SIGNALS AND SYSTEMS – LAB ASSIGNMENT

Q1:

Code:

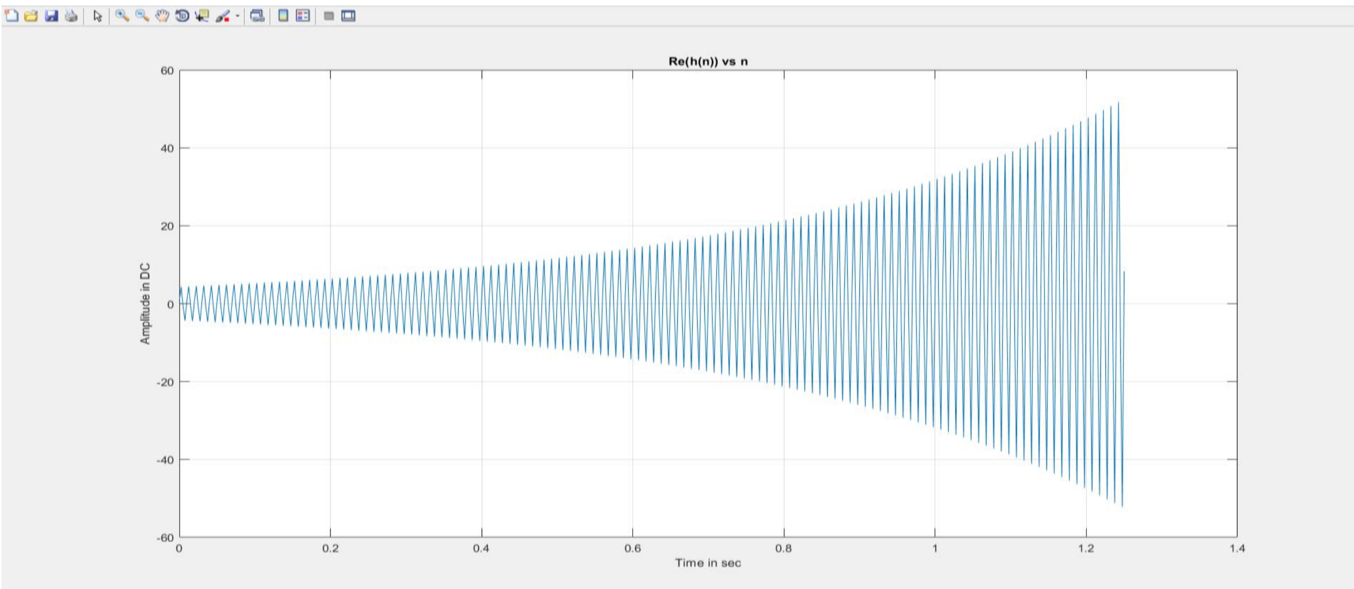
```
clc
% f(t)= |c| * exp(at) * exp(jwt + theeta)
% fs = 400Hz,  |c| = 2, a = 2, w =2pi100, theeta = pi/4.

fs = 400;     %Sampling frequence
Ts = 1/fs;    %Sampling Period
n = 0:500;    %No. of Points
mod_c = 2;
a = 2;
w = 2*pi*100;
theeta = pi*(1/4);
f_n = mod_c*exp(a*(n-0.9)*Ts).*exp(1i*w*(n-0.9)*Ts +
theeta); % Function in terms of discrete time
Re_f = (f_n + conj(f_n))/2;  % Real part of the function
Im_f = (f_n - conj(f_n))/(2*1i);     % Imaginary part of the
function
Mag_f = abs(f_n);                    % Magnitude of Function
Phase_f = angle(f_n);                % Phase of function
%Plotting the real part of function
plot(n*Ts,Re_f)
grid on
xlabel('Time in sec');
ylabel('Amplitude in DC');
title('Re(h(n)) vs n');
figure
% Plotting the imaginary part of function
plot(n*Ts,Im_f)
grid on
xlabel('Time in sec');
ylabel('Amplitude in DC');
title('Im(h(n)) vs n');
figure
% Plotting the Magnitude of function
plot(n*Ts,Mag_f)
grid on
xlabel(';Time in sec');
ylabel(';Magnitude in DC');
title('Mag(h(n)) part vs n');
```

