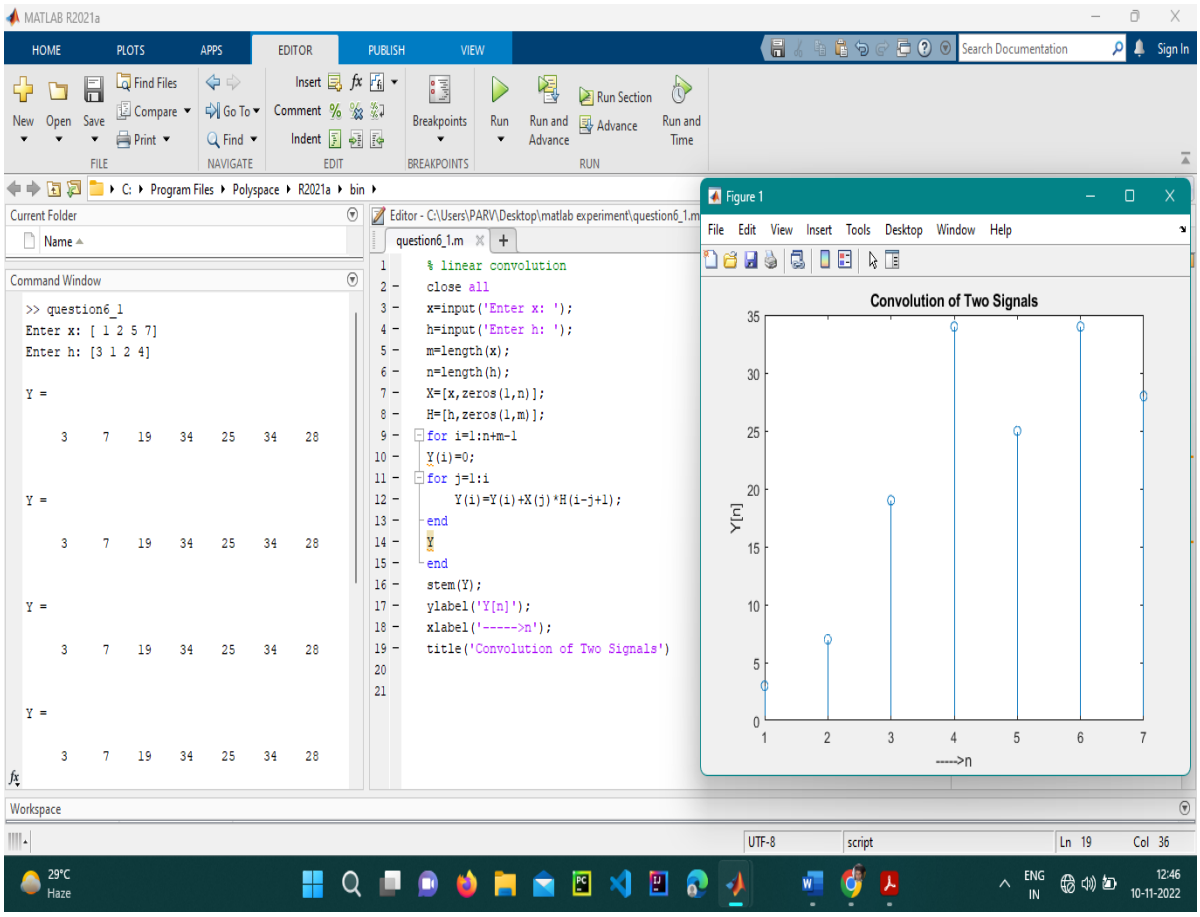
Answer-

For Convolution-

MATLAB code-

```
% 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')
```

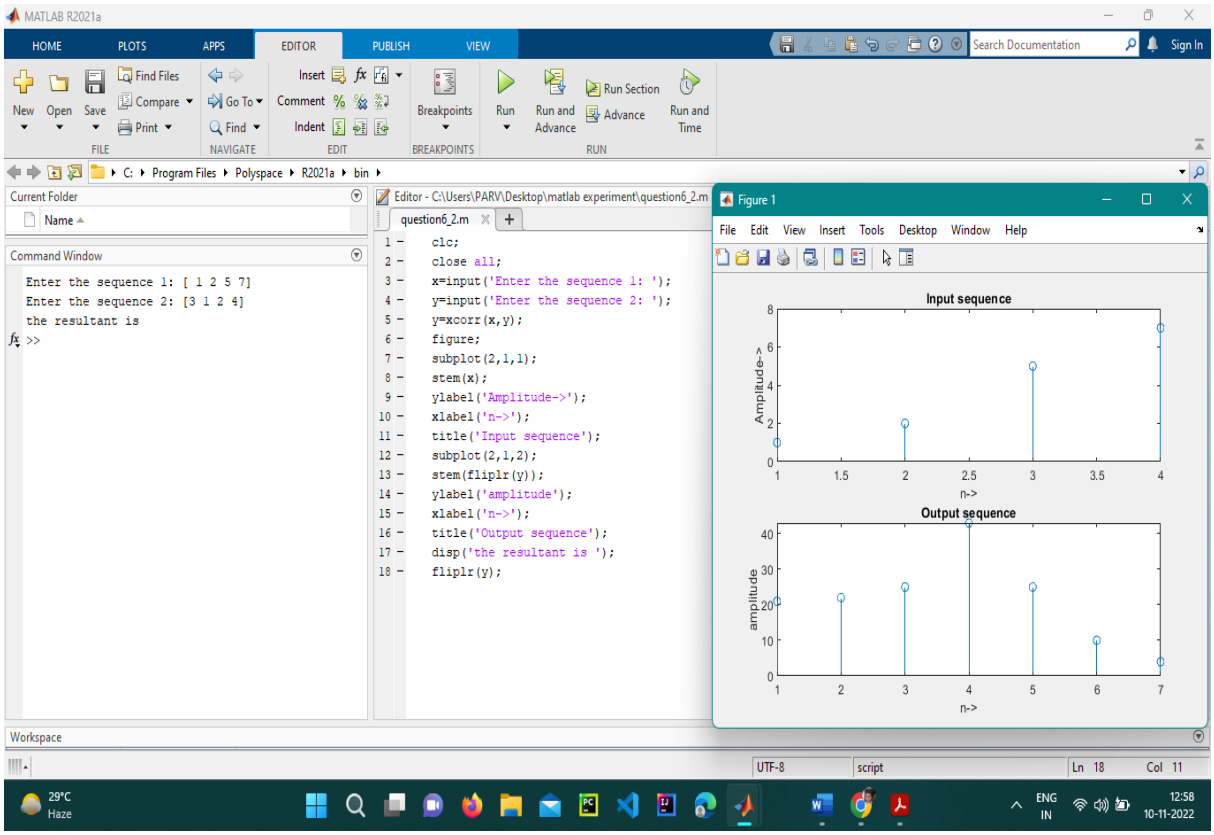


For Auto Correlation-

MATLAB code-

```
clc;
close all;
x=input('Enter the sequence 1: ');
y=input('Enter the sequence 2: ');
