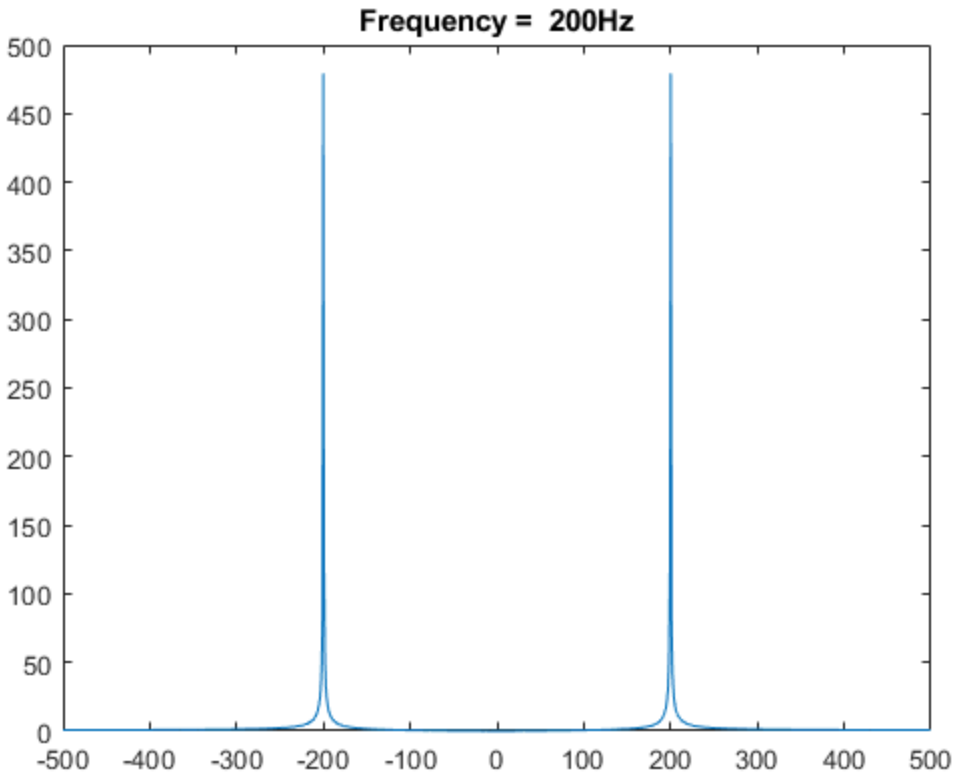
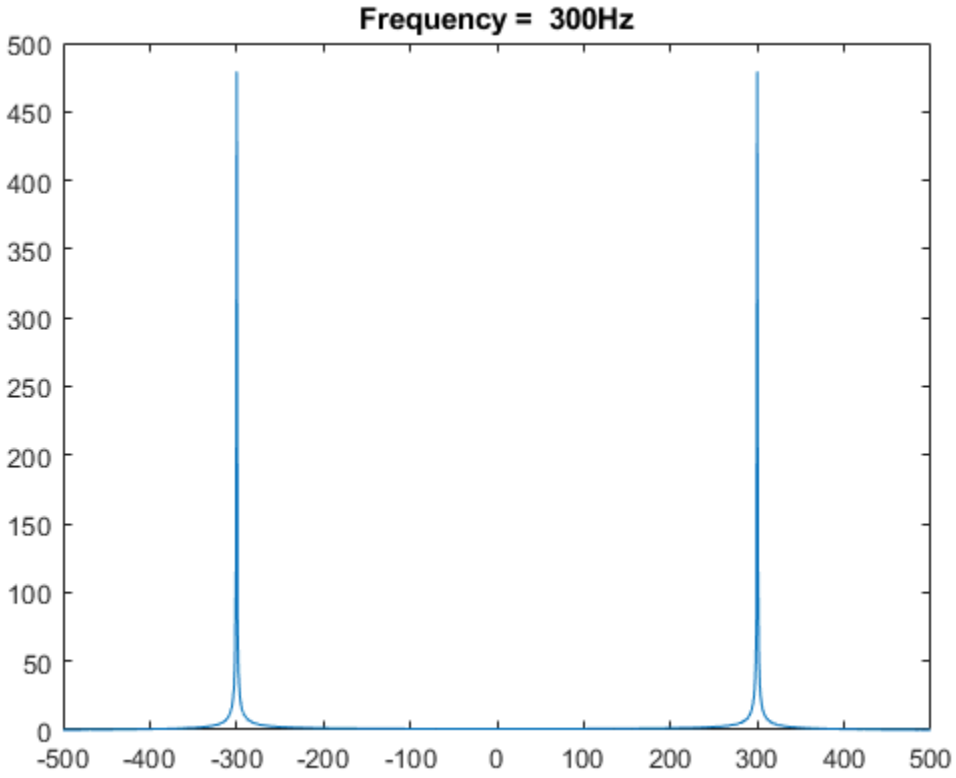
Table of Contents

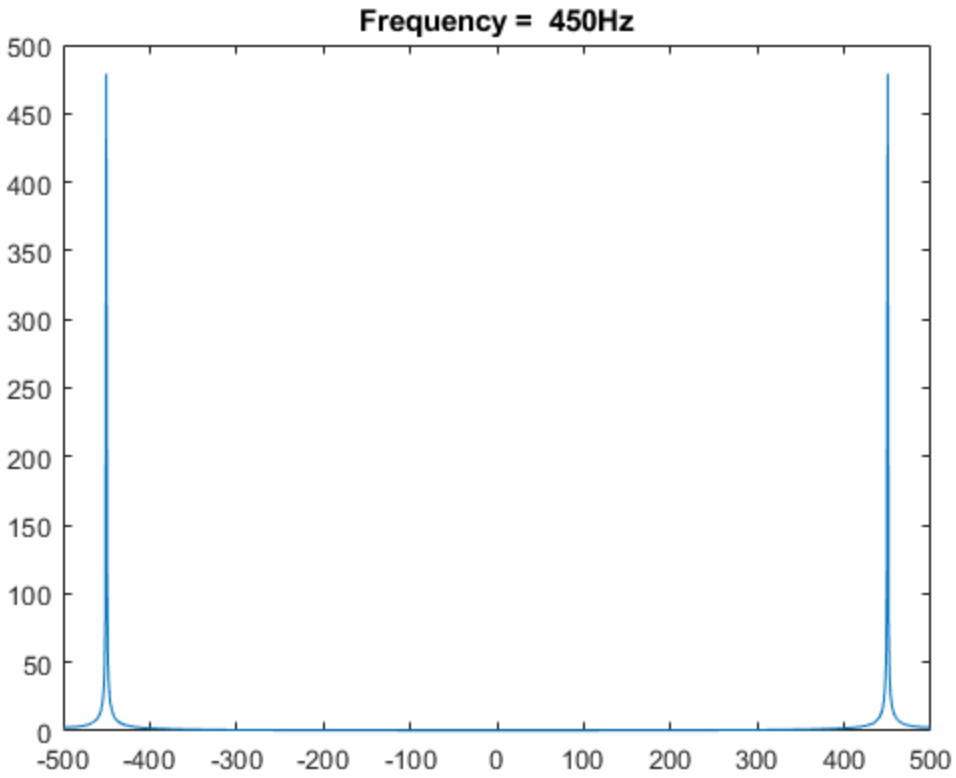
7.5 a

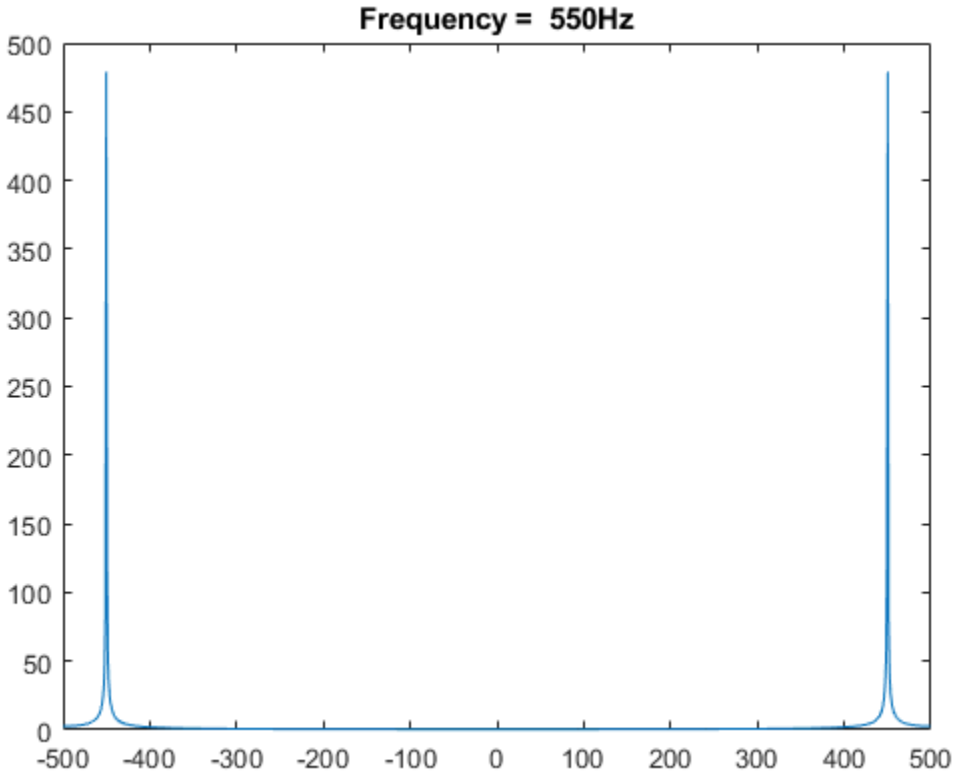
Trying f = 200, 300, 450, 550, 600, 800, 2200 Hz

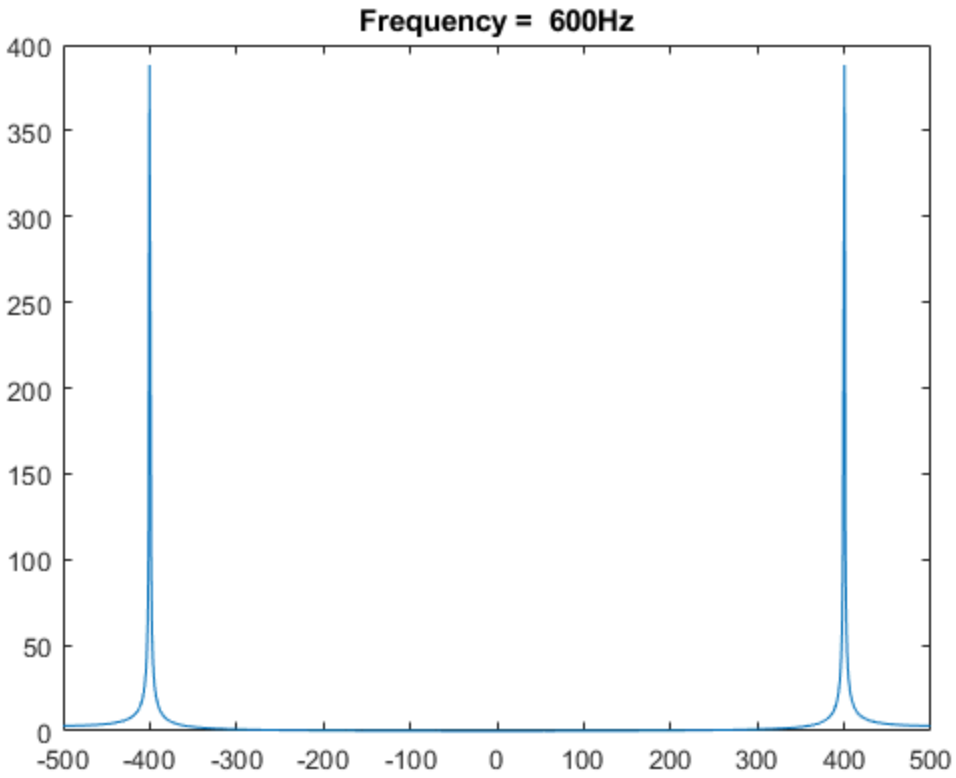
```
f = [200, 300, 450, 550, 600, 800, 2220];
Ts=1/1000;
time=10.0; % f req , sampling inte rval , time
t=Ts : Ts : time ; % def ine a time vector
for x = 1:7
 w=sin (2* pi* f(x) *t ) ; % de f ine the s inuso id
N=2^10; % s i z e of a n a l y s i s window
ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
fw=fft (w( 1 :N)) ; % do DFT/FFT
fws=fftshift( fw ) ; % s h i f t i t for plot t ing
figure
plot (ssf , abs( fws ))
title(['Frequency =  ',num2str(f(x)),'Hz'])
end
```