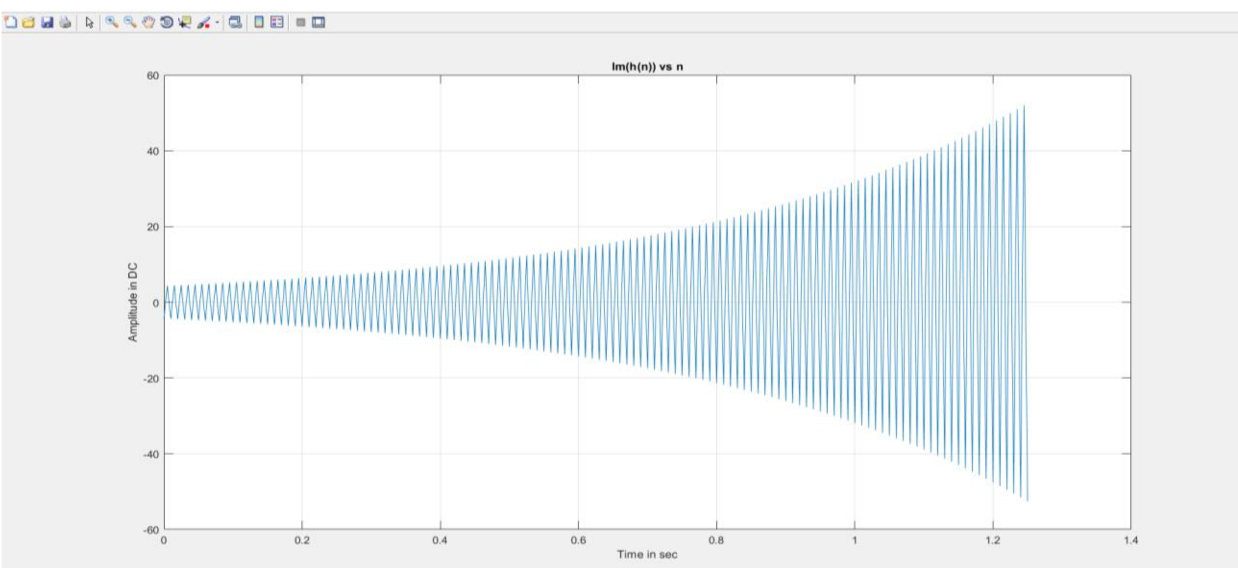
```
figure
% Plotting the Phase of function
plot(n*Ts,Phase_f)
grid on
xlabel('Time in sec');
ylabel('Phase in DC');
title('Phase(h(n)) vs n');
```

Output:

Re(h(n)):



Im(h(n)):



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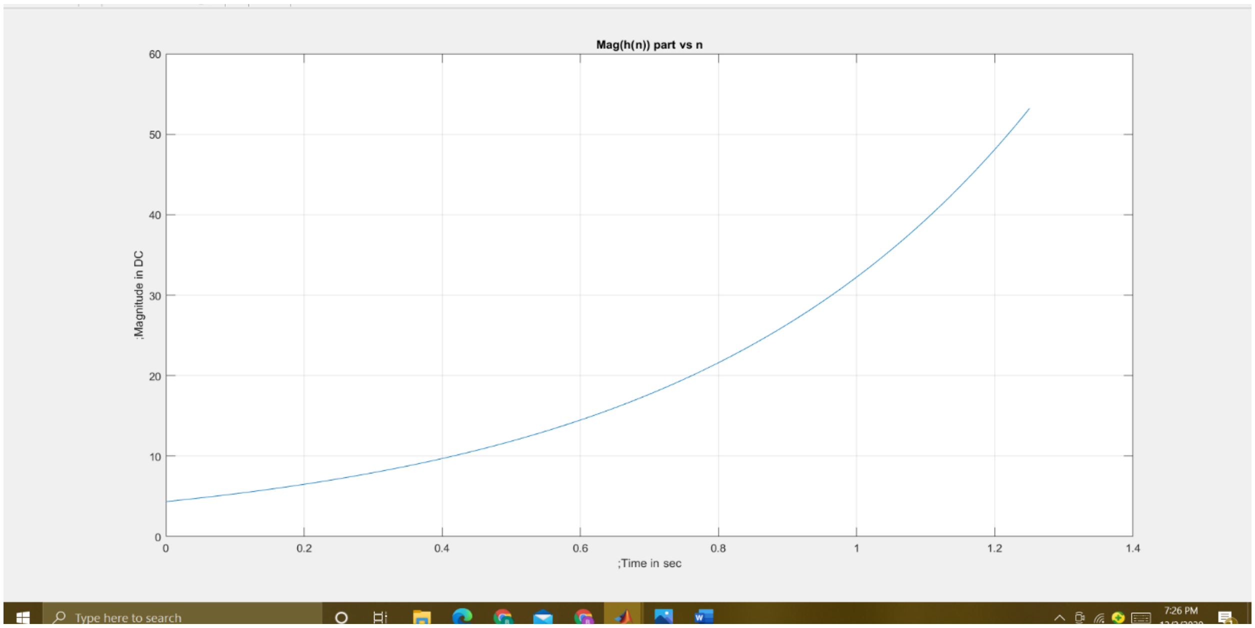
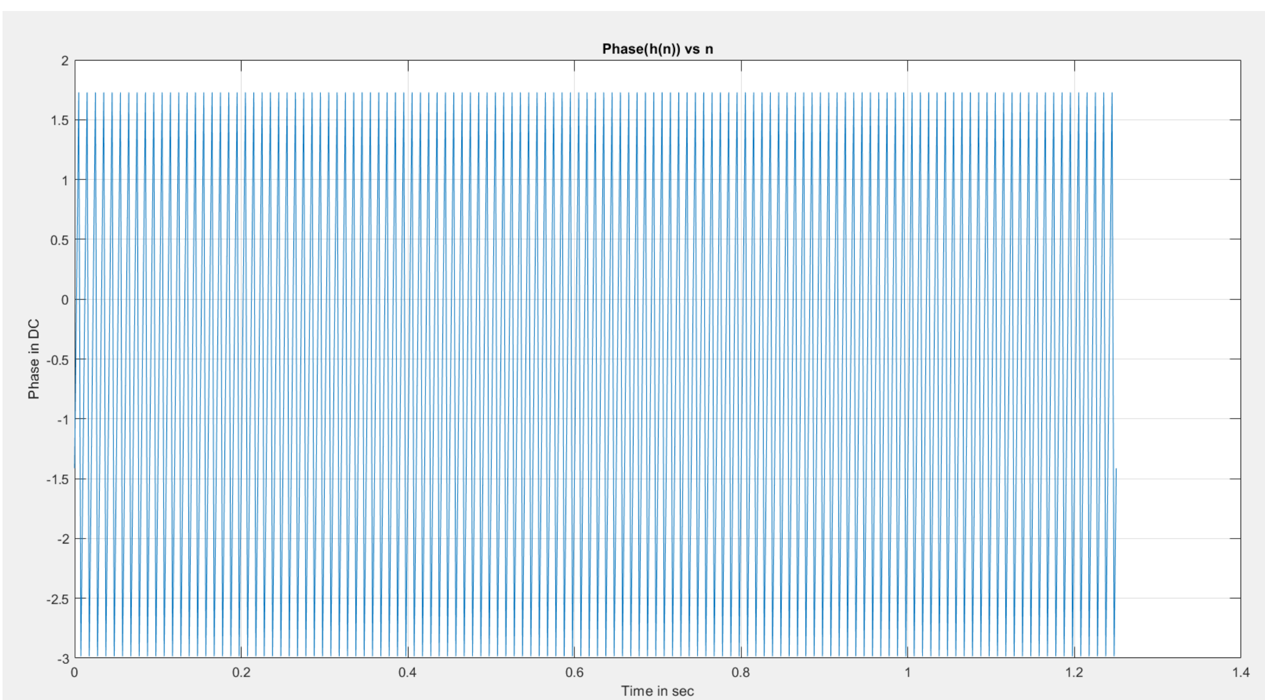
Mag(h(n)):



