BME 306 Lab 4 - Fourier Analysis Introduction

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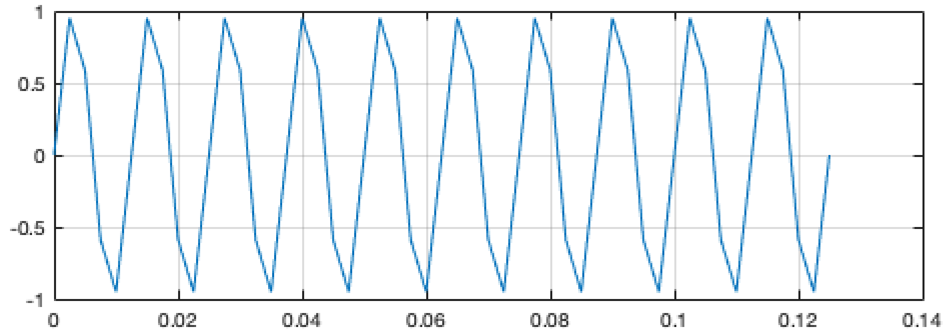
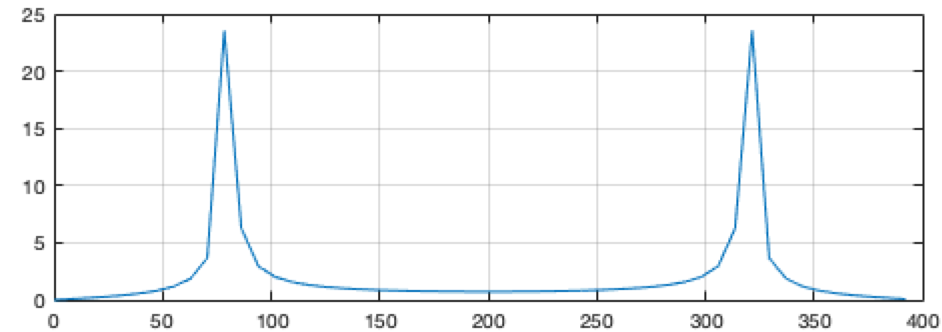
Alexander Ross 10/14/19

Question 1

```
fs = 400;
t = 0:1/fs:0.125;
s = sin(2*pi*80*t);
DTF = abs(fft(s));

N = length(t)
t2 = 0:(fs/N):(400-(400/N));

figure();
subplot(2,1,1)
plot(t,s);
grid on
hold on
subplot(2,1,2)
plot(t2,DTF)
grid on

% Frequencies of the peaks: 78.4314, 321.5686
```