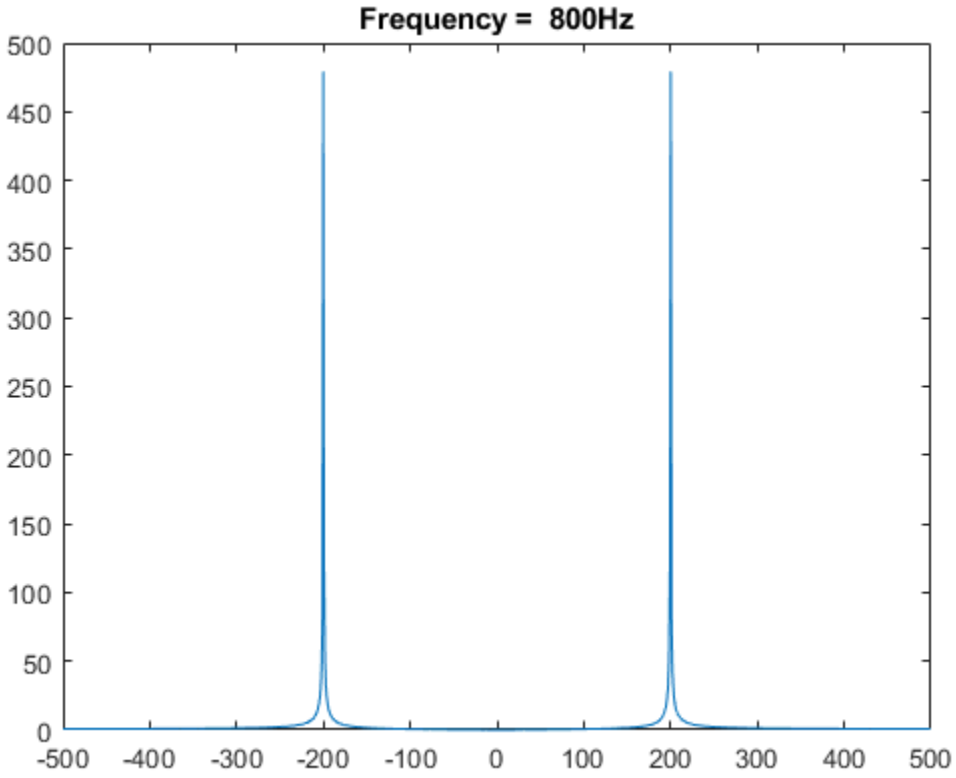

Frequency = 200Hz
500
450
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

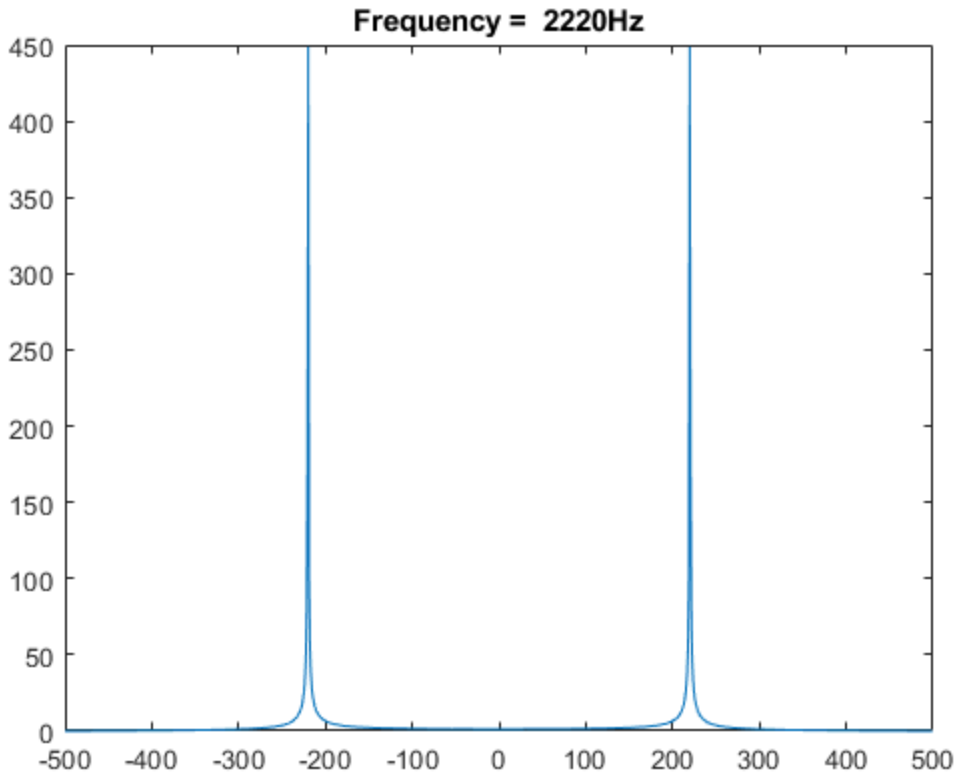

Frequency = 300Hz
500
450
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Frequency = 450Hz
500
450
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Frequency = 550Hz
500
450
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Frequency = 600Hz
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

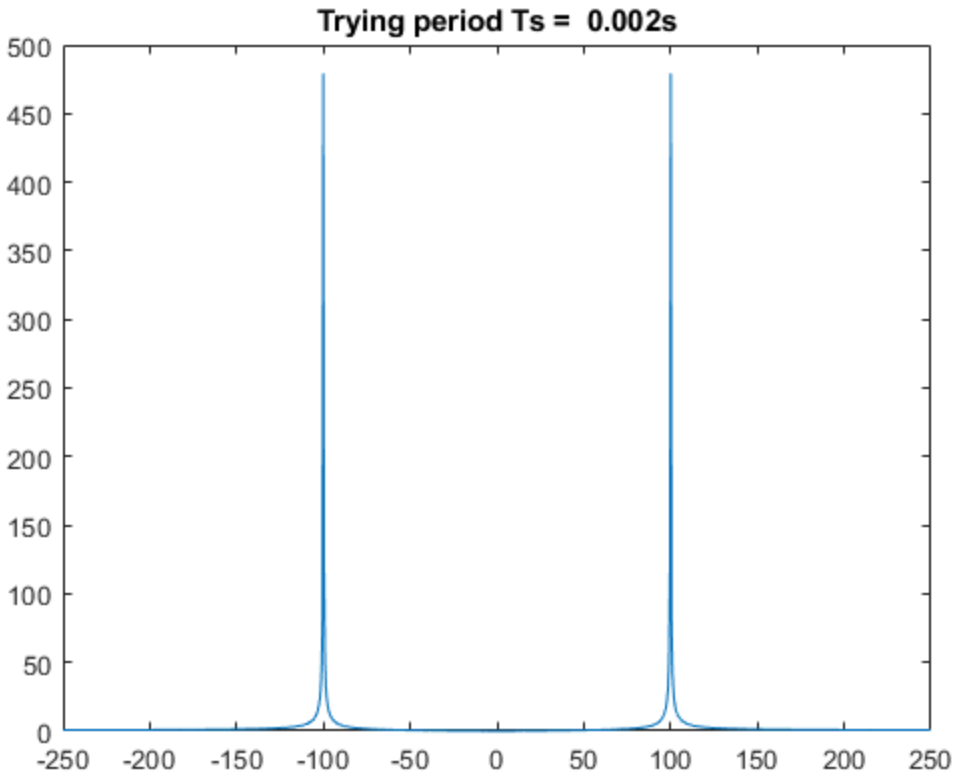

Frequency = 800Hz
500
450
400
350
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

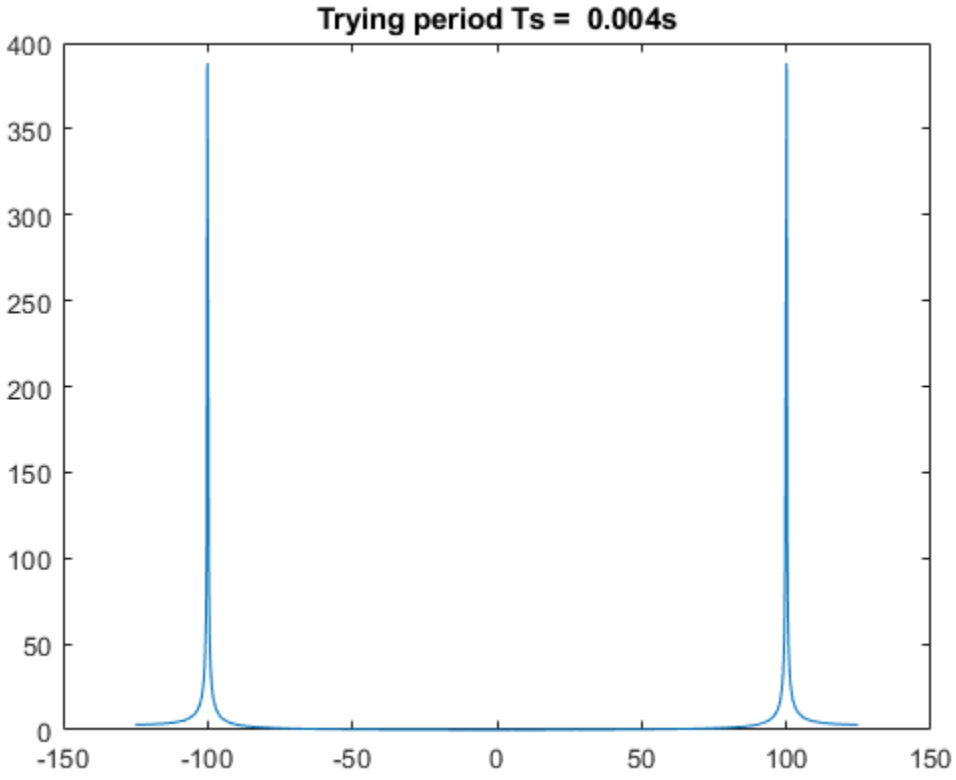


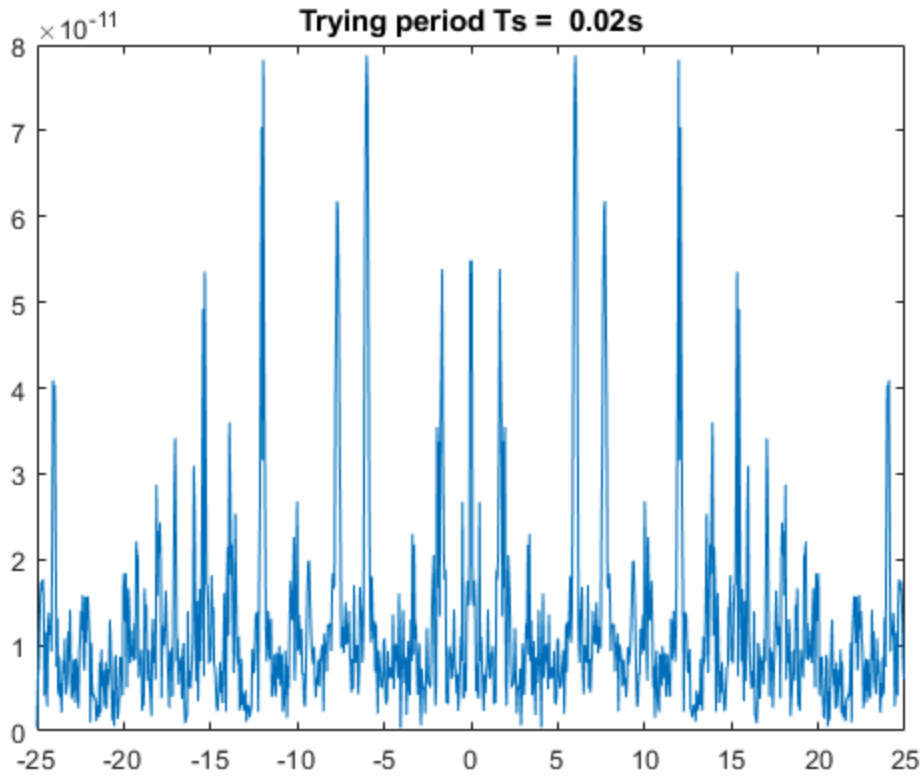
7.5 b

Testing different Ts values

```
f = 100;
Ts= [(1/500), (1/250), (1/50)];
time=50.0; % f req , sampling inte rval , time
for x = 1:3
t=Ts(x) : Ts(x) : time ; % def ine a time vector
 w=sin (2* pi* f *t ); % de f ine the s inuso id
N=2^10; % s i z e of a n a l y s i s window
ssf=(-N/2:N/2-1)/(Ts(x)*N) ; % f requency vector
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf , abs( fws ))
title(['Trying period Ts =  ',num2str(Ts(x)),'s'])
end
```


Trying period Ts = 0.002s
500
450
400
350
300
250
200
150
100
50
0
-250
-200
-150
-100
-50
0
50
100
150
200
250