Phase(h(n)):



Explaination and Observation:

We were given a function h(t) = |c| ∗ exp(at) ∗ exp(jωt + θ) and plot the respective real, imaginary , magnitude and phase parts of the sampled signal:

Since continuous time signals cant be directly plotted/handled in matlab we first sample it and then plot it as the envelove of all the discrete sequence points

Real Part: **Shape: it is an exponentially increasing sinusoid curve**

Explaination: It is plot corresponding to

Re(h[n]) = |c|(e^(a*n*Ts+pi/4))*cos(200*pi*n*Ts) where it is clearly seen that there is multiplication of a cosine function and an exponential function . Hence is the shape where the amplitude of the curve varies according to the cos term

Imaginary Part: **Shape: it is an exponentially increasing sinusoid curve**

Explaination: It is plot corresponding to

Re(h[n]) = |c|(e^(a*n*Ts+pi/4))*sin(200*pi*n*Ts) where it is clearly seen that there is multiplication of a sine function and an exponential function . Hence is the shape where the amplitude of the curve varies according to the sine term

Magnitude : **Shape: It is a purely increasing exponential curve .**

Explaination: It is a plot corresponding the

Mag(h[n]) = |c|(e^(a*n*Ts+pi/4)) . It is clearly visible that it is an exponential function and hence the shape of the curve which meets the x axis at n = 0 i.e |c|e^(pi/4)

Phase : **Shape: Though it is expected to be sinusoidal we observe that it**

is triangular in nature but periodic .This does not mean that there is an error

This is due to the fact that plot() function simply joins the points the integers at which values are existant instead of giving the actual curve which also involves the values of h(t) at non integers .

Q2:

Code a:

```
function [y_n] = conv_parui_019(x_n,h_n)
    convo_length = numel(x_n)+numel(h_n)-1; % length of
theconvolved output
    tem_hn = flip(h_n);  %Temporary flipped h[n]
    tem_hn1 = zeros(convo_length,numel(x_n)); %Zero matrix
for filling Shifted Versions of h[n] at every stage of its
movement over x[n]
    k=1;
%Looping over the required length of convolved output
%This is done to generate shifted versions of h[n] for each
convolved output value
    for i=1:convo_length
        if i<= numel(h_n)
            tem_hn1(i,1:i)=tem_hn(1,(end-i)+1:end);
        else
            if i<= numel(x_n)
                tem_hn1(i,i-numel(h_n)+1:i)=tem_hn;
            else
                tem_hn1(i,end-(numel(h_n)-k-
1):end)=tem_hn(1,1:(numel(h_n)-k));
                k=k+1;
            end
        end
    end
    y_n = transpose(tem_hn1*transpose(x_n)); %Vector
calculation of shifted h[n] with their corresponding x[n]
end
```