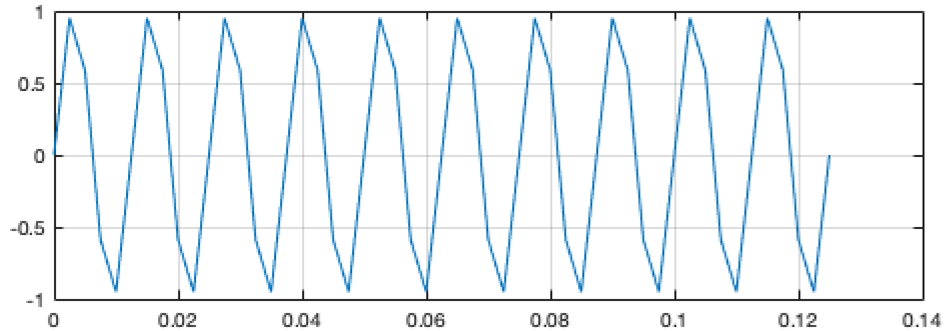
```
N =

    51
```

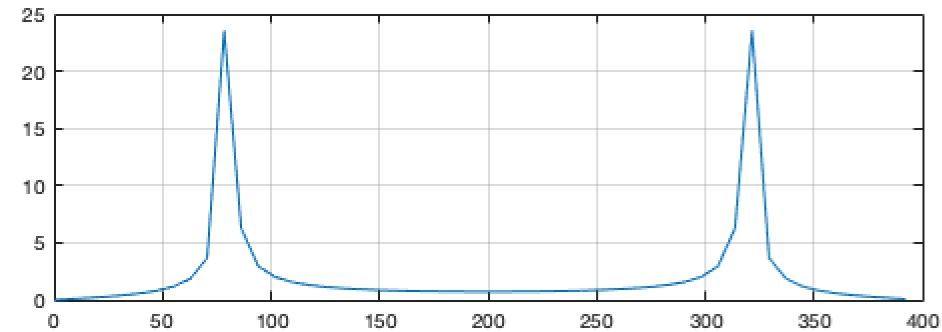


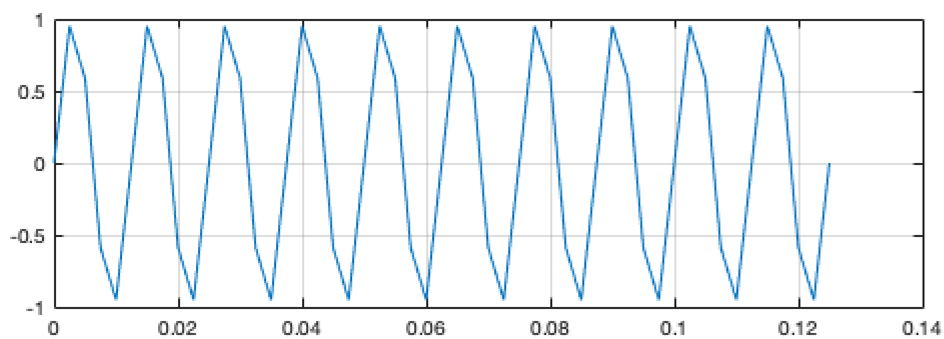


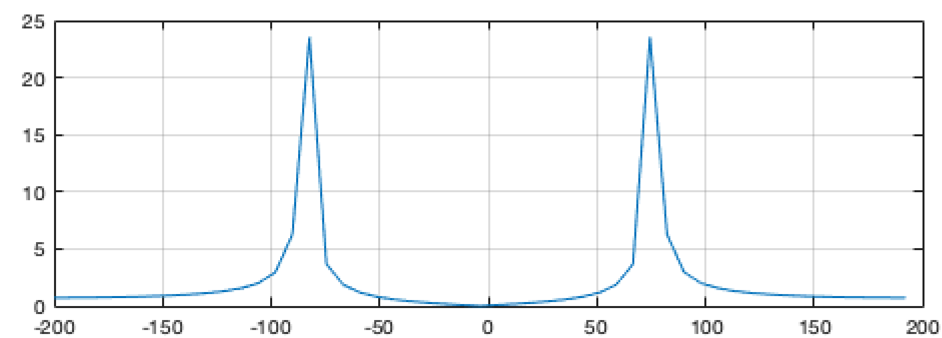
Question 2

```
fs = 400;
t = 0:1/fs:0.125;
s = sin(2*pi*80*t);
DTF = fftshift(abs(fft(s)));

N = length(DTF);
t2 = (-fs/2):(fs/N):400/2-400/N;

figure();
subplot(2,1,1)
plot(t,s);
grid on
hold on
subplot(2,1,2)
plot(t2,DTF)
grid on

% Answer: -82.3529, 74.5098
```