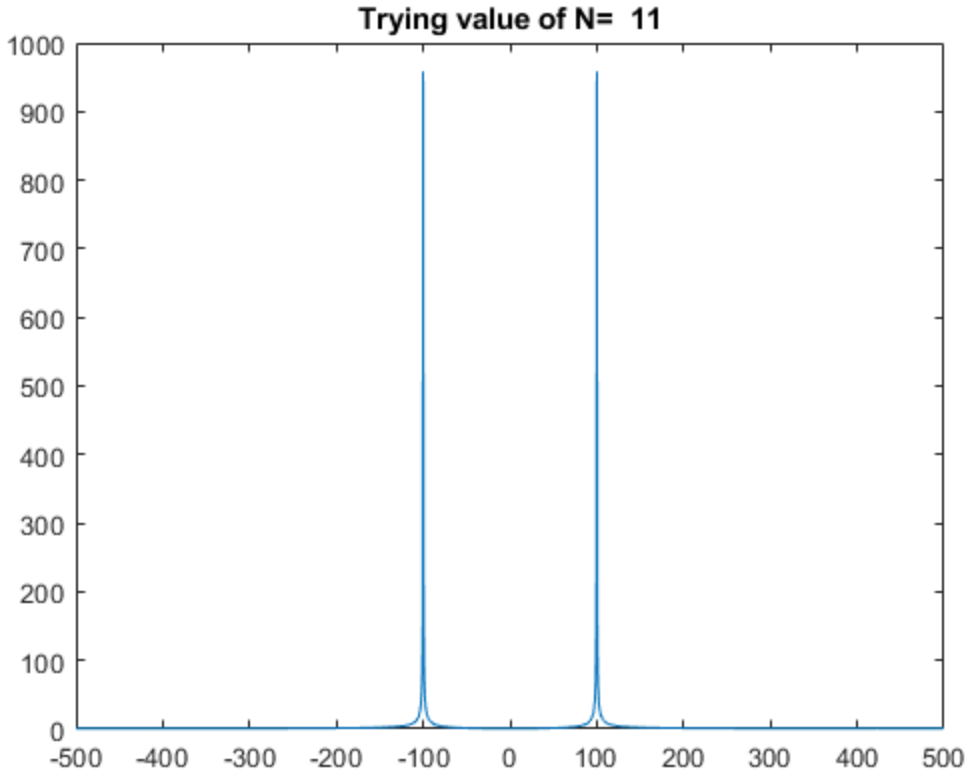

Trying period Ts = 0.004s
400
350
300
250
200
150
100
50
0
-150
-100
-50
0
50
100
150

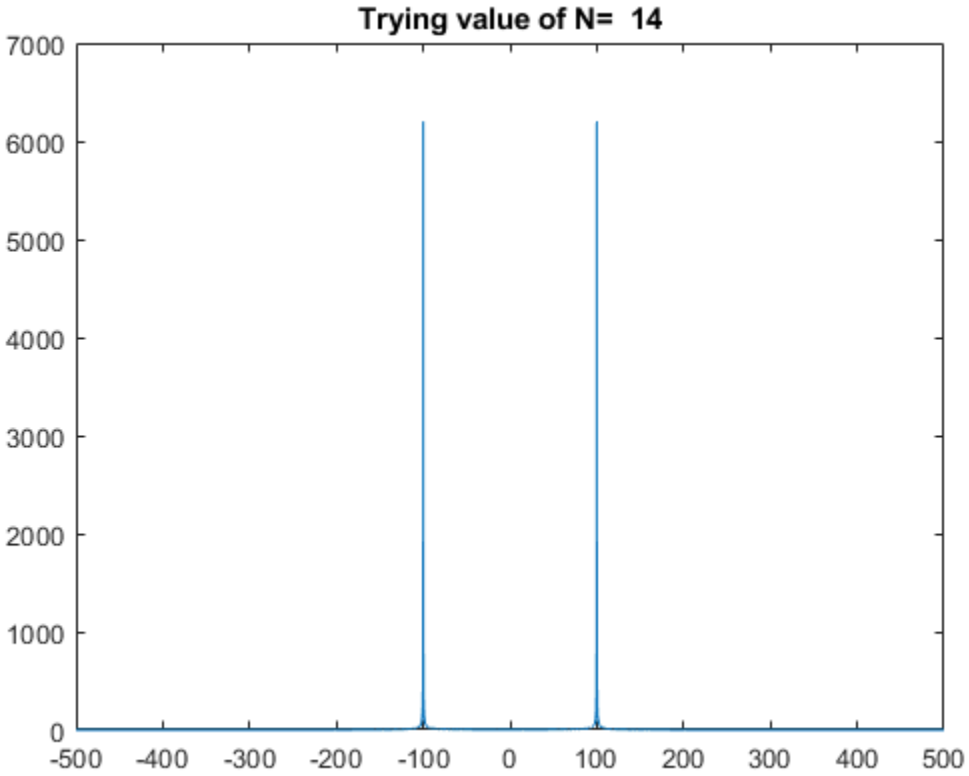


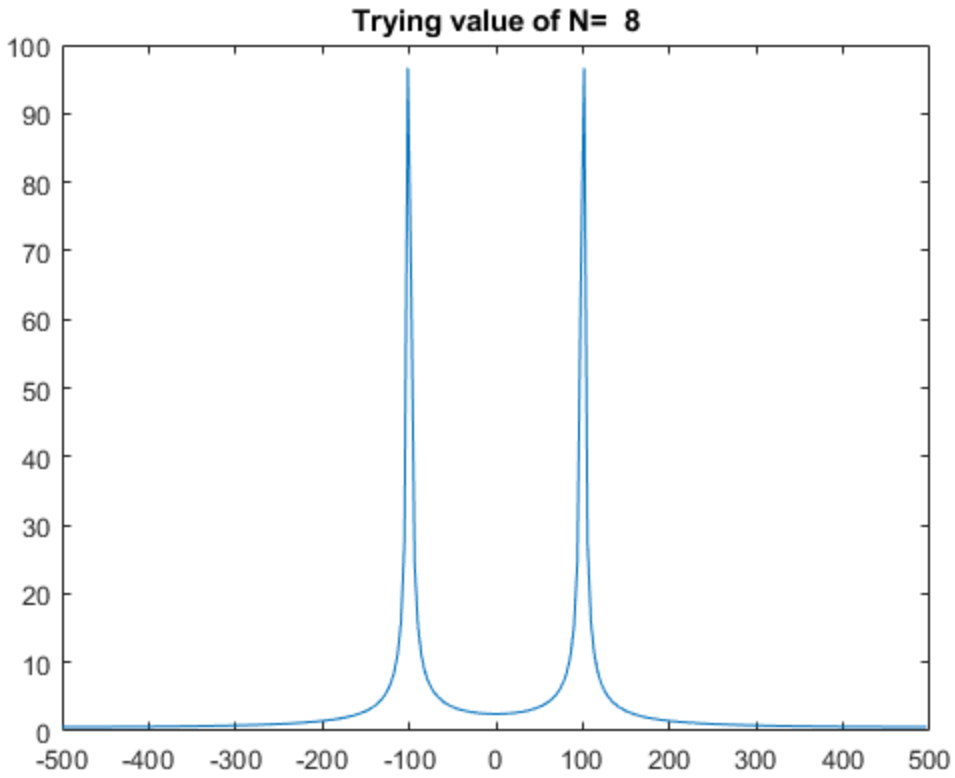
7.5 c

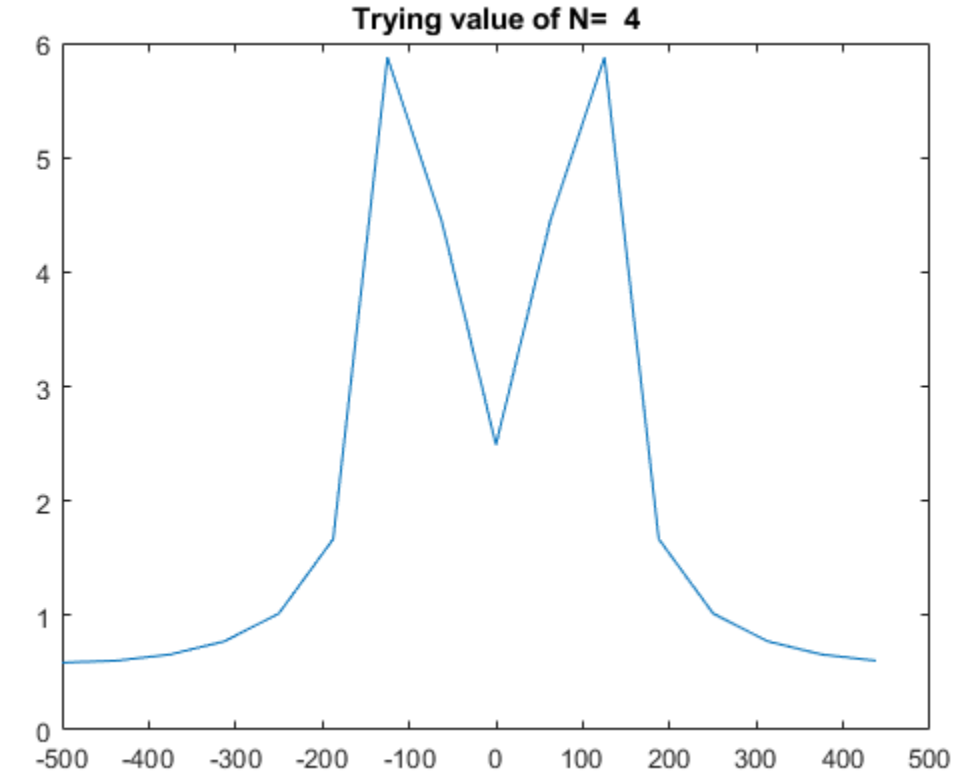
Testing different values of N

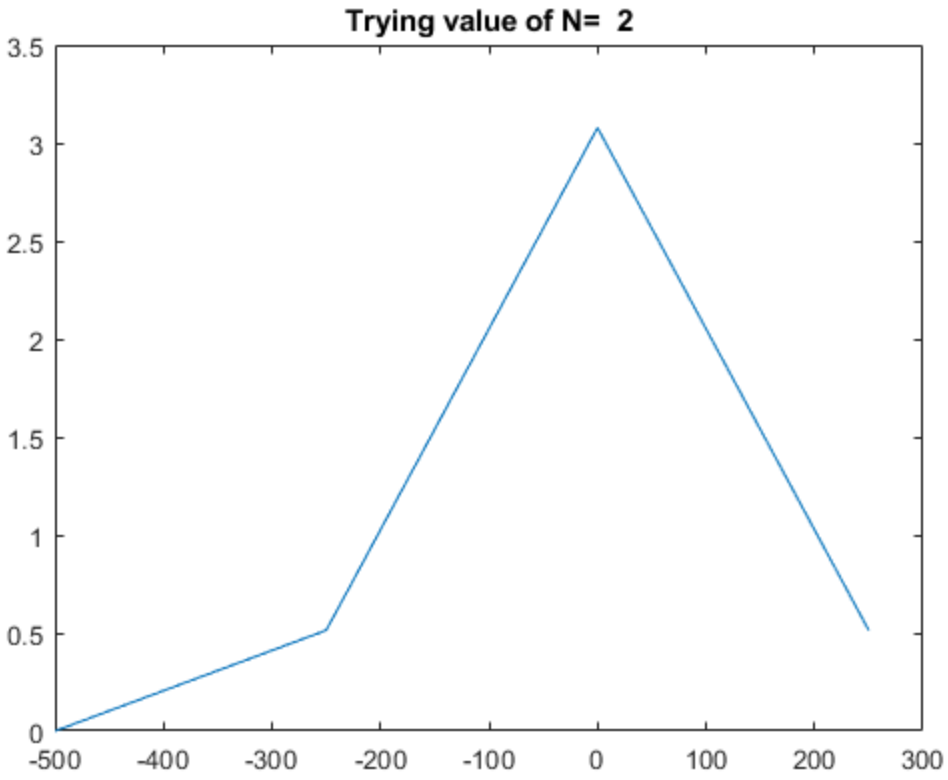
```
N_values = [11, 14, 8, 4, 2, 20];
f = 100;
Ts= 1/1000;
time=2000.0; % f req , sampling inte rval , time
for x = 1:6
t=Ts:Ts:time ; % def ine a time vector
 w=sin (2* pi* f *t ); % de f ine the s inuso id
N=2^N_values(x); % s i z e of a n a l y s i s window
ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf ,abs( fws ))
title(['Trying value of N=  ',num2str(N_values(x))])
end
```

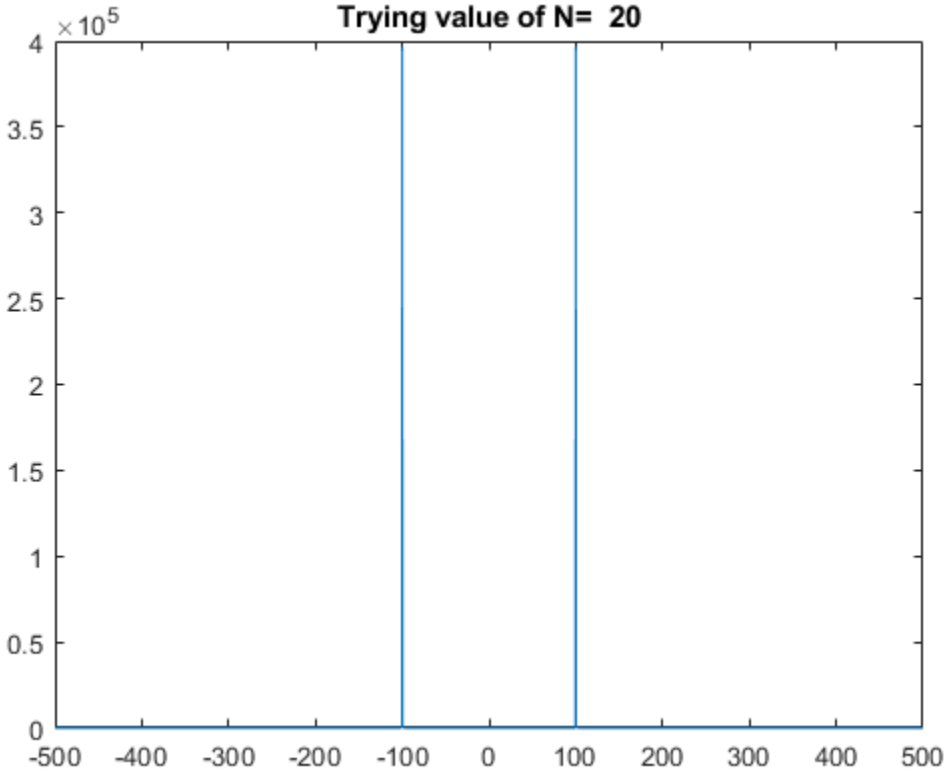

Trying value of N= 11
1000
900
800
700
600
500
400
300
200
100
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Trying value of N= 14
7000
6000
5000
4000
3000
2000
1000
0
-500
-400
-300
-200
-100
0
100
200
300
400
500