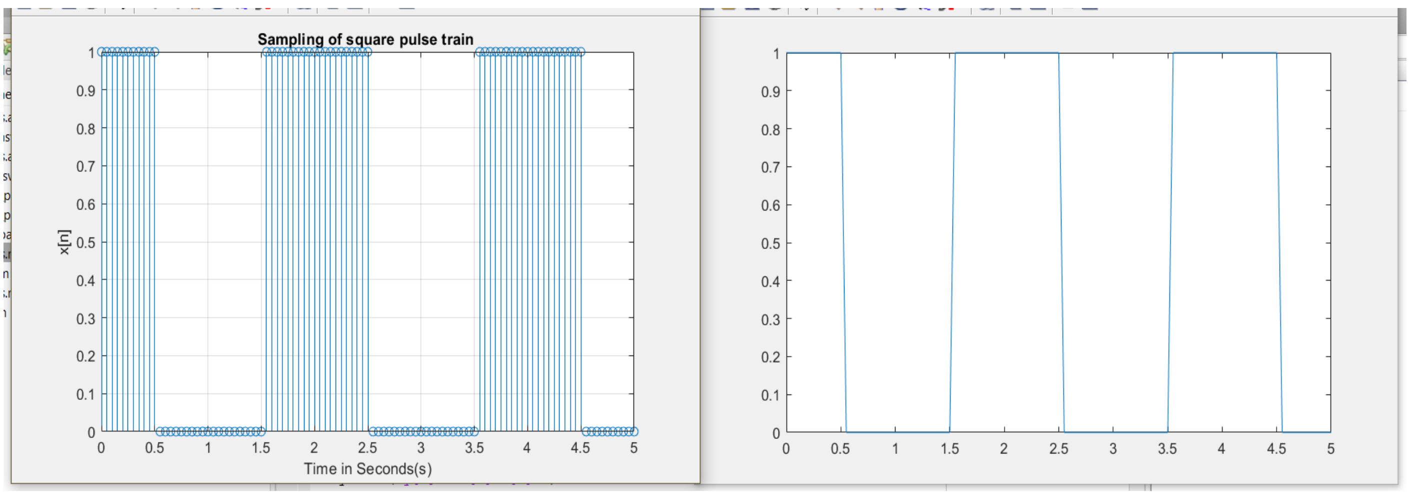
Code b:

```
% x(t) = x(t+2) is a square pulse
Fs = 20;     %Sampling frequency
offset=0.5; %shift of graph in positive y direction
amp=0.5;     %amplitude of square pulse curve symmetric
about x-axis
t=0:1/Fs:5; %Time range for graph, sampled at Fs = 20
x_n= offset + amp*square((pi*t)+1.5);    %Generating desire
curve
y_n = conv_parui_019(sq_wav,sq_wav);  %Convolving x_n
stem(t,x_n)
grid on
```

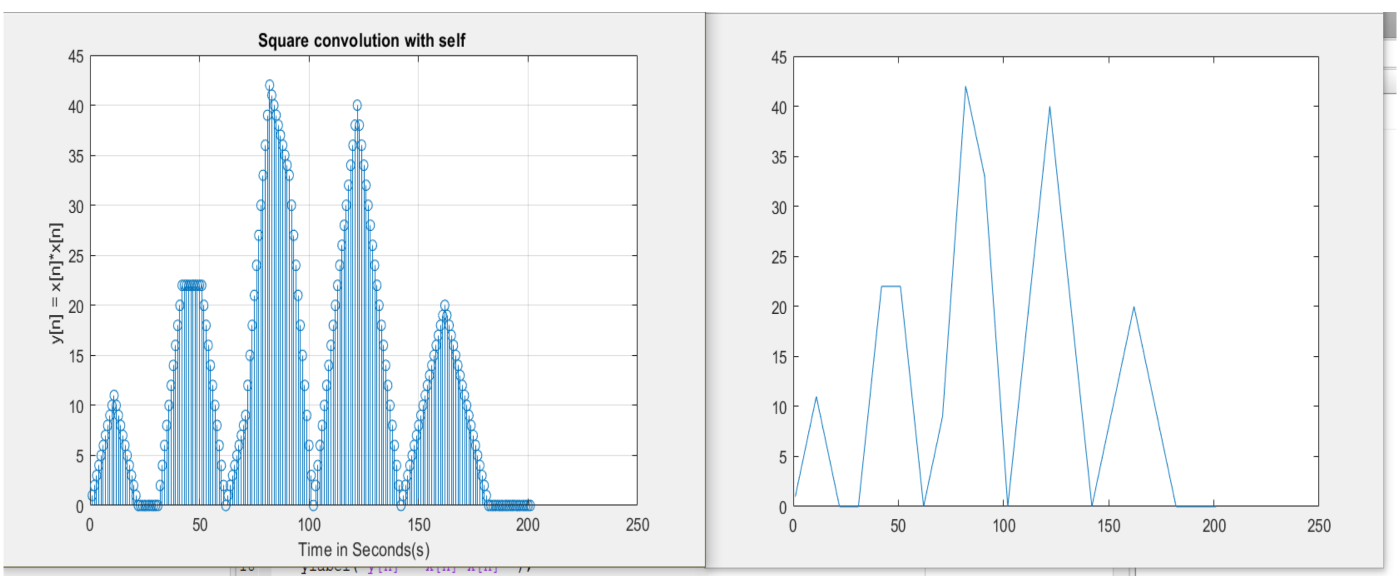
```
xlabel('Time in Seconds(s)');
ylabel('x[n]');
title('Sampling of square pulse train ')
figure
stem(y_n)
grid on
xlabel('Time in Seconds(s)');
ylabel('y[n] = x[n]*x[n] ');
title('Square convolution with self ')
```