1
0.5
0
-0.5
-1
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14

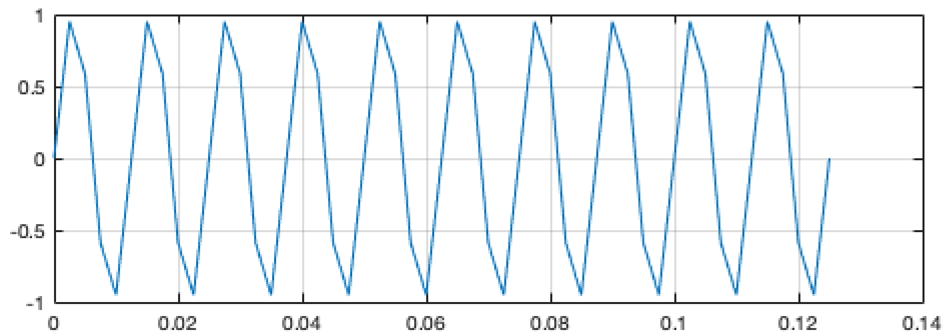

25
20
15
10
5
0
0 50 100 150 200 250 300 350 400

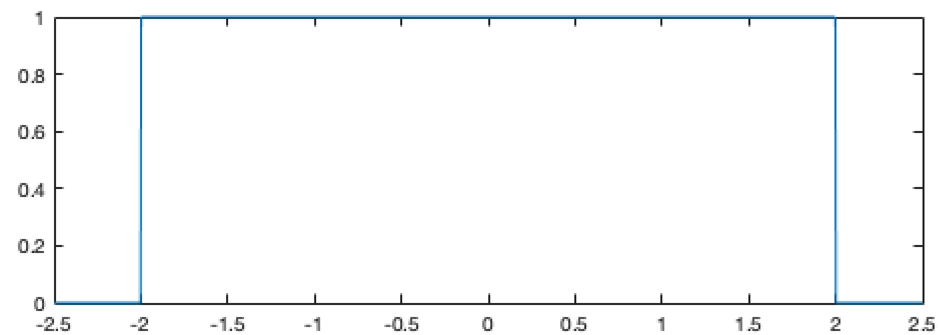

1
0.5
0
-0.5
-1
0 0.02 0.04 0.06 0.08 0.1 0.12 0.14


25
20
15
10
5
0
-200 -150 -100 -50 0 50 100 150 200

Question 3

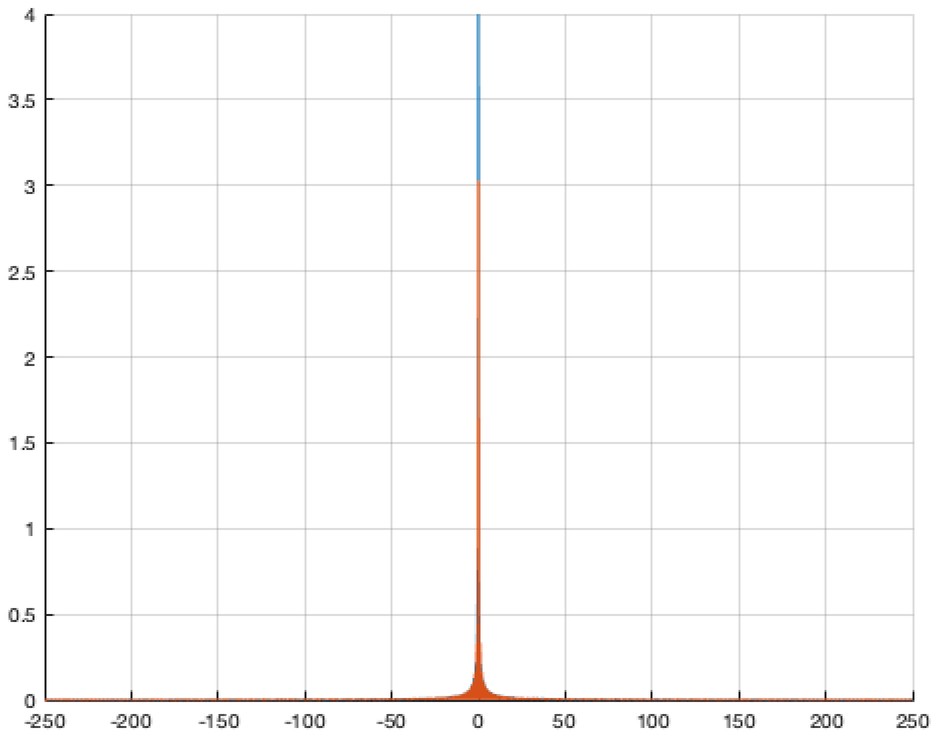
```
t = -2.5:1/500:2.5;
s = rectangularPulse(-2,2,t);
plot(t,s);
```





Question 4

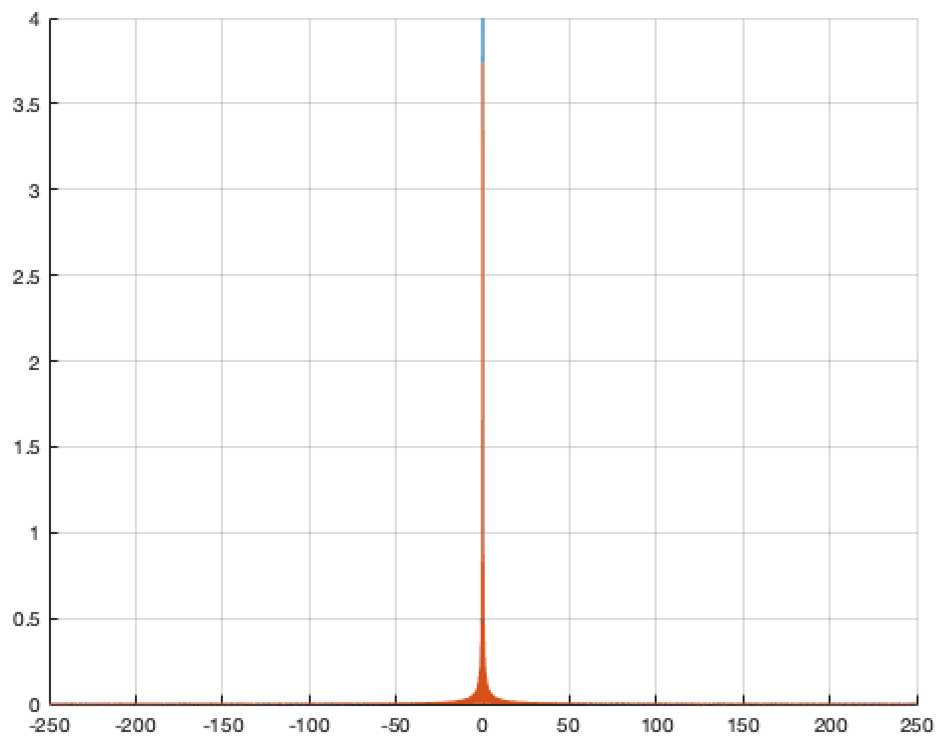
```
fs = 500;
t = -2.5:1/500:2.5;
s = rectangularPulse(-2,2,t);

N = length(t);
t2 = (-fs/2):(fs/N):500/2-500/N;

s2 = abs(4*sinc(4*t2));
s3 = 1/fs*fftshift(abs(fft(s)));

figure();
hold on
plot(t2,s3);
plot(t2,s2)
grid on
hold off
```