Trying value of N= 8
100
90
80
70
60
50
40
30
20
10
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

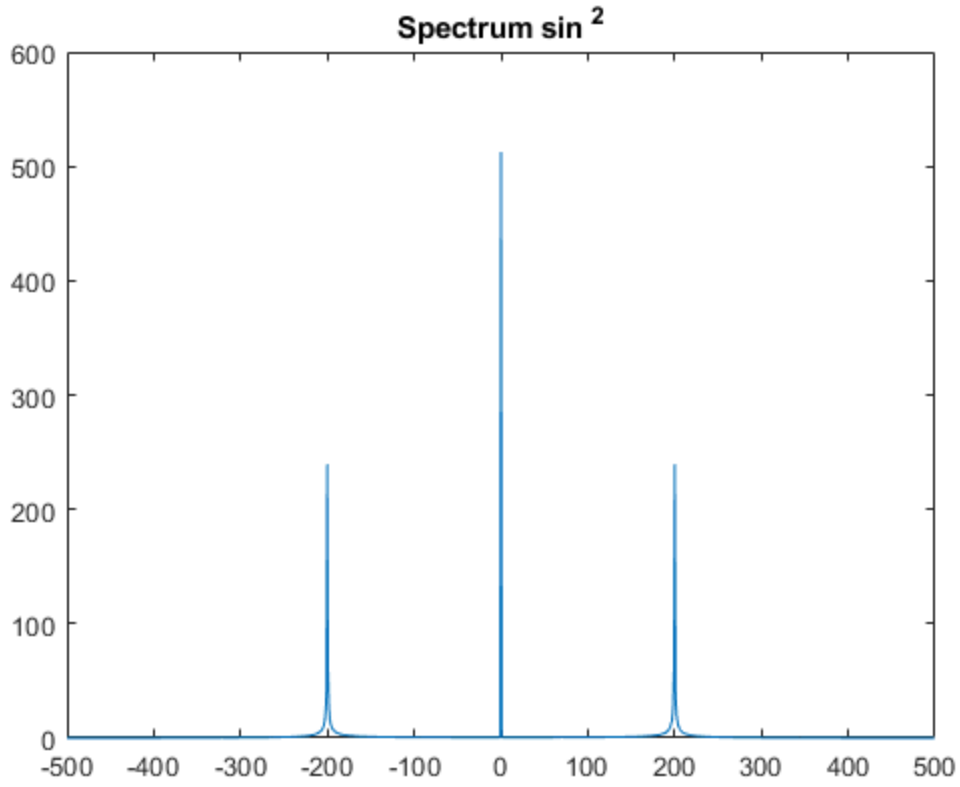

Trying value of N= 4
6
5
4
3
2
1
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

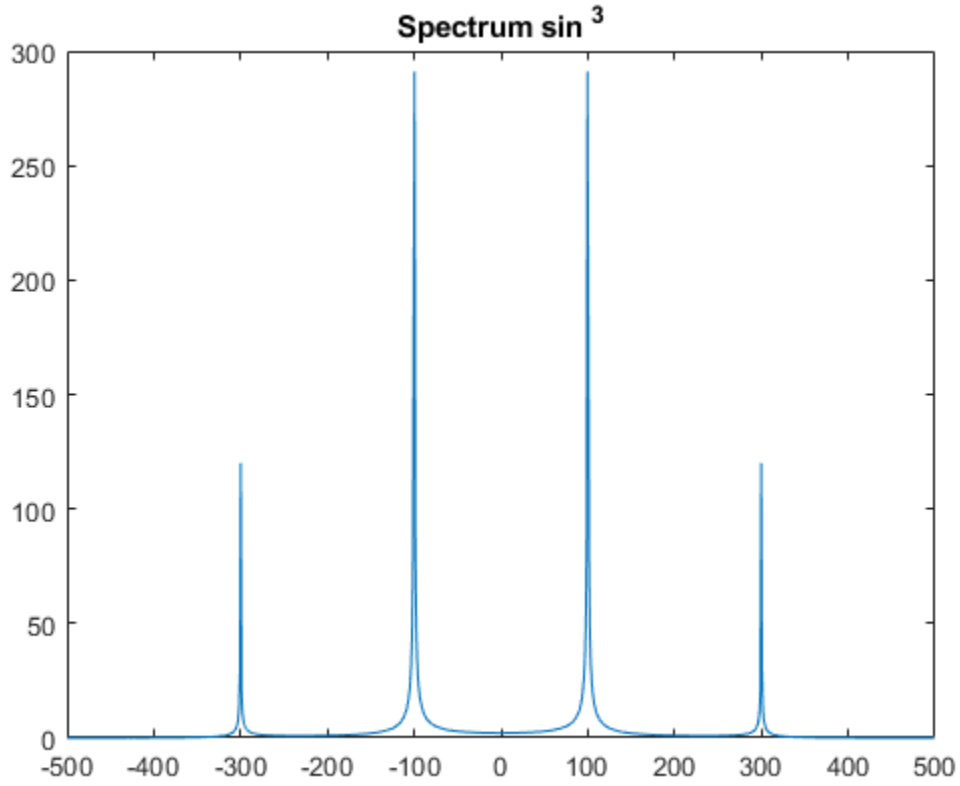

Trying value of N= 2
3.5
3
2.5
2
1.5
1
0.5
0
-500
-400
-300
-200
-100
0
100
200
300

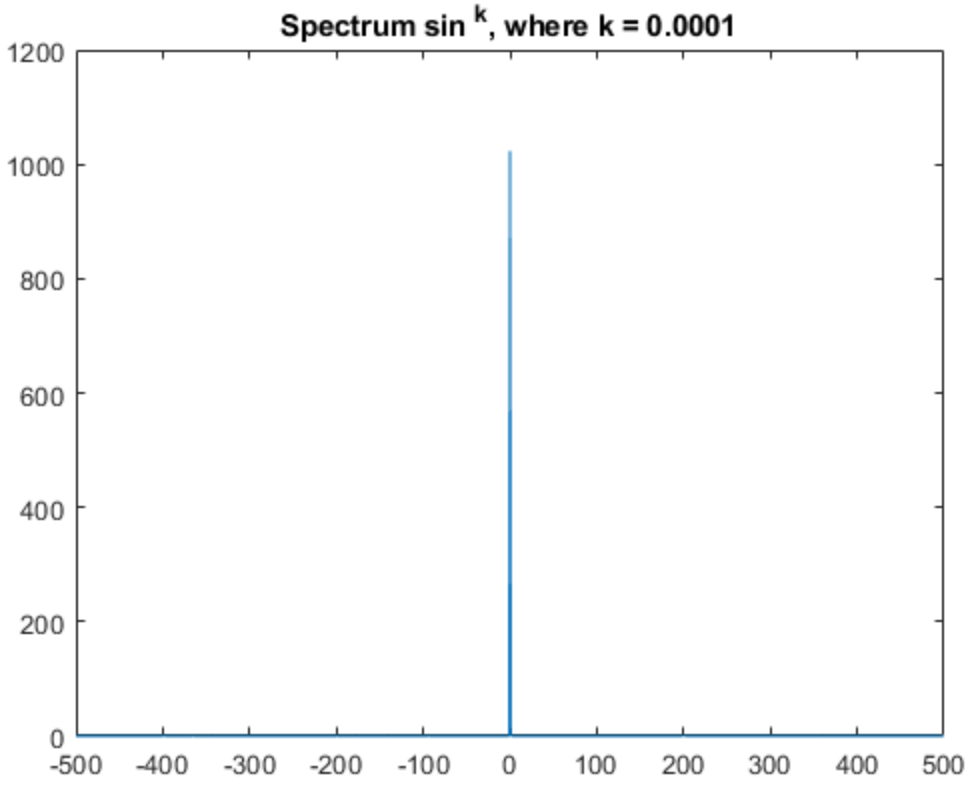

Trying value of N= 20
×10^5
4
3.5
3
2.5
2
1.5
1
0.5
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

Exercise 7.6

```
f = 100;
Ts= 1/1000;
time=10.0; % f req , sampling inte rval , time
t=Ts:Ts:time ; % def ine a time vector
w=sin (2* pi* f *t ).^2; % de f ine the s inuso id
N=2^10; % s i z e of a n a l y s i s window
ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf ,abs( fws ))
title('Spectrum sin ^2')

w=sin (2* pi* f *t ).^3;
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf ,abs( fws ))
title('Spectrum sin ^3')

k = 0.0001;
w=sin (2* pi* f *t ).^k;
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf ,abs( fws ))
title('Spectrum sin ^k, where k = 0.0001')

% The bigger the k value the smaller the amplitude value at each
% peak and the smaller the k value it convolves into a single point
```

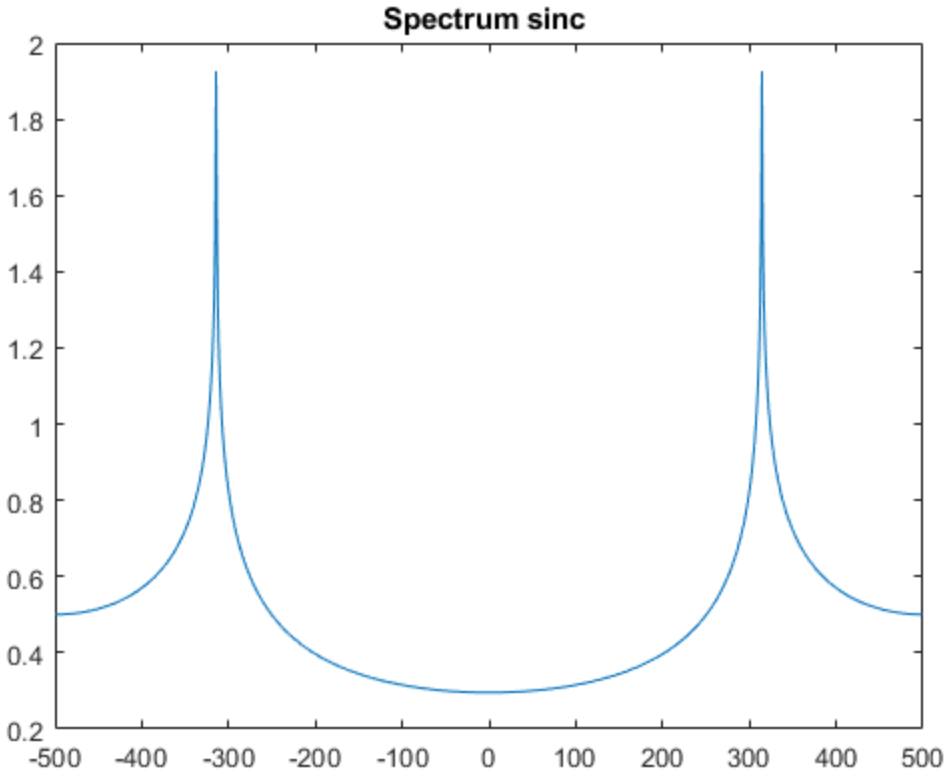

Spectrum sin 2
600
500
400
300
200
100
0
-500
-400
-300
-200
-100
0
100
200
300
400
500

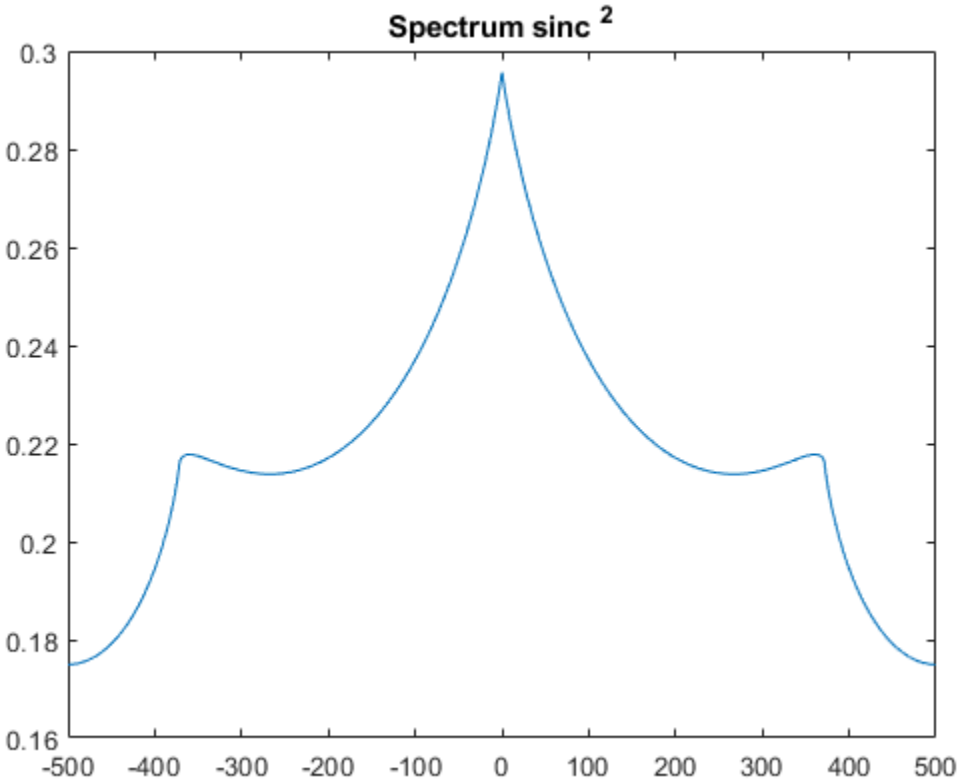

Spectrum sin 3
300
250
200
150
100
50
0
-500
-400
-300
-200
-100
0
100
200
300
400
500