Output:

Square pulse train (t=0 to 5 s)



Convolved output:



Explaination and Observation:

This question was divided in 2 parts .

Part a) where we created a function to perforn convolution between two discrete sequences.

Part b)Where we first had to sample a square pulse train from time = 0 to 5s and then call the convolution function generated in part a to convolve the square function with itself i.e y[n] = x[n]*x[n]

At the final stage we obtained two plots :

1] Square Pulse Train from [x(t) = x(t+2)]

- **The base function for which is**

For a single period (Time period = 2) <u>from t = -1 to +1 secs</u>

x(t) = { 1 |t|<1 ; 0 otherwise }

- **<u>Since it is sampled at a frequency Fs = 20 from time 0 to 5, there are a total of 20*5 = 100 points over which the plot is created</u>**
- **When we observe the stem graph (graph with discrete points) it appears accurate .However when we observe the plot graph (graph with envelope , *<u>seemingly</u>* continuous , we see that at points like t = 0.5,1.5,2.5,.. there is a slight slope instead of the curve being perfect verticle as it should be …this however is not a function error bt is caused as a result of the fact that there is a join of point to point instead of actual graph of the continuous function.**

2]Convolution plot :

- **On convolving x[n] (point n = 100) with itself we get a total points of 100+100 i.e n = 200 points over which the convolution is defined and plotted**

- **Though the overall function x(t) issymmetric about the y axis at = 0 ,Since the plot of x[n] from t = 0 to 5s is non symmetric about any vertical axis , the convolution so produced is also <u>non symmetric and non periodic</u>**

Code explaination for the square Wave:

The function Square(t, duty) generated a square pulse train that starts from zero with a time period of T = 2pi and

Also this plot generated has an amplitude that ranges from Max = +1 to min = -1

On multiplying t by pi inside the square function we get our desired time period T = 2 from the default T = 2 pi

The shift of 1.5 is done to bring the graph at appropriate shfted version

The amplitude = 0.5 multiplied to the square function ensures that the graph has max = 0.5 to min = -0.5 i.e a total value of 1

Offset of 0.5 shifts the function 0.5 units upwards such that the values are now max = 1 min = 0 whichwas required..

This was sampled at a frequency of 20 Hz ovet t = 0 to 5 hence total no. of points = 5*20 = 100 in v=between 0 to 5s

Q3:

Code a:

```
function [a_k] = dtfs_parui_019(x_n,num)
    N = numel(x_n);      %length of period
    y = zeros(1,N);      % storing for Fourier series
    for k=1:N
        a = 0;
        for n=1:N
        a = a+ x_n(n)*exp(-1i*2*pi*(n-1)*(k-1)/N);
        end
        y(k) = a;
    a_k = y(1,1:num);
    end
```

Code b:

```
clc;
clear all;
close all;
%g(t) = sin(2pi50t) + cos(2pi100t) + sin (2pi250t), sample
g(t) with fs = 1000Hz

fs = 1000;    %Sampling frequence
Ts = 1/fs;   %Sampling Period
n = 0:199;
g_n =sin(2*pi*50*n*Ts) +cos(2*pi*100*n*Ts) +
sin(2*pi*250*n*Ts);
period = 20;
k = numel(g_n)-1;
freq_ax = 0:(fs/numel(g_n)):(numel(g_n)-1)*(fs/numel(g_n));
G_k = dtfs_parui_019(g_n,k+1);
Re_G = (G_k + conj(G_k))/2;  % Real part of the function
Im_G = (G_k - conj(G_k))/(2*1i);
plot(Re_G)
grid on
xlabel('k');
ylabel('Real part of G_k in DC');
title('G[k] versus k');
figure
plot(Im_G)
```

```
grid on
xlabel('k');
ylabel('Imaginary part of G_k in DC');
title('G[k] vs k');
figure
plot(abs(G_k))
grid on
xlabel('k');
ylabel('Magnitude of G_k in DC');
title('G[k] vs k');
figure
plot(angle(G_k))
grid on
xlabel('k');
ylabel('Phase of G_k in DC');
title('G[k] vs k');

plot(freq_ax,Re_G)
grid on
xlabel('Frequency in Hz');
ylabel('Real part of G_k in DC');
title('G[k] versus Frequency');
figure
plot(freq_ax,Im_G)
grid on
xlabel('Frequency in Hz');
ylabel('Imaginary part of G_k in DC');
title('G[k] vs Frequency');
figure
plot(freq_ax,abs(G_k))
grid on
```