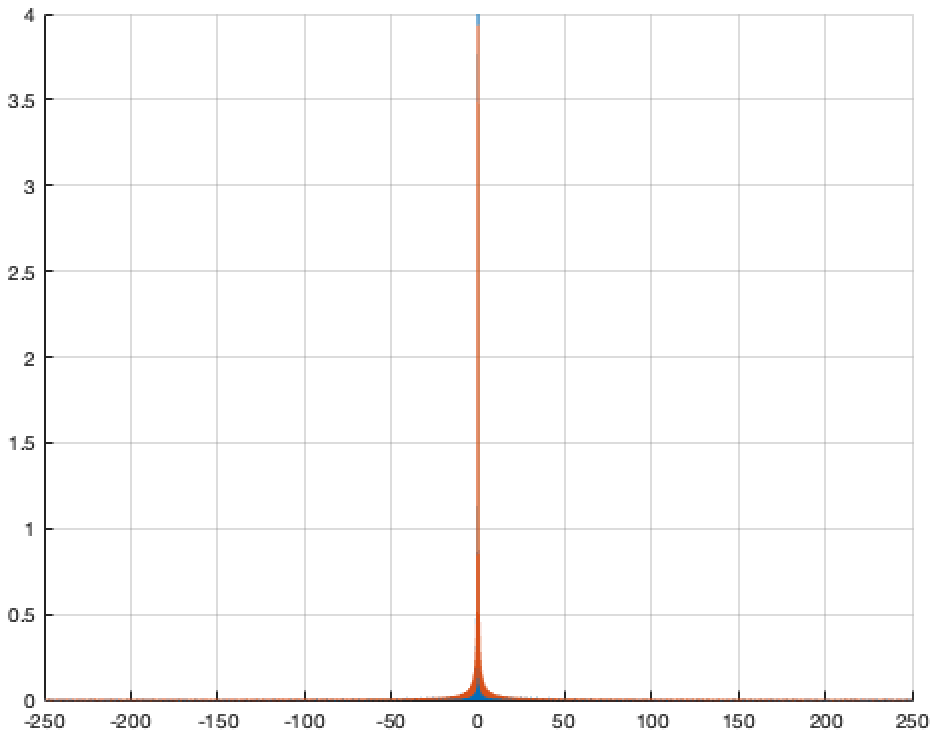


Question 5

```
fs = 500;
t = -5:1/500:5;
s = rectangularPulse(-2,2,t);

N = length(t);
t2 = (-fs/2):(fs/N):500/2-500/N;

s2 = abs(4*sinc(4*t2));
s3 = 1/fs*fftshift(abs(fft(s)));

figure();
hold on
plot(t2,s3);
plot(t2,s2)
grid on
hold off


% -----------

fs = 500;
t = -10:1/500:10;
s = rectangularPulse(-2,2,t);
```

```
N = length(t);
t2 = (-fs/2):(fs/N):500/2-500/N;

s2 = abs(4*sinc(4*t2));
s3 = 1/fs*fftshift(abs(fft(s)));

figure();
hold on
plot(t2,s3);
plot(t2,s2)
grid on
hold off

% Answer: Increasing the length of the time vector makes the amplitude
 of
% the plots closer together.  The analytical solution becomes more
% accurate as the time vector.
```