Exercise 7.7

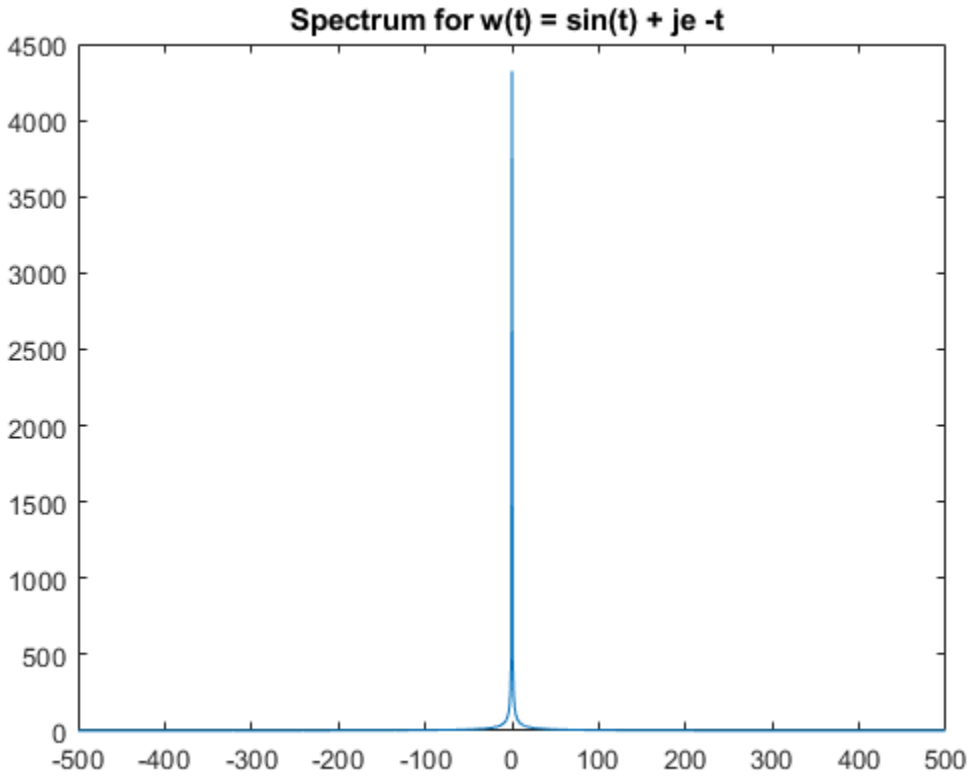
```
f = 100;
Ts= 1/1000;
time=20.0; % f req , sampling inte rval , time
t=Ts:Ts:time ; % def ine a time vector
w=sinc(2* pi* f *t ); % de f ine the s inuso id
N=2^10; % s i z e of a n a l y s i s window
ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf ,abs( fws ))
title('Spectrum sinc ')

% Testing sinc ^2
w=sinc(2* pi* f *t ).^2; % de f ine the s inuso id
N=2^10; % s i z e of a n a l y s i s window
ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf ,abs( fws ))
title('Spectrum sinc ^2')
```


Spectrum sinc
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
-500
-400
-300
-200
-100
0
100
200
300
400
500


Spectrum sinc 2
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
-500
-400
-300
-200
-100
0
100
200
300
400
500

Exercise 7.8

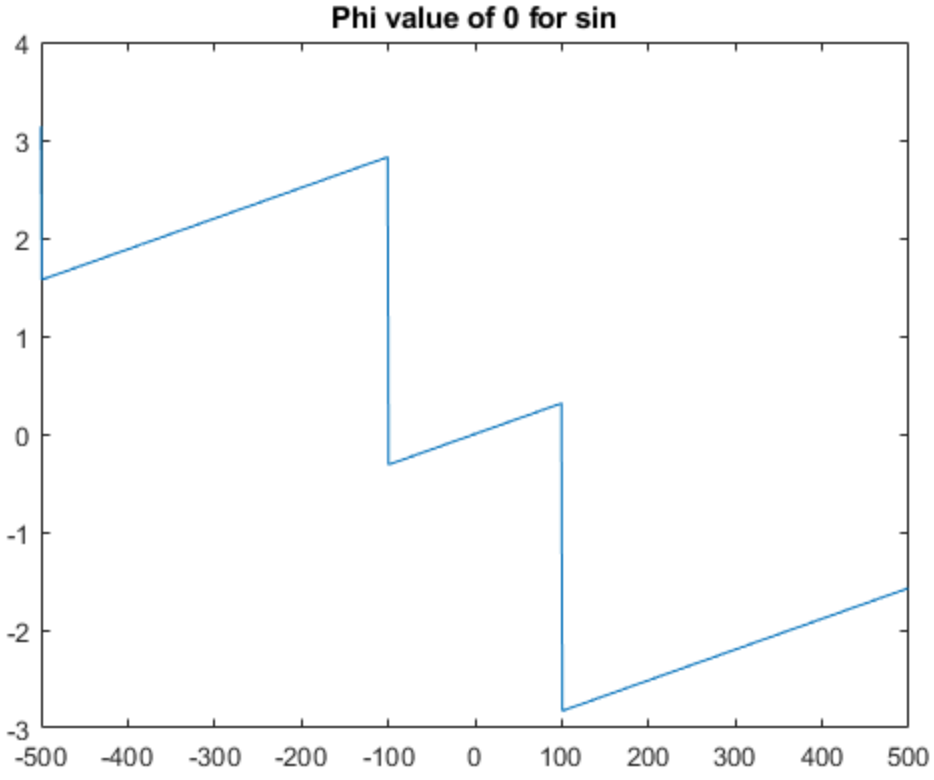
```
f = 100;
Ts= 1/1000;
time=10.0; % f req , sampling inte rval , time
t=Ts:Ts:time ; % def ine a time vector
w=sin(t) + x*exp(-t); % de f ine the s inuso id
N=2^10; % s i z e of a n a l y s i s window
ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
fw=fft (w(1:N)) ; % do DFT/FFT
fws=fftshift(fw) ; % s h i f t i t for plot t ing
figure
plot (ssf ,abs( fws ))
title('Spectrum for w(t) = sin(t) + je^ -t ')

% Using specsin2.m is probably the way to go because of the fftshift
% organizing the frequencies nicely.
```

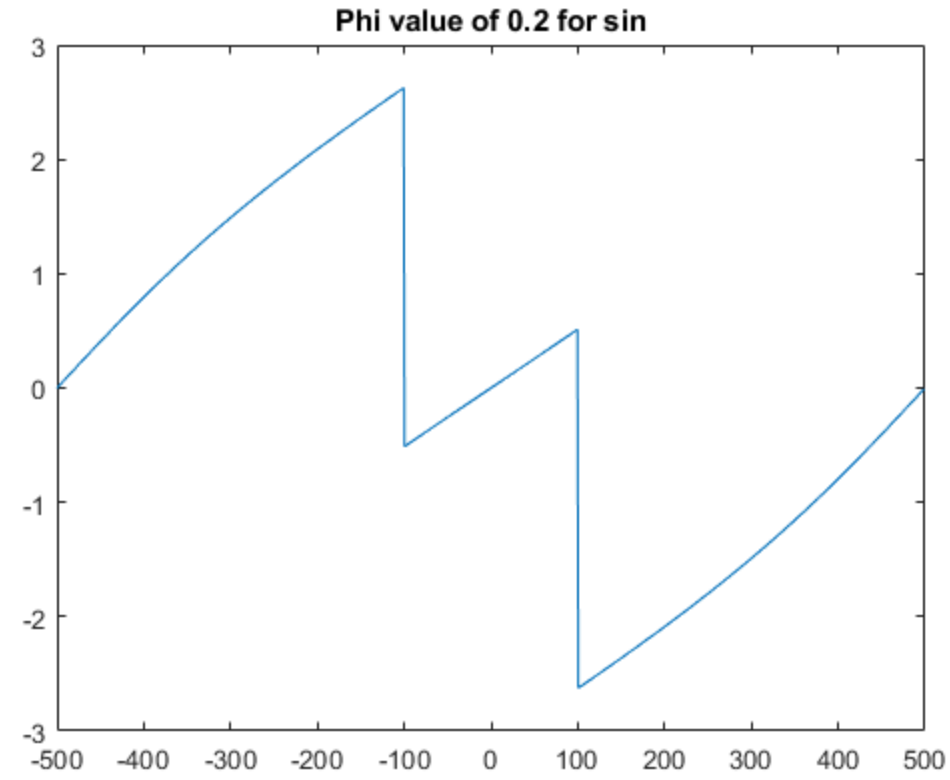


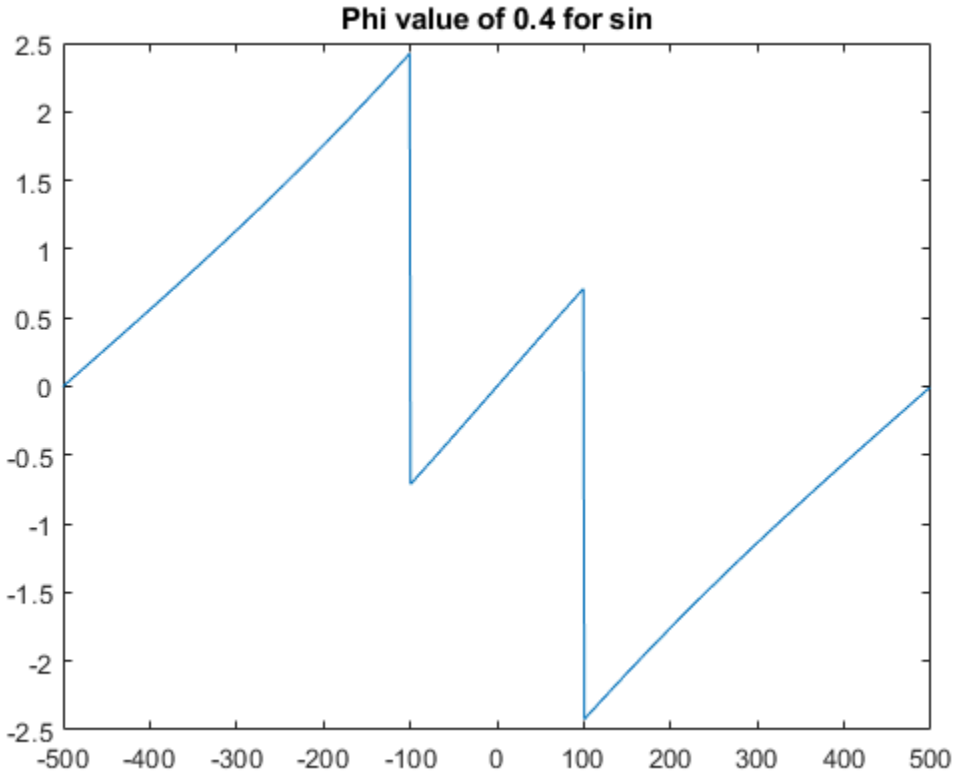
Exercise 7.9

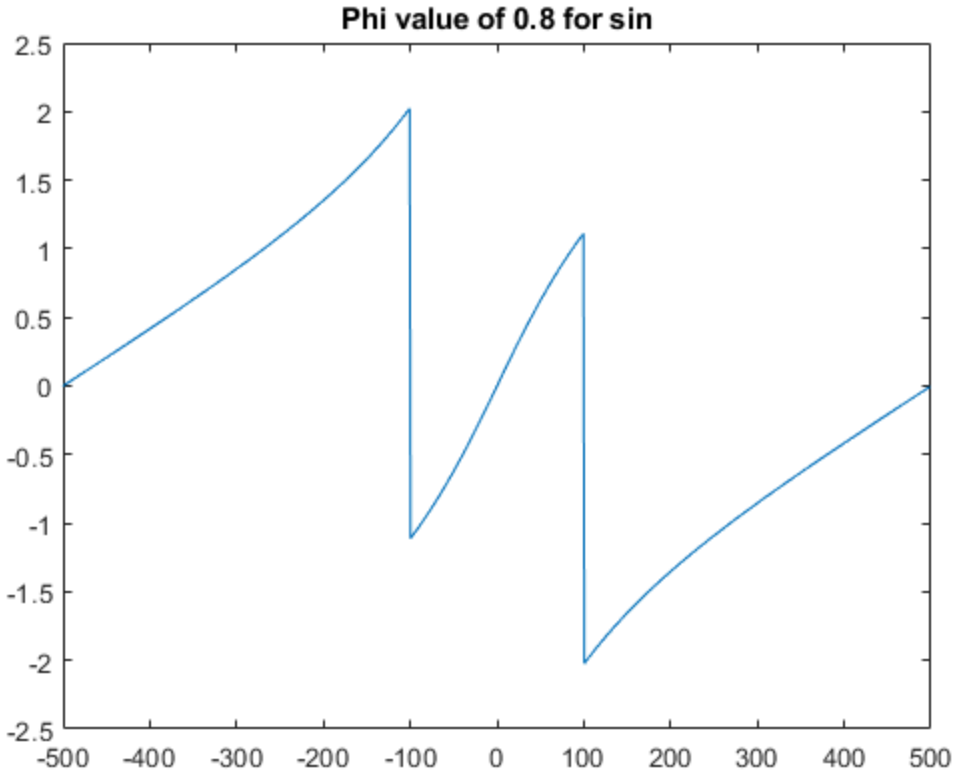
```
f = 100;
Ts= 1/1000;
phi = [0, 0.2, 0.4, 0.8, 1.5, 3.14];
time=10.0; % f req , sampling inte rval , time
t=Ts:Ts:time ; % def ine a time vector
```