y=xcorr(x,y);
figure;
```

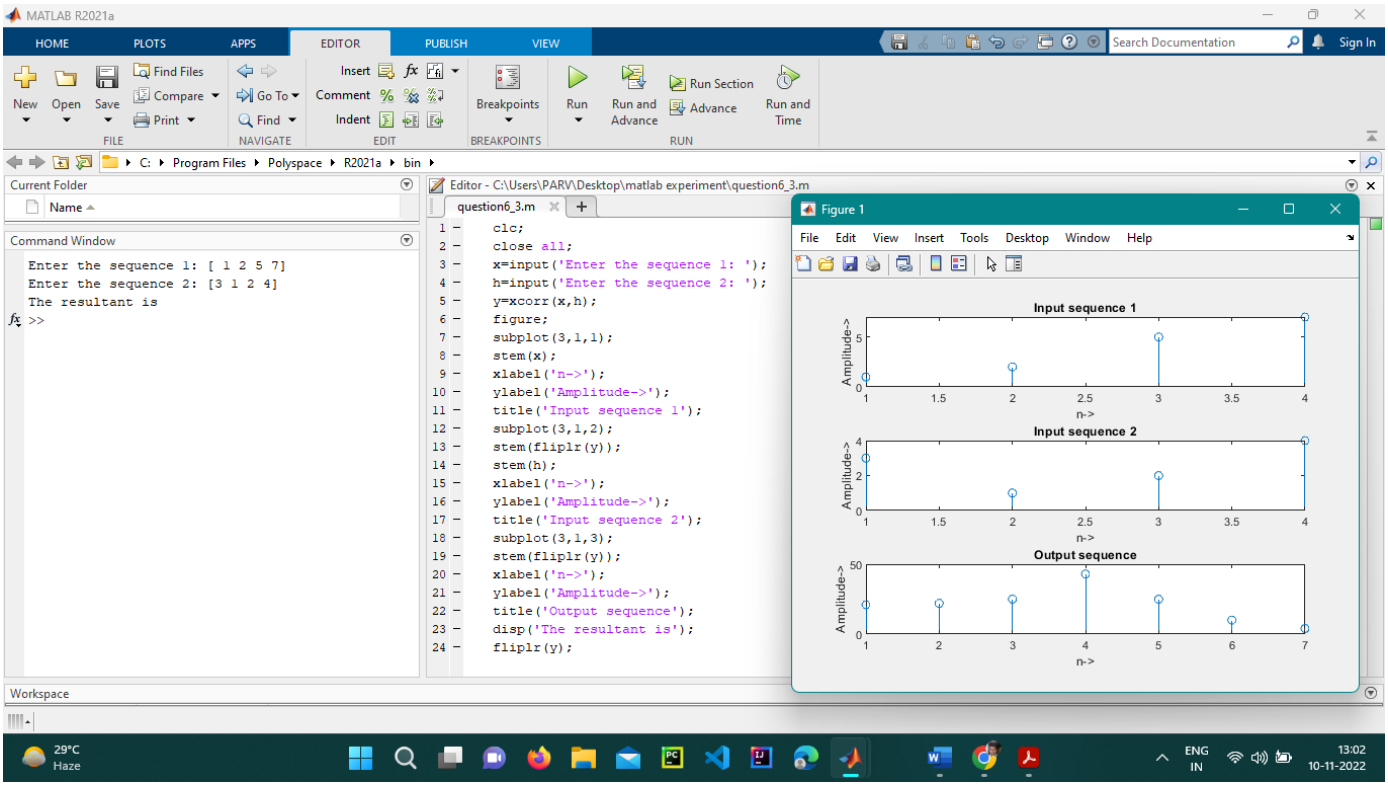
```
subplot(2,1,1);
stem(x);
ylabel('Amplitude->');
xlabel('n->');
title('Input sequence');
subplot(2,1,2);
stem(fliplr(y));
ylabel('amplitude');
xlabel('n->');
title('Output sequence');
disp('the resultant is ');
fliplr(y);
```