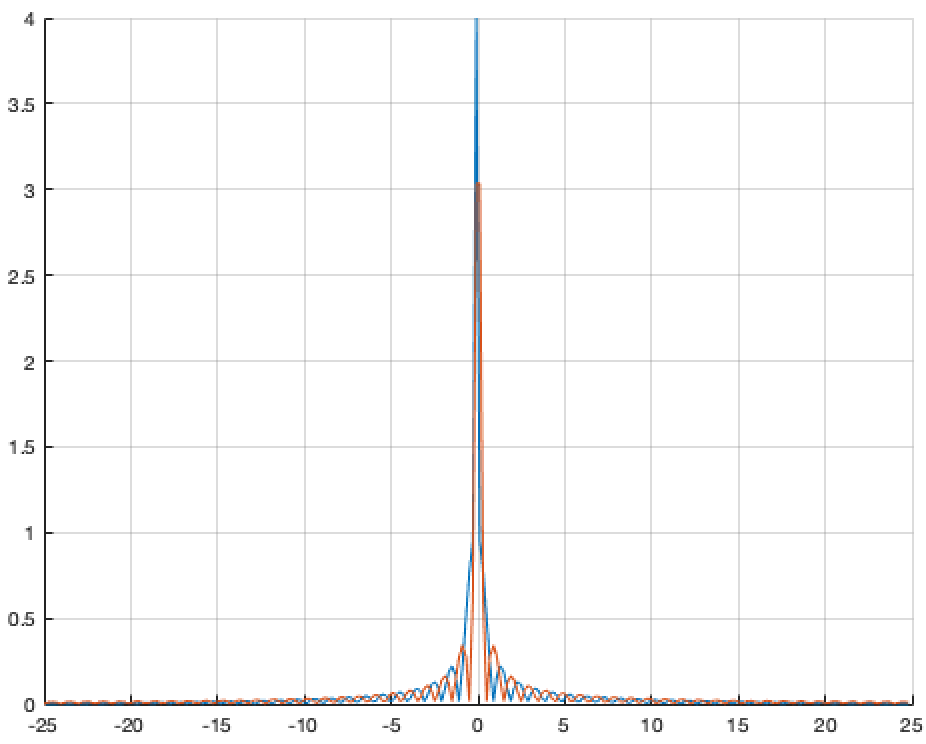


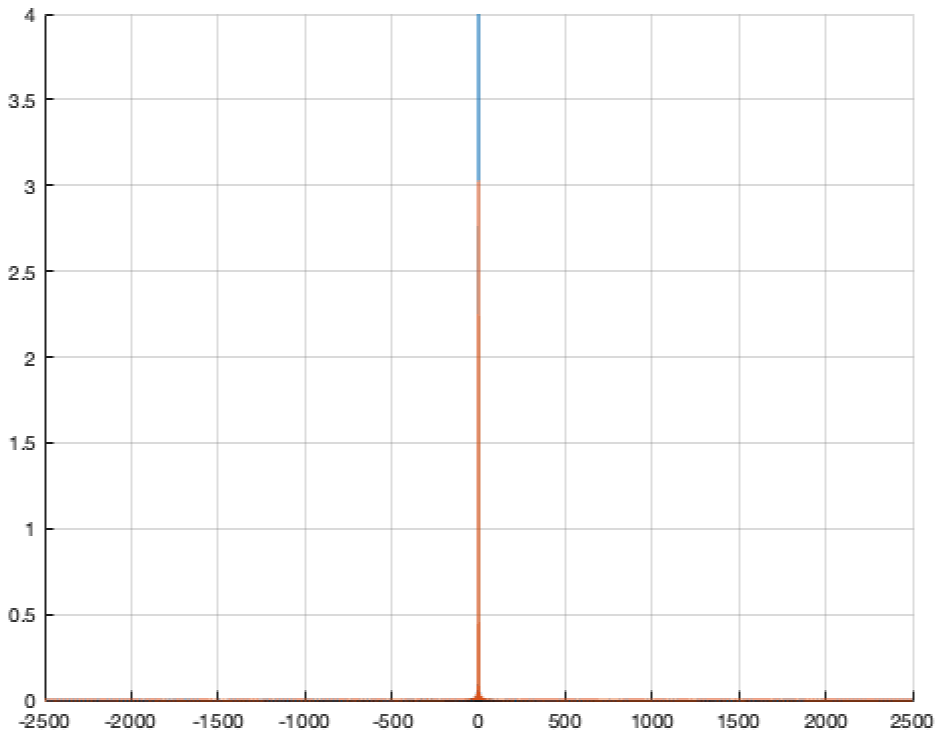


Question 6

```
fs = 50;
t = -2.5:1/50:2.5;
s = rectangularPulse(-2,2,t);

N = length(t);
t2 = (-fs/2):(fs/N):50/2-50/N;

s2 = abs(4*sinc(4*t2));
s3 = 1/fs*fftshift(abs(fft(s)));

figure();
hold on
plot(t2,s3);
plot(t2,s2)
grid on
hold off


% -----------

fs = 5000;
t = -2.5:1/5000:2.5;
s = rectangularPulse(-2,2,t);
```

```
N = length(t);
t2 = (-fs/2):(fs/N):5000/2-5000/N;

s2 = abs(4*sinc(4*t2));
s3 = 1/fs*fftshift(abs(fft(s)));

figure();
hold on
plot(t2,s3);
plot(t2,s2)
grid on
hold off

% Comparison: The plot of 50Hz is more accurate, while 5000Hz is less
 accurate for the
% analytical solution than at 500Hz.  The amplitude overlap of the two
% functions is significantly increased at 50Hz, and is reduced at
 5000Hz.
% Additionally, the time vector from the previous problem
% changed, so the dimensions of the plotted function are different.
```