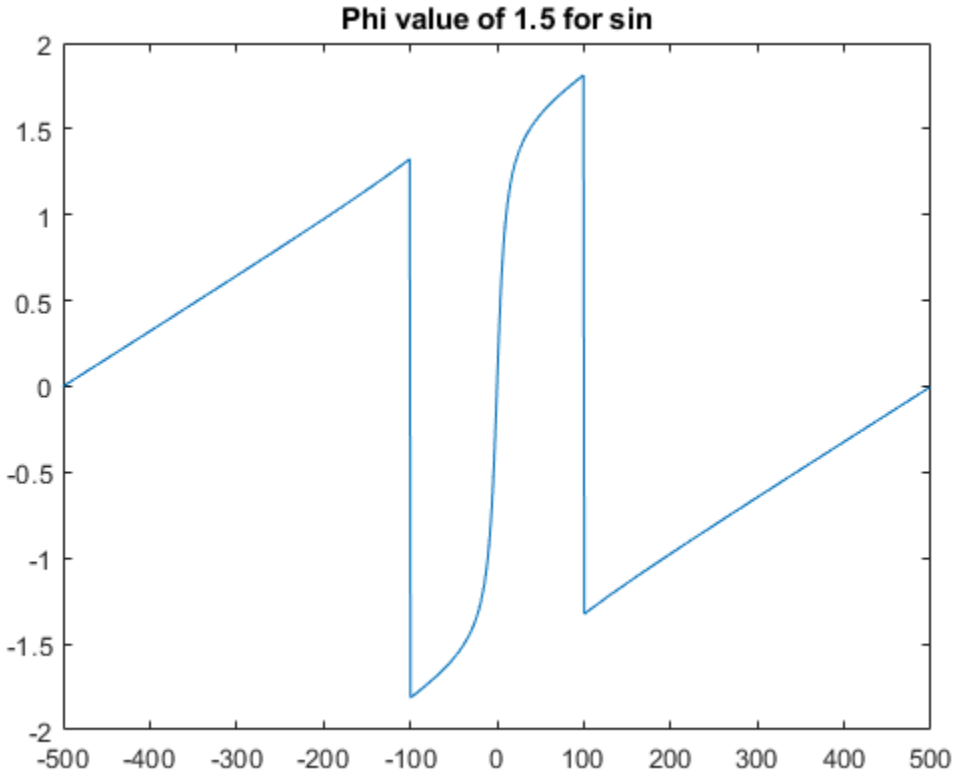
```
for x = 1:6
    w=sin((2*pi*f*t) + phi(x)); % de f ine the s inuso id
    N=2^10; % s i z e of a n a l y s i s window
    ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
    fw=fft (w(1:N)) ; % do DFT/FFT
    fws=fftshift(fw) ; % s h i f t i t for plot t ing
    figure
    plot (ssf ,unwrap(angle( fws )))
    title(['Phi value of ',num2str(phi(x)), ' for sin'])
end


% Finding phase output of sin.^2
for x = 1:6
    w=sin((2*pi*f*t) + phi(x)).^2; % de f ine the s inuso id
    N=2^10; % s i z e of a n a l y s i s window
    ssf=(-N/2:N/2-1)/(Ts*N) ; % f requency vector
    fw=fft (w(1:N)) ; % do DFT/FFT
    fws=fftshift(fw) ; % s h i f t i t for plot t ing
    figure
    plot (ssf ,unwrap(angle( fws )))
    title(['Phi value of ',num2str(phi(x)), ' for sin ^2'])
end
```

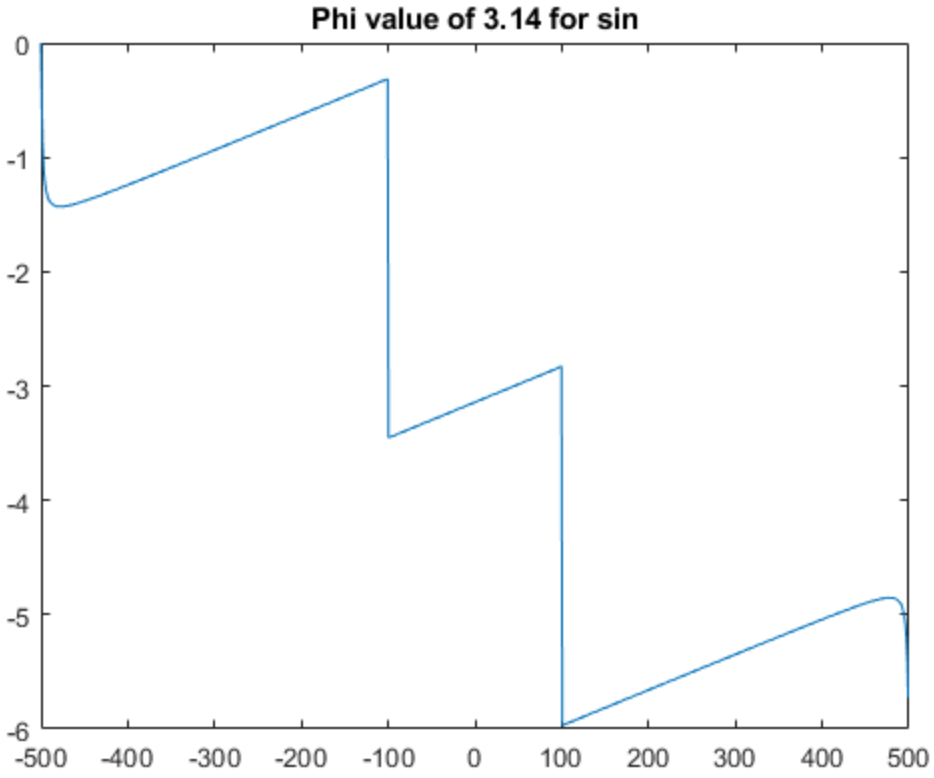


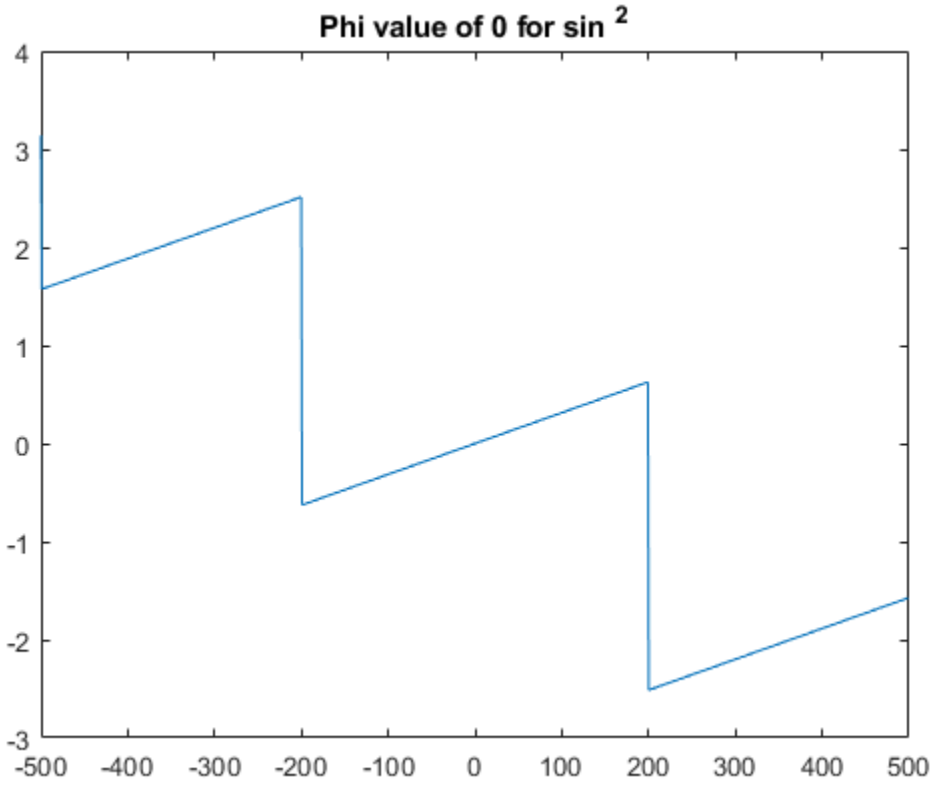

Phi value of 0.2 for sin
3
2
1
0
-1
-2
-3
-500
-400
-300
-200
-100
0
100
200
300
400
500

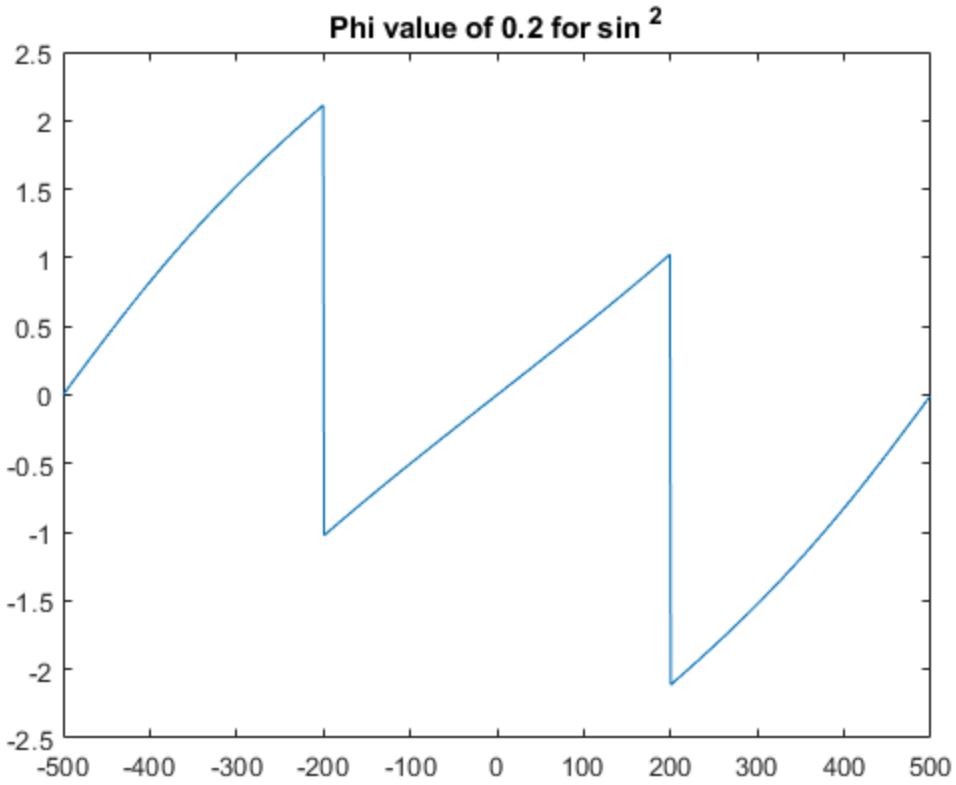

Phi value of 0.4 for sin
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-500
-400
-300
-200
-100
0
100
200
300
400
500

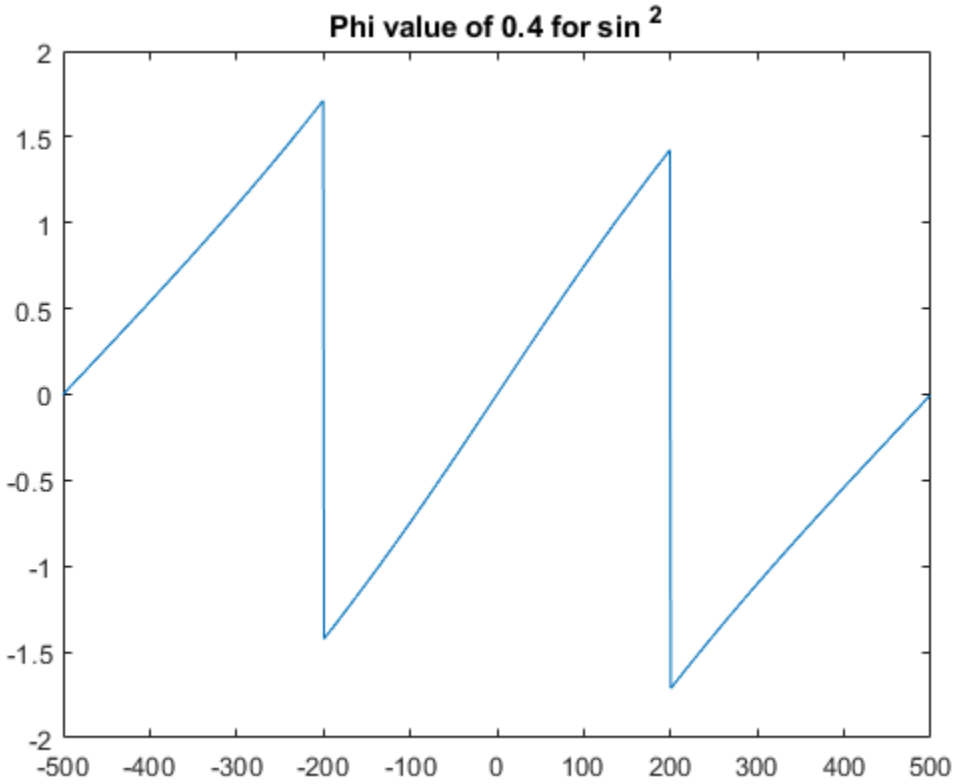

Phi value of 0.8 for sin
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-500
-400
-300
-200
-100
0
100
200
300
400
500