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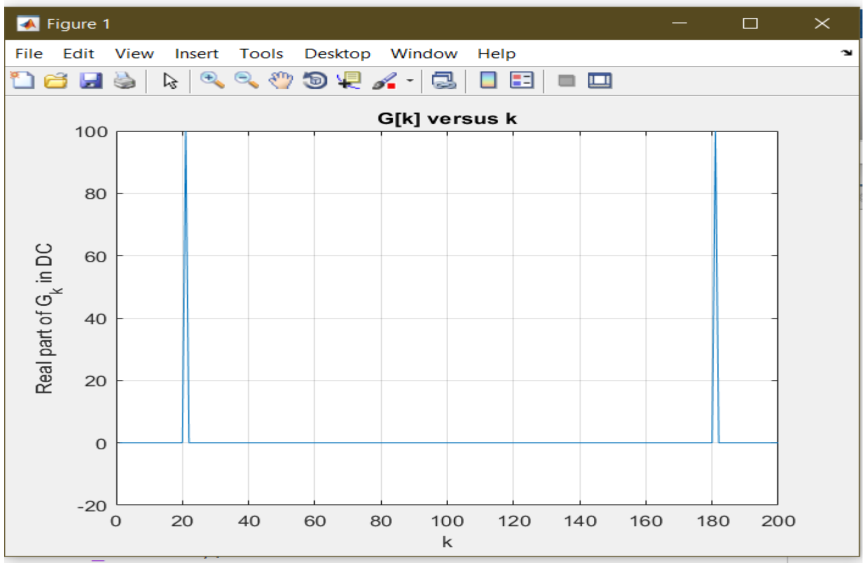
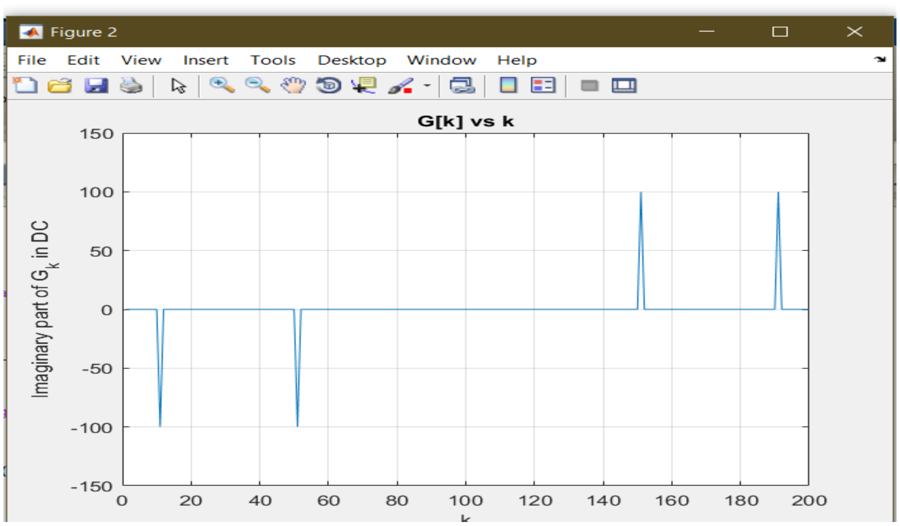
Output:

Plots a)Real part ; b)Imaginary Part ; c)Magnitude ; d)Phase

A] Versus k (where k = 199)