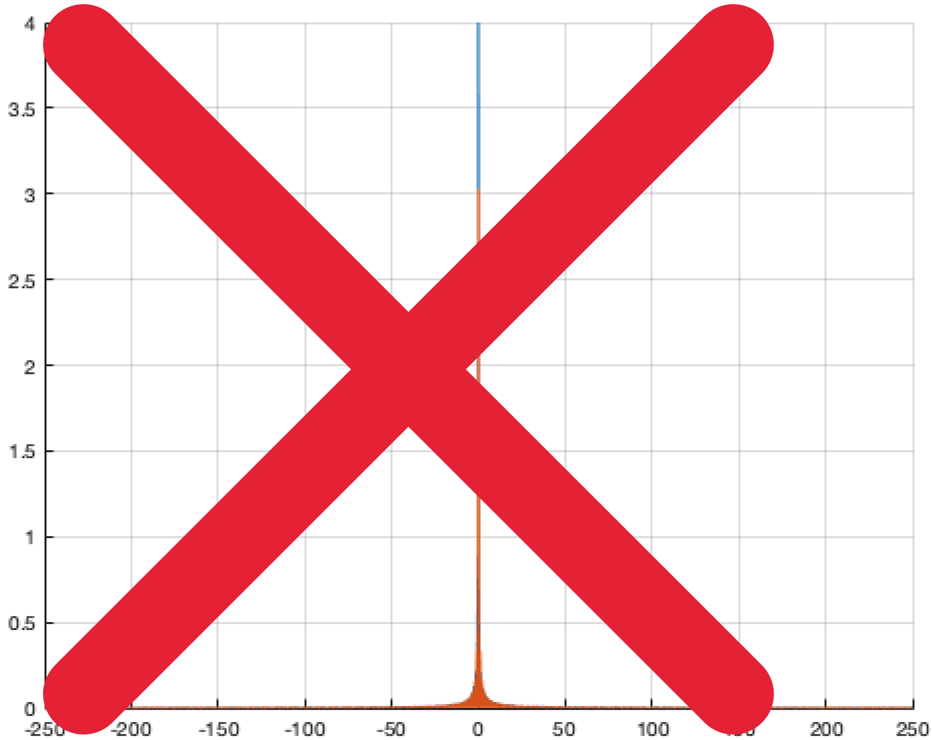
Question 7

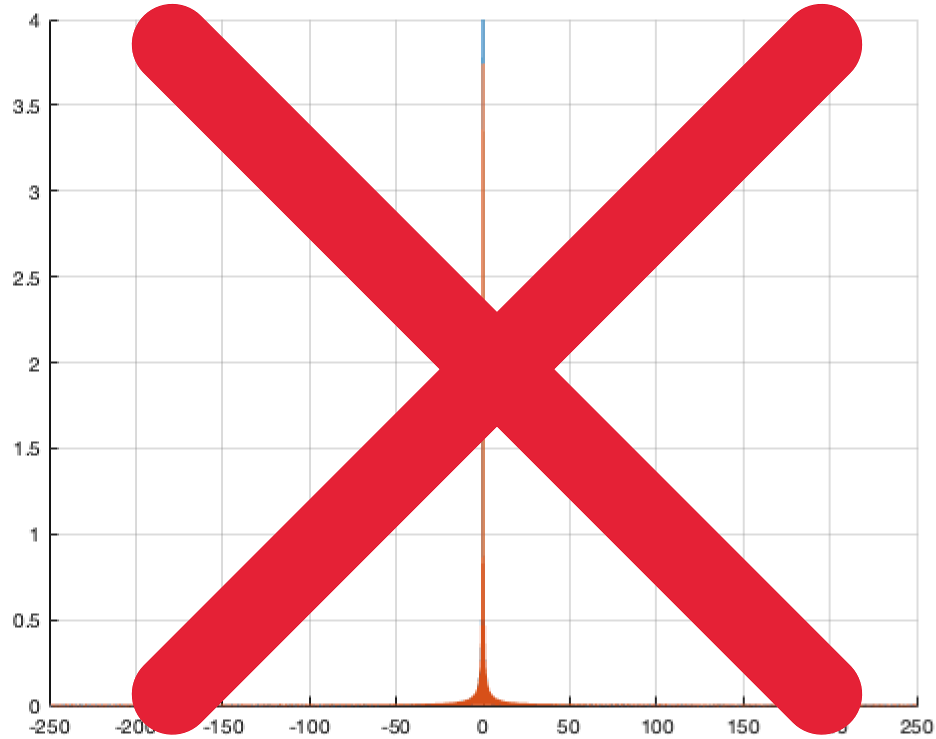
```
% The spectra from Question 5 with the longest time vector showed the
 most
% accurate depiction of the continious-time signal.  Longer time
 vector is
% directly related to how well the analytical solution matches the
% continous time signal
```