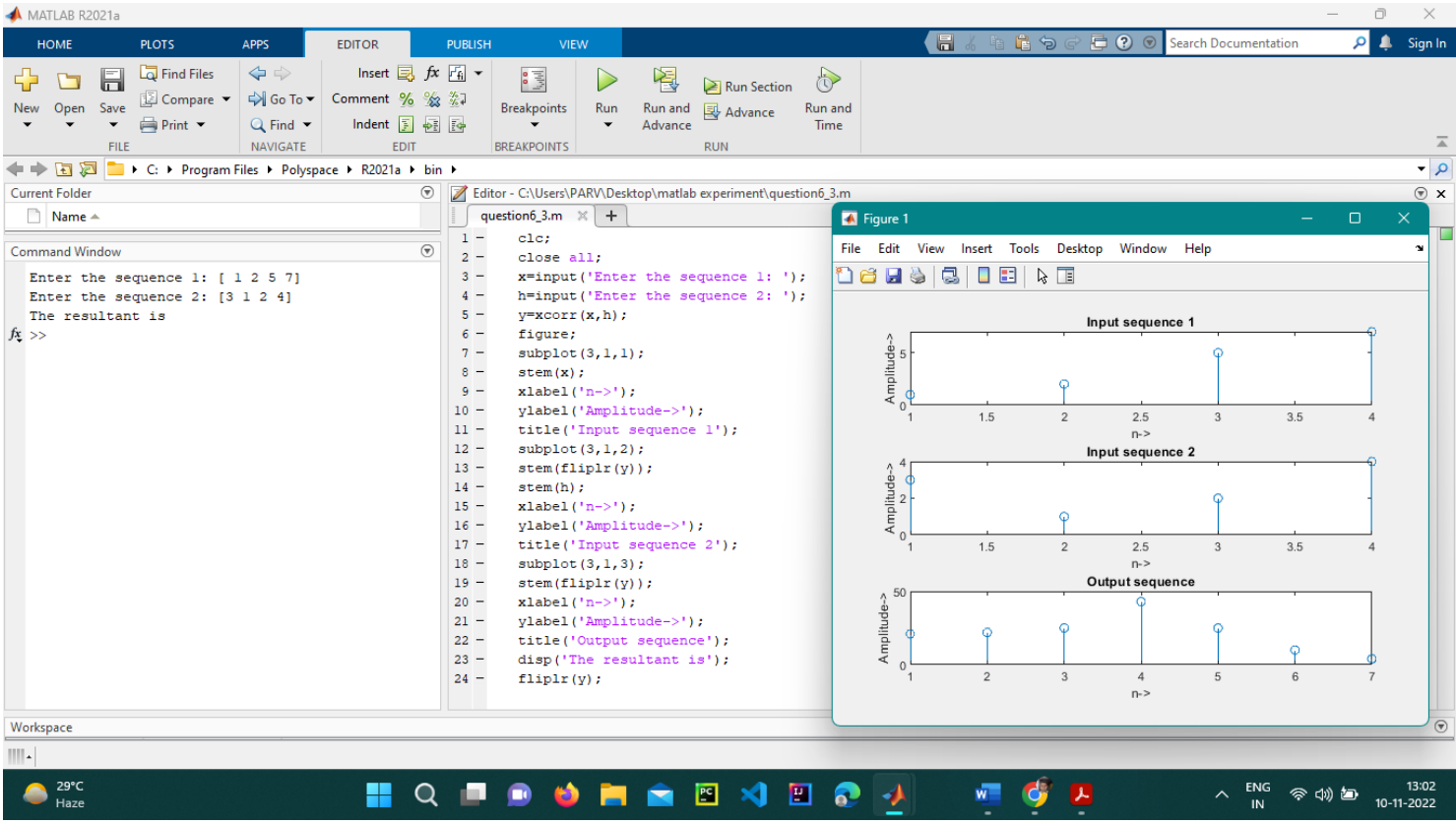


For cross-correlation-

MATLAB code-

```
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');
subplot(3,1,2);
stem(fliplr(y));
stem(h);
xlabel('n->');
ylabel('Amplitude->');
title('Input sequence 2');
subplot(3,1,3);
stem(fliplr(y));
xlabel('n->');
ylabel('Amplitude->');
title('Output sequence');
disp('The resultant is');
fliplr(y);
```


MATLAB R2021a
HOME
PLOTS
APPS
EDITOR
PUBLISH
VIEW
Search Documentation
Sign In
New
Open
Save
Find Files
Compare
Print
FILE
Go To
Find
NAVIGATE
Insert
Comment
Indent
EDIT
Breakpoints
BREAKPOINTS
Run
Run and Advance
Run Section
Advance
Run and Time
RUN
C: ▸ Program Files ▸ Polyspace ▸ R2021a ▸ bin ▸
Current Folder
Name
Command Window
Enter the sequence 1: [1 2 5 7]
Enter the sequence 2: [3 1 2 4]
The resultant is
>>
Editor - C:\Users\PARV\Desktop\matlab experiment\question6_3.m
question6_3.m
1 clc;
2 close all;
3 x=input('Enter the sequence 1: ');
4 h=input('Enter the sequence 2: ');
5 y=xcorr(x,h);
6 figure;
7 subplot(3,1,1);
8 stem(x);
9 xlabel('n->');
10 ylabel('Amplitude->');
11 title('Input sequence 1');
12 subplot(3,1,2);
13 stem(fliplr(y));
14 stem(h);
15 xlabel('n->');
16 ylabel('Amplitude->');
17 title('Input sequence 2');
18 subplot(3,1,3);
19 stem(fliplr(y));
20 xlabel('n->');
21 ylabel('Amplitude->');
22 title('Output sequence');
23 disp('The resultant is');
24 fliplr(y);
Figure 1
File Edit View Insert Tools Desktop Window Help
Input sequence 1
Amplitude->
n->
Input sequence 2
Amplitude->
n->
Output sequence
Amplitude->
n->
Workspace
29°C
Haze
ENG
IN
13:02
10-11-2022



Question6.