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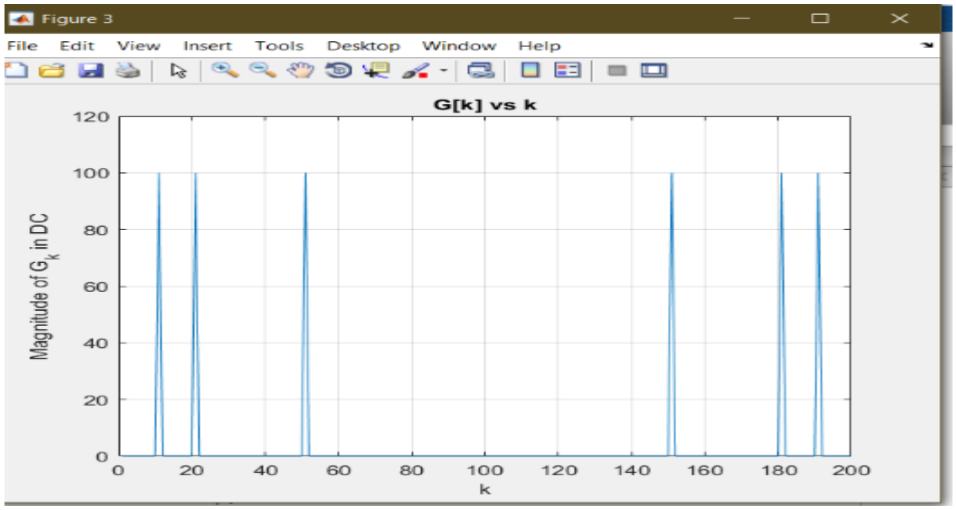
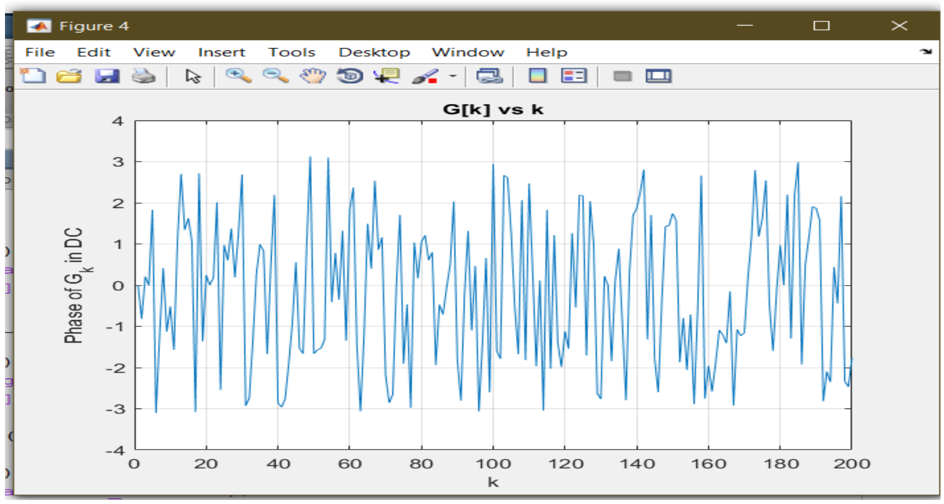
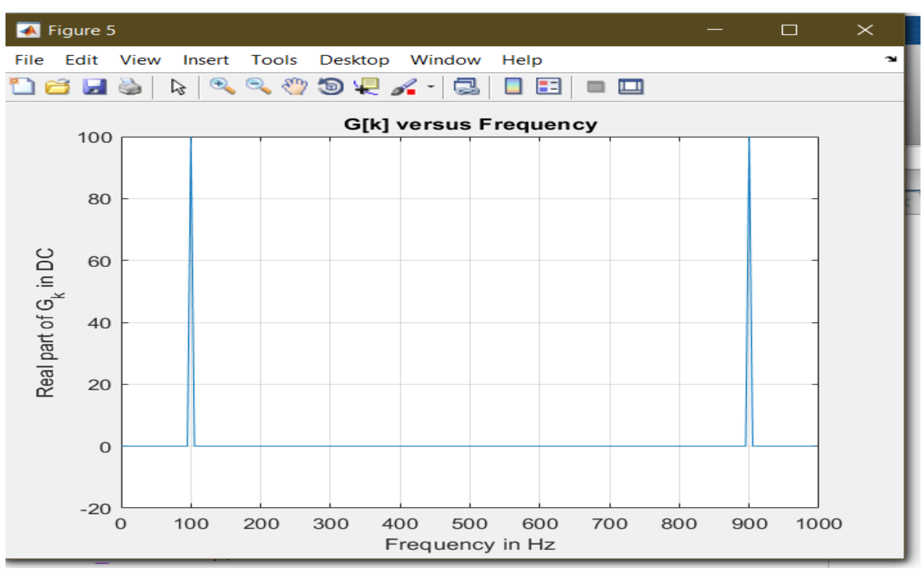




B] Versus Frequency in Hz:



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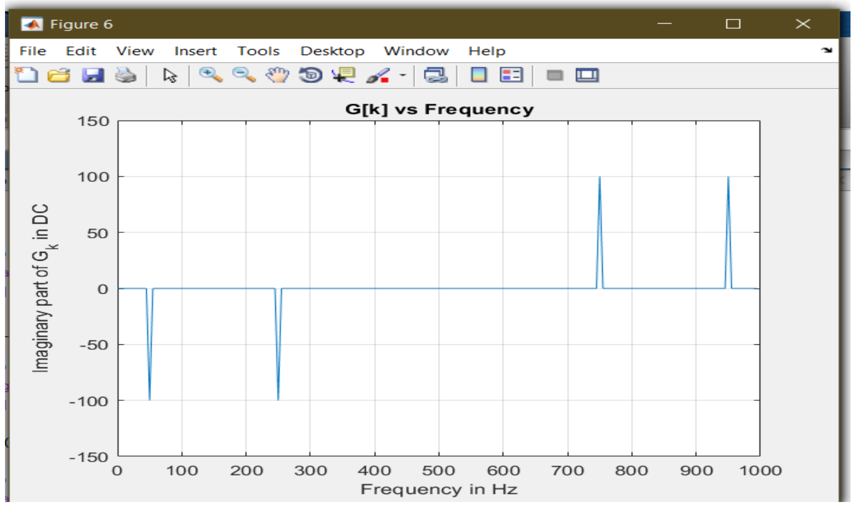