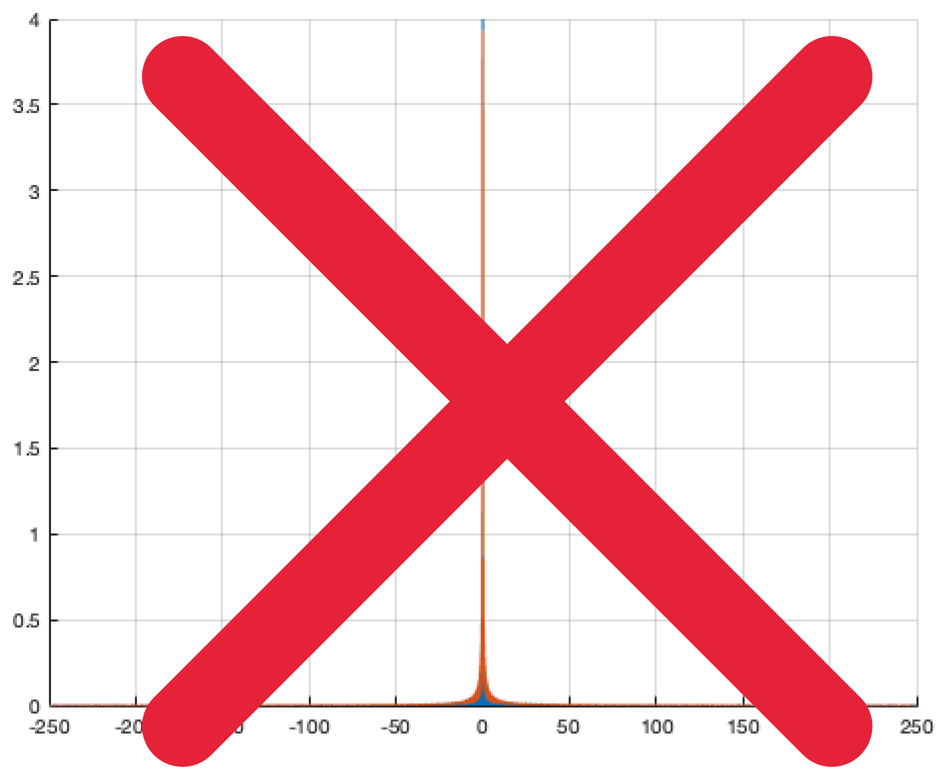
Question 8

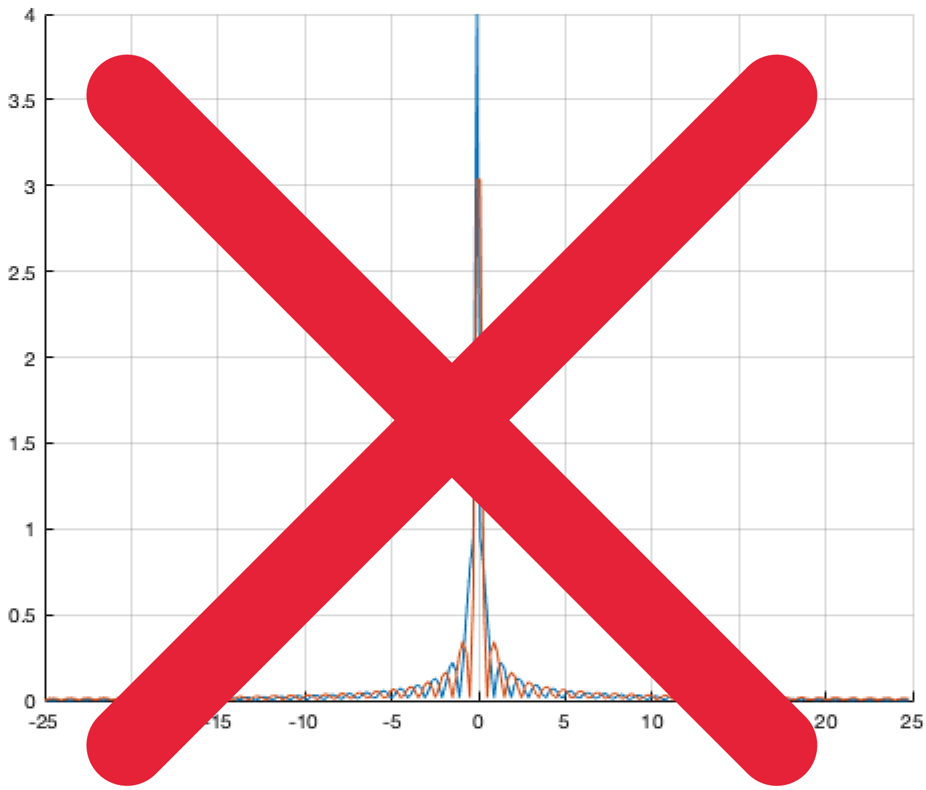
```
t = 20;

myVoice = audiorecorder;

pause(2);

% Define callbacks to show when
% recording starts and completes.
myVoice.StartFcn = 'disp(''Start speaking.'')';
recordblocking(myVoice,t);
myVoice.StopFcn = 'disp(''End of recording.'')';

doubleArray = getaudiodata(myVoice);
```