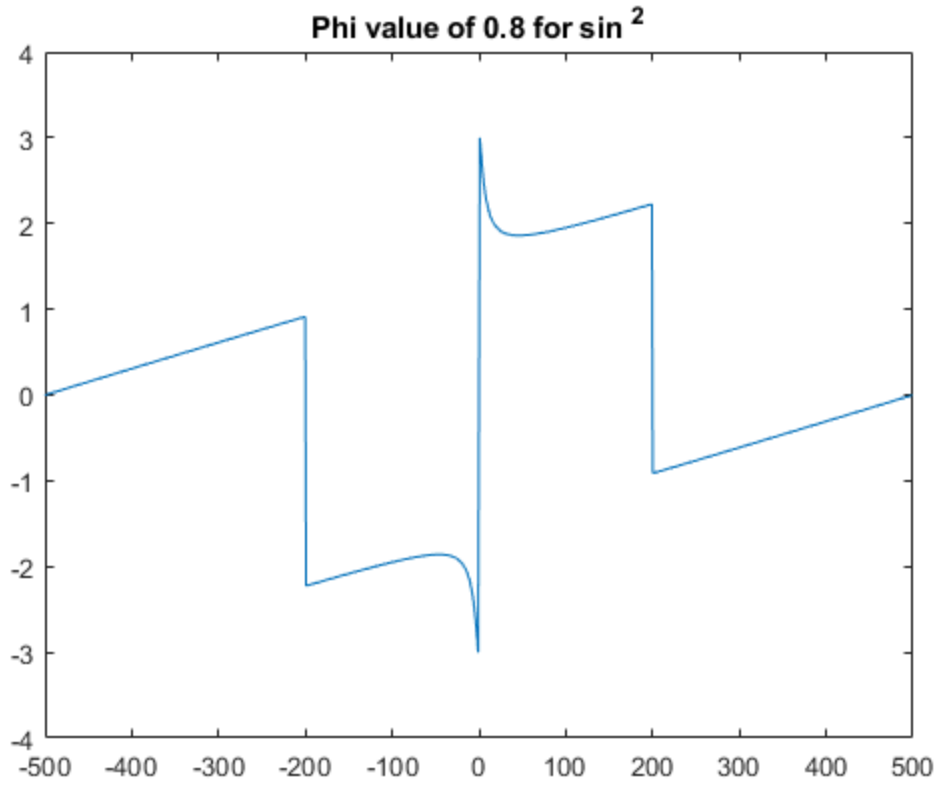

Phi value of 1.5 for sin
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-500
-400
-300
-200
-100
0
100
200
300
400
500

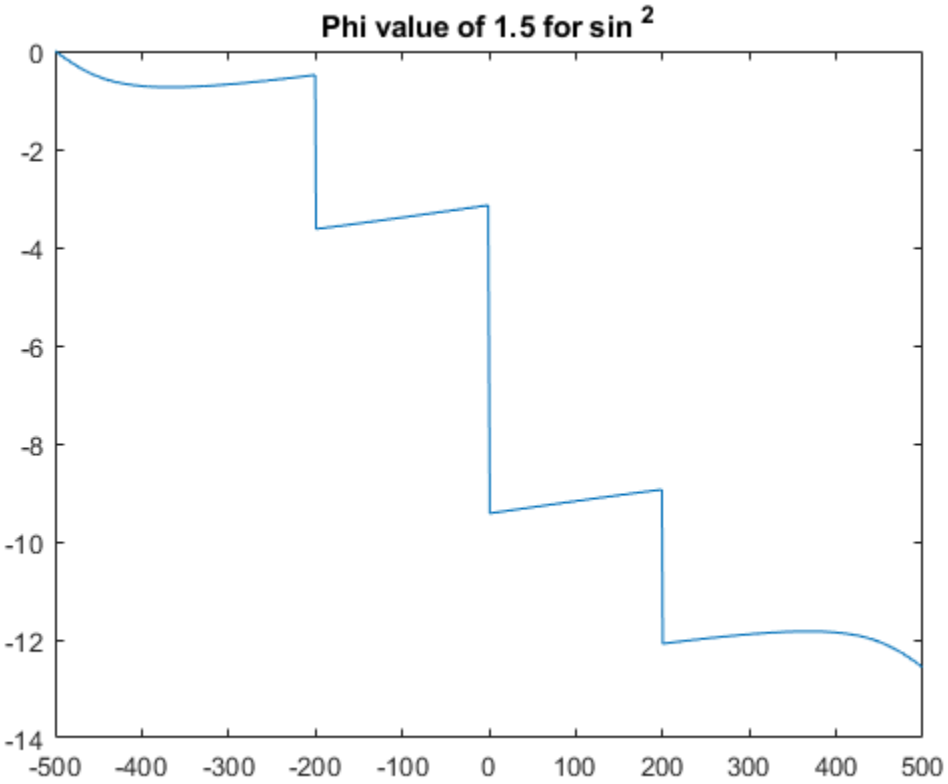

Phi value of 3.14 for sin
0
-1
-2
-3
-4
-5
-6
-500
-400
-300
-200
-100
0
100
200
300
400
500

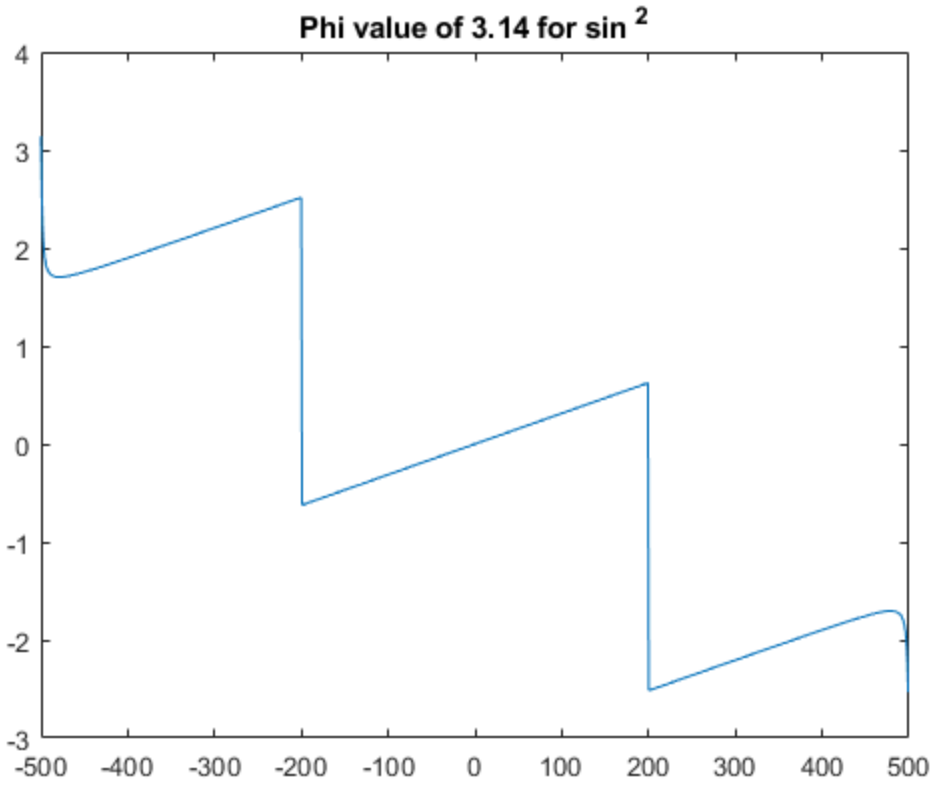

Phi value of 0 for sin 2
4
3
2
1
0
-1
-2
-3
-500
-400
-300
-200
-100
0
100
200
300
400
500


Phi value of 0.2 for sin 2
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-500
-400
-300
-200
-100
0
100
200
300
400
500


Phi value of 0.4 for sin 2
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-500
-400
-300
-200
-100
0
100
200
300
400
500


Phi value of 0.8 for sin 2
4
3
2
1
0
-1
-2
-3
-4
-500
-400
-300
-200
-100
0
100
200
300
400
500


Phi value of 1.5 for sin 2
0
-2
-4
-6
-8
-10
-12
-14
-500
-400
-300
-200
-100
0
100
200
300
400
500

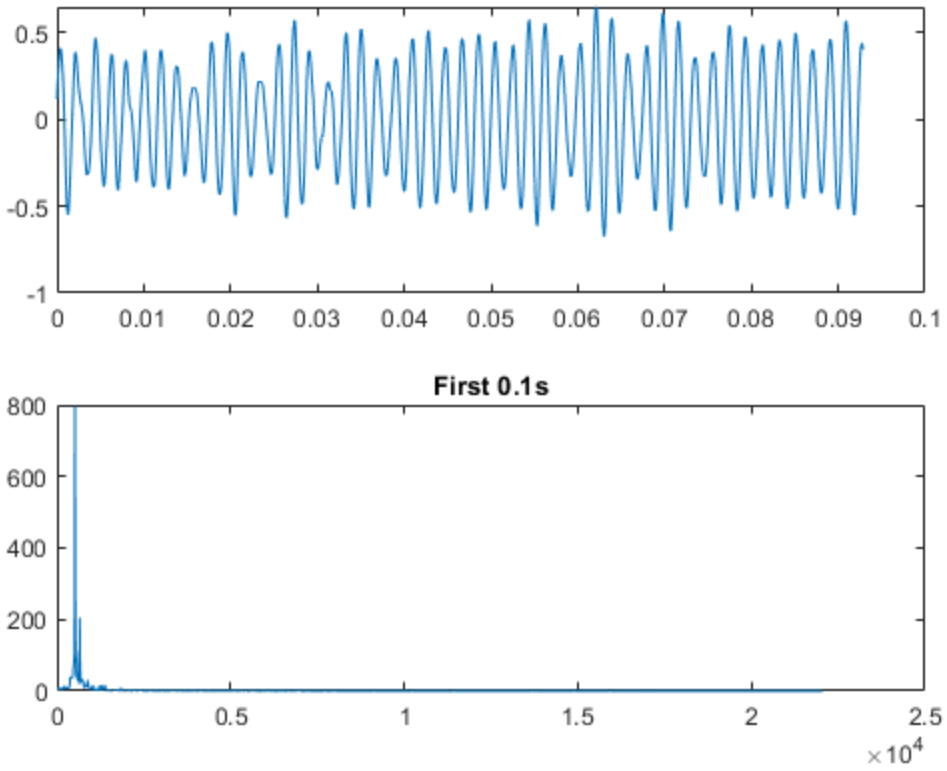


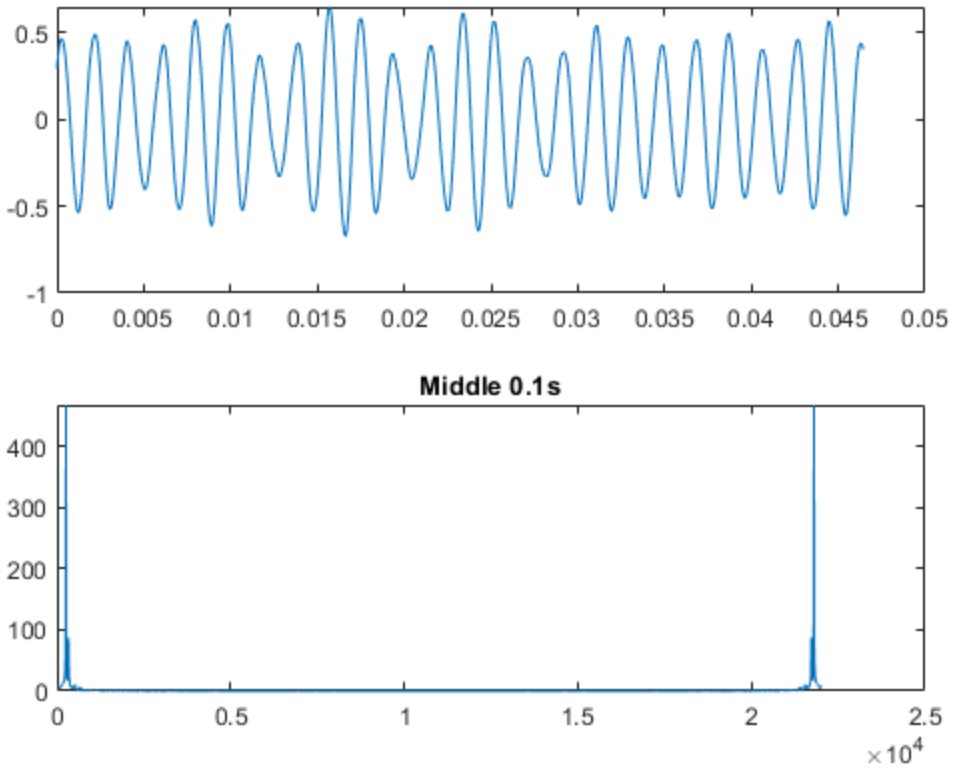
Exercise 7.10

Finding the value of N for 0.1 s s = (1/Ts) * 2 ^ N

```
filename='gong.wav' ;                % name of wave file goes here
[ x , sr ]=audioread( filename ) ;     % read in wavefile
Ts=1/ sr ;                           % sample interval and # of
 samples
N=2^12; x=x(1:N)';                   % length for analysis
sound(x , 1 / Ts )                   % play sound , if sound card
 installed
time=Ts * ( 0 : length(x)-1);  % establish time base for plotting
figure
subplot ( 2 , 1 , 1 ) , plot ( time , x )          % and plot top
 figure
magx=abs ( fft(x) ) ;                % take FFT magnitude
ssf =(0:N/2-1)/(Ts*N) ; % establish freq base for plotting
subplot( 2 , 1 , 2 ), plot( ssf, magx ( 1:N/2) ) % plot mag spectrum
title('First 0.1s');

% Exercise 7.10 Taking Middle Sample
% Taking value in the middle of the sound
filename='gong.wav' ;                % name of wave file goes here
[ x , sr ]=audioread( filename ) ;     % read in wavefile
Ts=1/ sr ;
N=2^12;
```