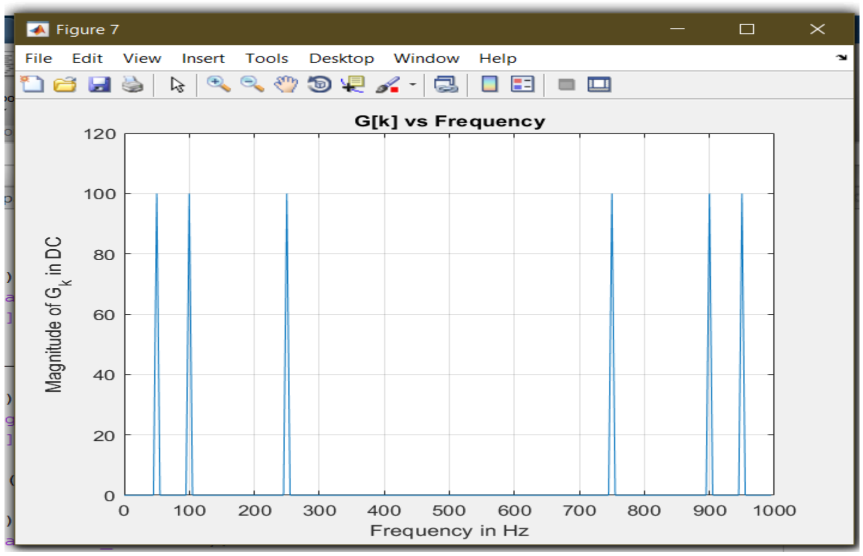

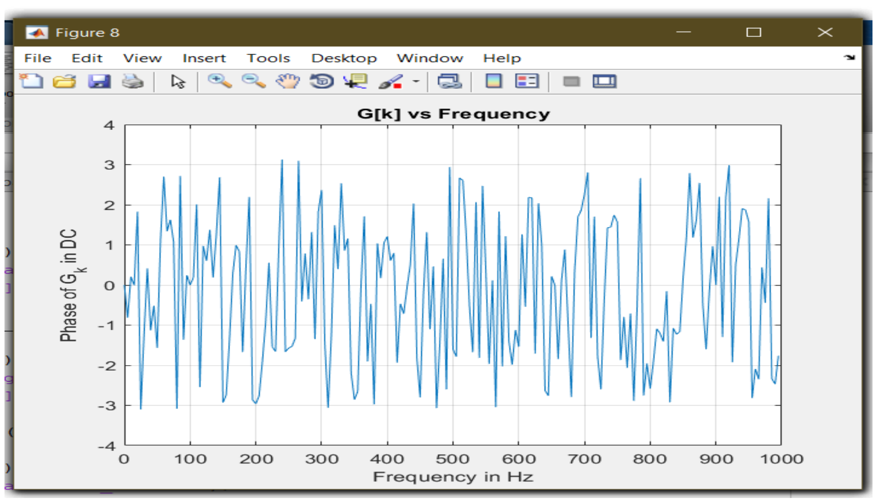

Explaination and observations :

We had 2 parts in this question

Part 1] Creating a function to find the discrete time fourier series coefficients of a discrete sequence

Part 2] Sampling a function

$g(t) = \sin(2\pi 50t) + \cos(2\pi 100t) + \sin(2\pi 250t)$

to get g[n] and then subsequent discrete time fourier coefficients G[k]

plotting its real, imaginary, magnitude, phase with respect to k i.e total number of coefficients and Frequency in Hz

One important observation that is made is that the plots of Real, Imaginary, Phase and magnitude are almost identical for k and frequency:

It is to be noted that the function was sampled at a sampling frequency Fs = 1000Hz and n = 0 to 199

1]Real Part:

We observe that the real part of the fourier coefficients have a sudden peak at k = 20 and 180 and at freq = 100Hz ,900Hz, which is symmetric about the midpoint of the plot of the coefficients

Real part of coefficients are: Positive and Even about |er axis at k = 100,Freq = 500Hz

2]Imaginary Part:

We observe that the imaginary part of the fourier coefficients show skew symmetric nature about the vertical axis at the middle of the plot i.e k = 100 and Freq = 500Hz

Imaginary part of coefficients are: Odd about vertical axis at the plot i.e k = 100 and Freq = 500Hz

3] Magnitude Part: the graph has a Positive and even nature

4] Phase Part: shape of the graph is non periodic in nature