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

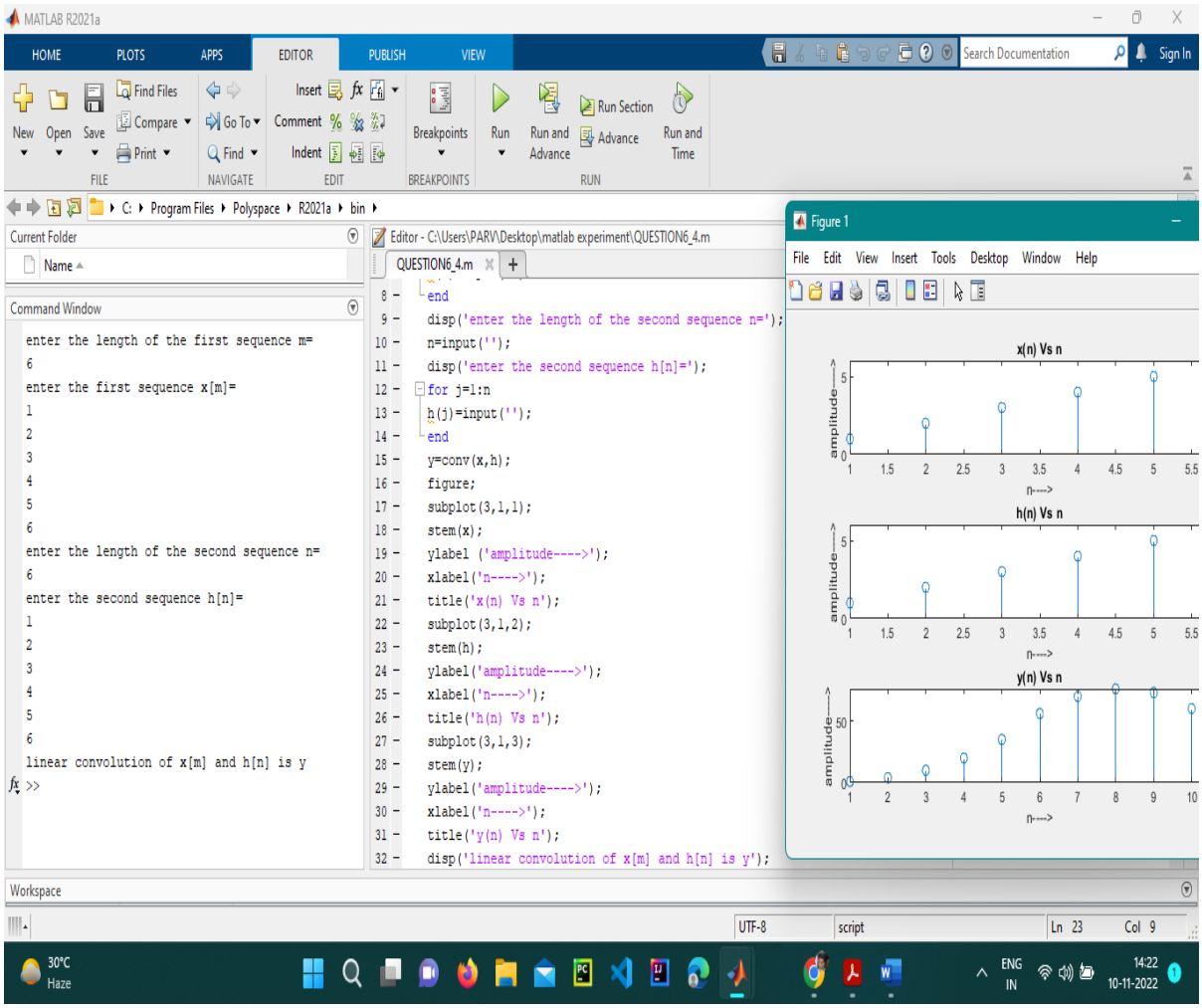
Answer-

MATLAB code-

```
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');disp('linear convolution of x[m] and h[n] is y');
```



Question 7

Write a MATLAB code to design IIR Butterworth low pass, high pass, band pass and band stop filter and verify its characteristics for given cut-off frequency:

low pass- 1200 Hz

Highpass-1200 Hz

Band pass- 1200 Hz to 1800Hz

Band stop- 1200 Hz to 1800Hz

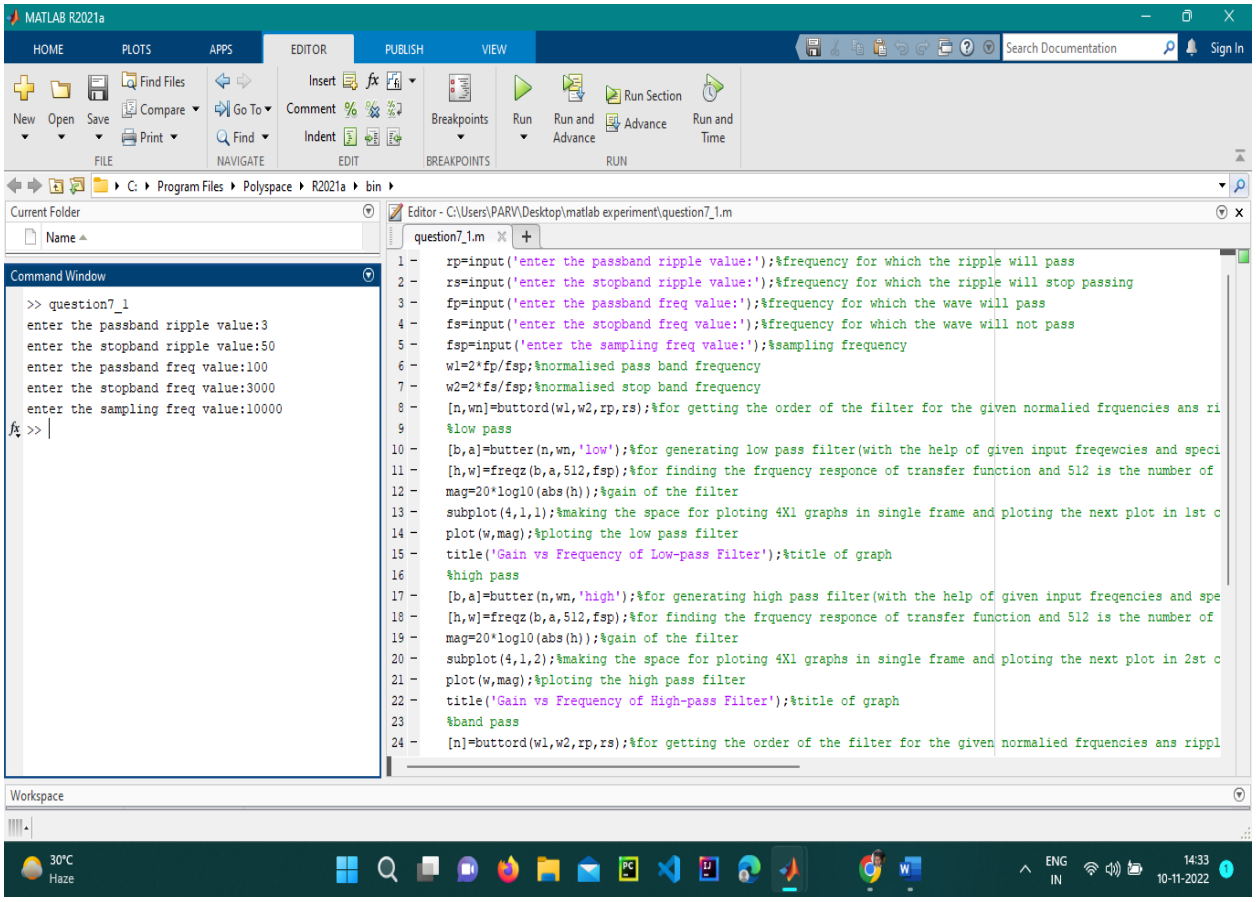
Answer-

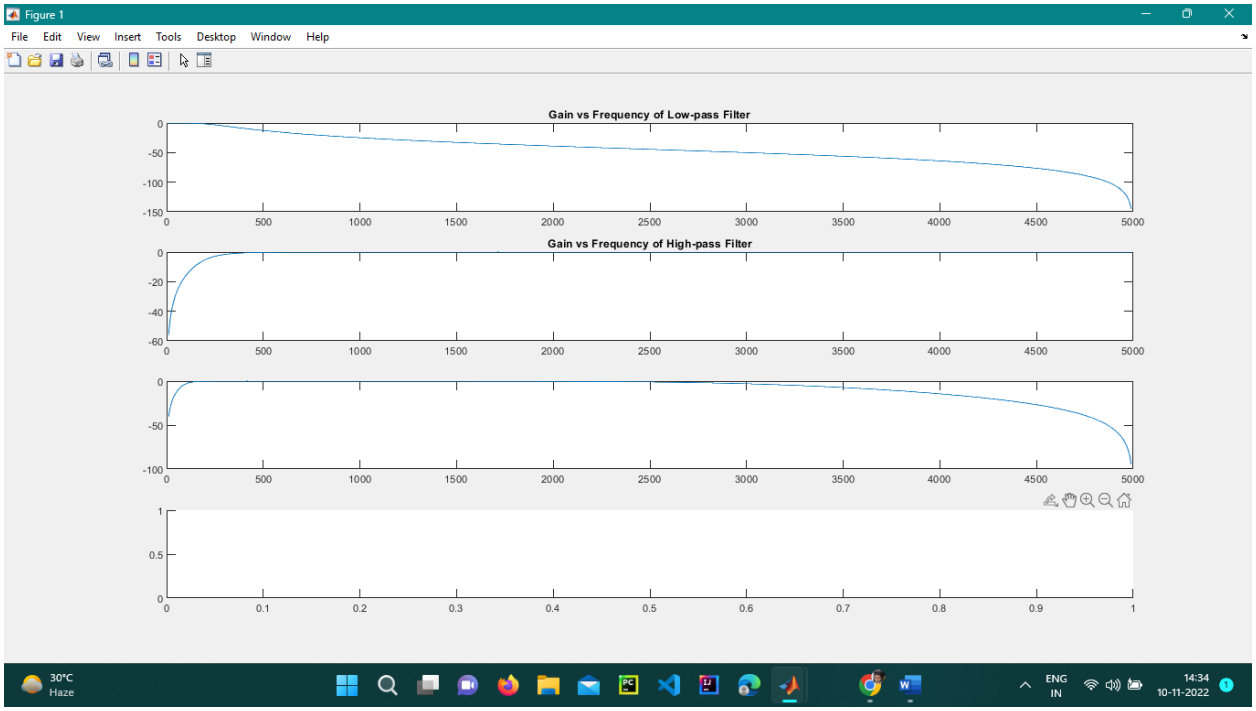
MATLAB code-

```
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');
%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');
%band pass
[n]=buttord(w1,w2,rp,rs);
wn=[w1,w2];
[b,a]=butter(n,wn,'band pass');
[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');
%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');
```





Question 8

Write a MATLAB code to design FIR low pass, high pass, band pass and band stop filters and verify its characteristics for given cut-off frequency:

Low pass- 1500 Hz

High pass-1500 Hz

Band pass- 1000 Hz to 2800Hz

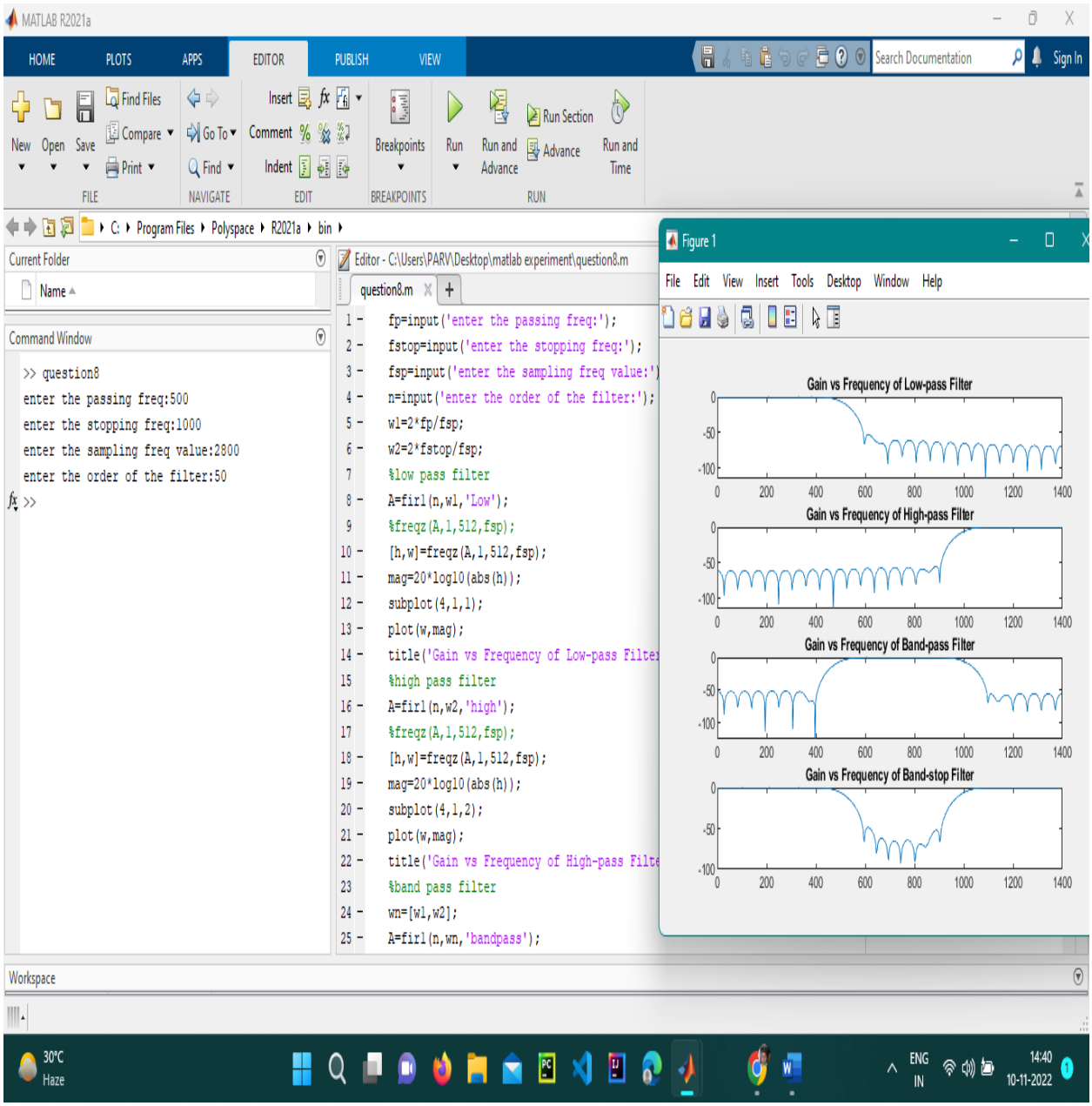
Band stop- 1000 Hz to 2800Hz

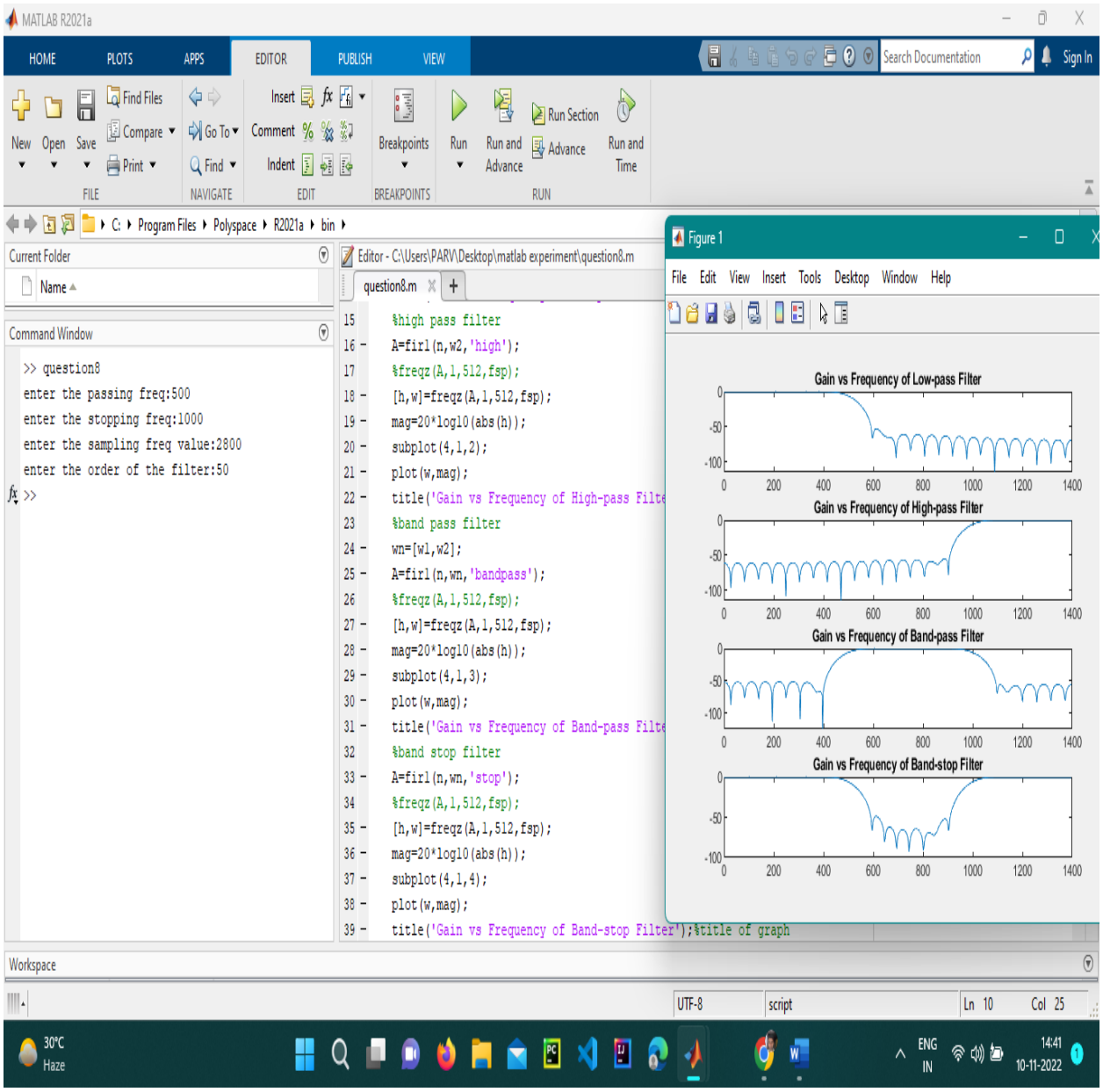
ANSWER-

MATLAB code-

```
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');
%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');
%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');
%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');%title of graph




MATLAB R2021a
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Save
Find Files
Compare
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Comment
Indent
EDIT
Breakpoints
BREAKPOINTS
Run
Run and Advance
Run Section
Advance
Run and Time
RUN
C: ▸ Program Files ▸ Polyspace ▸ R2021a ▸ bin ▸
Current Folder
Name
Command Window
>> question8
enter the passing freq:500
enter the stopping freq:1000
enter the sampling freq value:2800
enter the order of the filter:50
>>
Editor - C:\Users\PARV\Desktop\matlab experiment\question8.m
question8.m