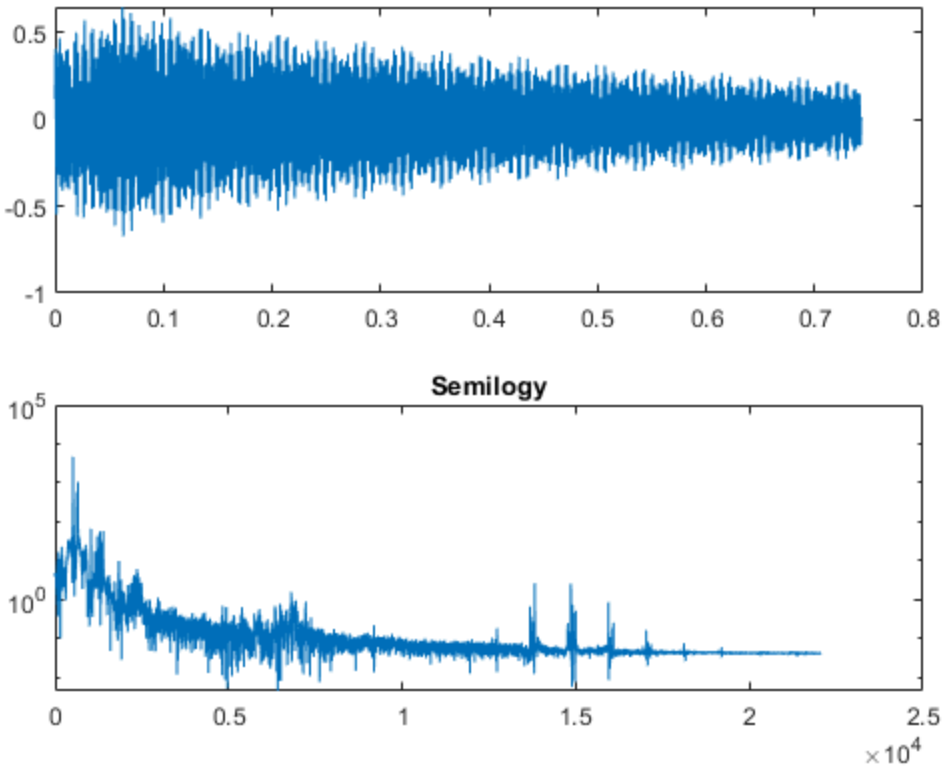
```
x=x(N/2:N)';                    % length for analysis
sound(x , 1 / Ts )                  % play sound , if sound card
 installed
time=Ts * ( 0 : length(x)-1);       % establish time base for
 plotting
figure
subplot ( 2 , 1 , 1 ) , plot ( time , x )          % and plot top
 figure
magx=abs ( fft(x) ) ;               % take FFT magnitude
ssf =(0:N/2-1)/(Ts*N) ;  % establish freq base for plotting
subplot( 2 , 1 , 2 ), plot( ssf, magx ( 1:N/2) ) % plot mag spectrum
title('Middle 0.1s');
```





Exercise 7.11

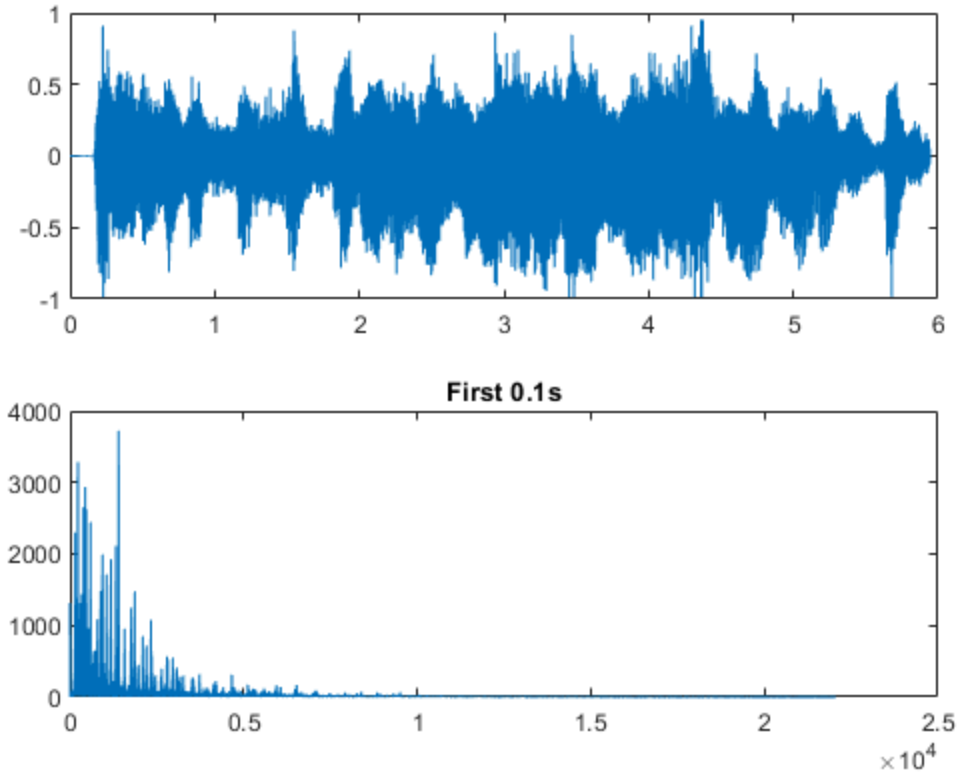
```
filename='gong.wav' ;                % name of wave file goes here
[ x , sr ]=audioread( filename ) ;     % read in wavefile
Ts=1/ sr ;                           % sample interval and # of
 samples
N=2^15; x=x(1:N)';                   % length for analysis
sound(x , 1 / Ts )                   % play sound , if sound card
 installed
time=Ts * ( 0 : length(x)-1);        % establish time base for
 plotting
figure
subplot ( 2 , 1 , 1 ) , plot ( time , x )          % and plot top
 figure
magx=abs ( fft(x) ) ;                % take FFT magnitude
ssf =(0:N/2-1)/(Ts*N) ; % establish freq base for plotting
subplot( 2 , 1 , 2 ), semilogy( ssf, magx ( 1:N/2) ) % plot mag
 spectrum
title('Semilogy');
```

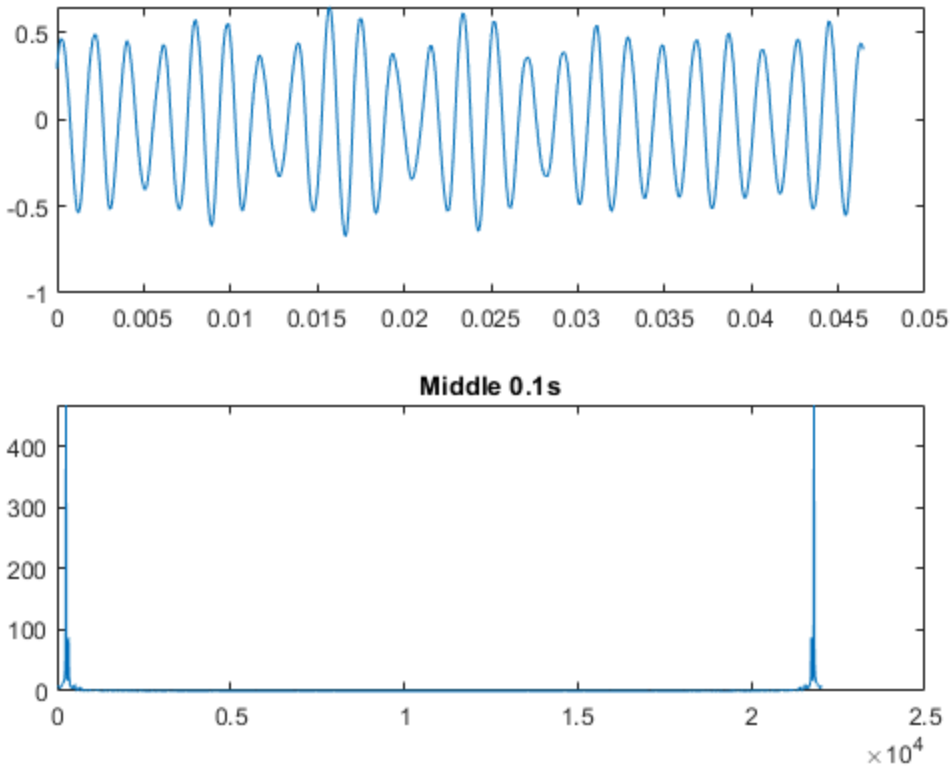


Exercise 7.13

```
filename='medieval.wav' ;                % name of wave file goes here
[ x , sr ]=audioread( filename ) ;     % read in wavefile
Ts=1/ sr ;                             % sample interval and # of
 samples
N=2^18; x=x(1:N)';                     % length for analysis
sound(x , 1 / Ts )                     % play sound , if sound card
 installed
time=Ts * ( 0 : length(x)-1);  % establish time base for plotting
figure
subplot ( 2 , 1 , 1 ) , plot ( time , x )          % and plot top
 figure
magx=abs ( fft(x) ) ;                  % take FFT magnitude
ssf =(0:N/2-1)/(Ts*N) ; % establish freq base for plotting
subplot( 2 , 1 , 2 ), plot( ssf, magx ( 1:N/2) ) % plot mag spectrum
title('First 0.1s');

% Exercise 7.10 Taking Middle Sample
% Taking value in the middle of the sound
filename='gong.wav' ;                  % name of wave file goes here
[ x , sr ]=audioread( filename ) ;     % read in wavefile
Ts=1/ sr ;
N=2^12;
x=x(N/2:N)';                    % length for analysis
```

```
sound(x , 1 / Ts )                    % play sound , if sound card
 installed
time=Ts * ( 0 : length(x)-1);         % establish time base for
 plotting
figure
subplot ( 2 , 1 , 1 ) , plot ( time , x )          % and plot top
 figure
magx=abs ( fft(x) ) ;                 % take FFT magnitude
ssf =(0:N/2-1)/(Ts*N) ;  % establish freq base for plotting
subplot( 2 , 1 , 2 ), plot( ssf, magx ( 1:N/2) ) % plot mag spectrum
title('Middle 0.1s');
```





Exercise 7.15

```
clc
clear all
a=[0.9] ; lena=length ( a)-1; % autor egr es s ive c o e f f i c i e n
 t s
b= [2] ; lenb=length (b ) ; % moving average c o e f f i c i e n t s
d=randn ( 1 ,20) ;
h=impz (b , a );
if lena>=lenb  % dimpulse needs lena>=lenb % impulse response of f i l
 t e r
yfilt=filter(h , 1 , d) % f i l t e r x [ k ] with h [ k ]
end
IIR=filter(b , a , d)



% Creating FIR
FIR = conv(h,d);
disp('IIR Results');
disp(IIR)
disp('FIR Results');
disp(FIR);
disp('Results are nearly identical');
```

```
IIR =

  Columns 1 through 7

    0.5992    1.0984   -3.2958   -2.2673   -0.9933    0.2437    2.5083

  Columns 8 through 14

   -0.6444    2.8034    1.0565    2.6091    0.2821   -1.4596   -3.2920

  Columns 15 through 20

    0.3455    1.8190   -0.6502   -1.2017   -0.6859   -2.4369

IIR Results
  Columns 1 through 7

    0.5992    1.0984   -3.2958   -2.2673   -0.9933    0.2437    2.5083

  Columns 8 through 14

   -0.6444    2.8034    1.0565    2.6091    0.2821   -1.4596   -3.2920

  Columns 15 through 20

    0.3455    1.8190   -0.6502   -1.2017   -0.6859   -2.4369

FIR Results
  Columns 1 through 7

    0.5992    1.0984   -3.2958   -2.2673   -0.9933    0.2437    2.5083

  Columns 8 through 14

   -0.6444    2.8034    1.0565    2.6091    0.2821   -1.4596   -3.2920

  Columns 15 through 20

    0.3455    1.8190   -0.6502   -1.2017   -0.6859   -2.4369

Results are nearly identical
```

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