15 %high pass filter
16 - A=fir1(n,w2,'high');
17 %freqz(A,1,512,fsp);
18 - [h,w]=freqz(A,1,512,fsp);
19 - mag=20*log10(abs(h));
20 - subplot(4,1,2);
21 - plot(w,mag);
22 - title('Gain vs Frequency of High-pass Filte
23 %band pass filter
24 - wn=[w1,w2];
25 - A=fir1(n,wn,'bandpass');
26 %freqz(A,1,512,fsp);
27 - [h,w]=freqz(A,1,512,fsp);
28 - mag=20*log10(abs(h));
29 - subplot(4,1,3);
30 - plot(w,mag);
31 - title('Gain vs Frequency of Band-pass Filte
32 %band stop filter
33 - A=fir1(n,wn,'stop');
34 %freqz(A,1,512,fsp);
35 - [h,w]=freqz(A,1,512,fsp);
36 - mag=20*log10(abs(h));
37 - subplot(4,1,4);
38 - plot(w,mag);
39 - title('Gain vs Frequency of Band-stop Filter');%title of graph
Figure 1
File Edit View Insert Tools Desktop Window Help
Gain vs Frequency of Low-pass Filter
Gain vs Frequency of High-pass Filter
Gain vs Frequency of Band-pass Filter
Gain vs Frequency of Band-stop Filter
0 -50 -100
0 200 400 600 800 1000 1200 1400
Workspace
UTF-8
script
Ln 10
Col 25
30°C
Haze
ENG
IN
14:41
10-11-2022