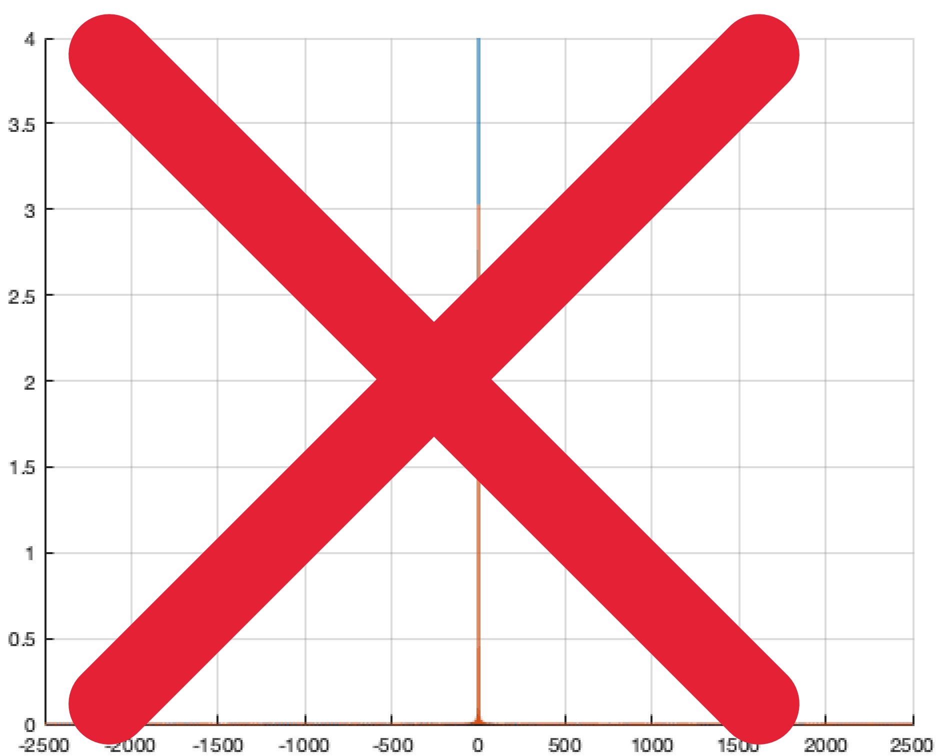
`Start speaking.`




4
3.5
3
2.5
2
1.5
1
0.5
0
-250
-150
-100
-50
0
50
100
150
250


4
3.5
3
2.5
2
1.5
1
0.5
0
-250
-100
-50
0
50
100
150
250


4
3.5
3
2.5
2
1.5
1
0.5
0
-25
-15
-10
-5
0
5
10
20
25


4
3.5
3
2.5
2
1.5
1
0.5
0
-2500
-2000
-1500
-1000
-500
0
500
1000
2000
2500

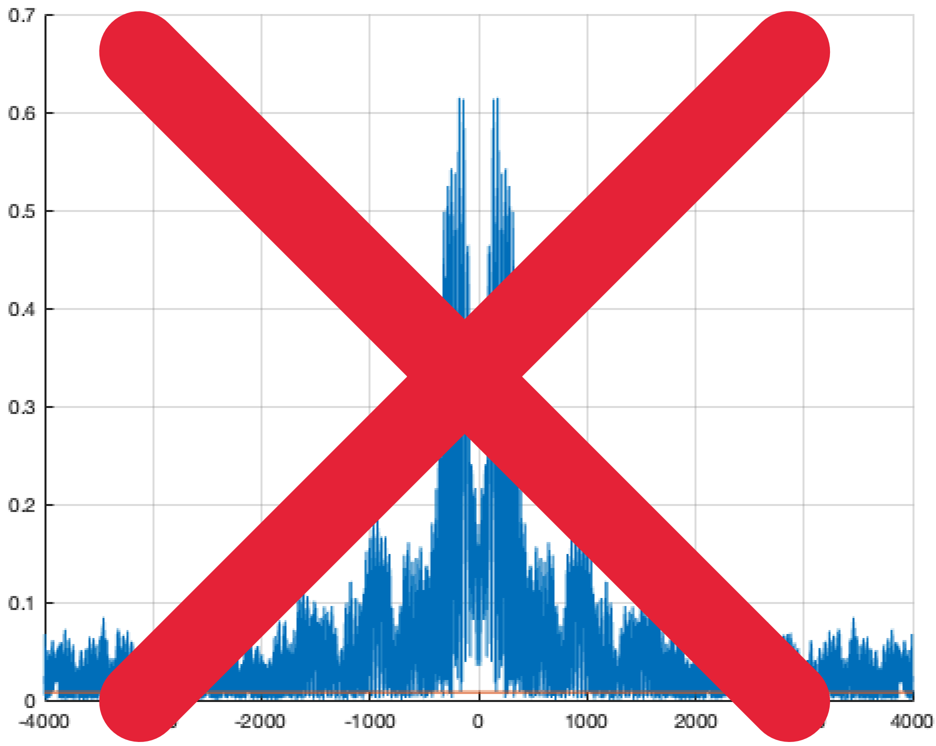
Question 9

```
t = 20;

myVoice2 = audiorecorder;

pause(2);

% Define callbacks to show when
% recording starts and completes.
myVoice2.StartFcn = 'disp(''Start speaking.'')';
recordblocking(myVoice2,t);
myVoice2.StopFcn = 'disp(''End of recording.'')';

doubleArray2 = getaudiodata(myVoice2);
```

```
Start speaking.
```

Question 10

```
fs = 8000;
t = (0:1/40:fs/2)';

N = length(t)-1;
t2 = (-(fs/2):(fs/(N)):(8000/2-8000/N))';

s1 = fftshift(abs(fft(doubleArray)));
s2 = fftshift(abs(fft(doubleArray2)));

figure();
hold on
plot(t2,s1);
plot(t2,s2)
grid on
hold off
```



Question 11

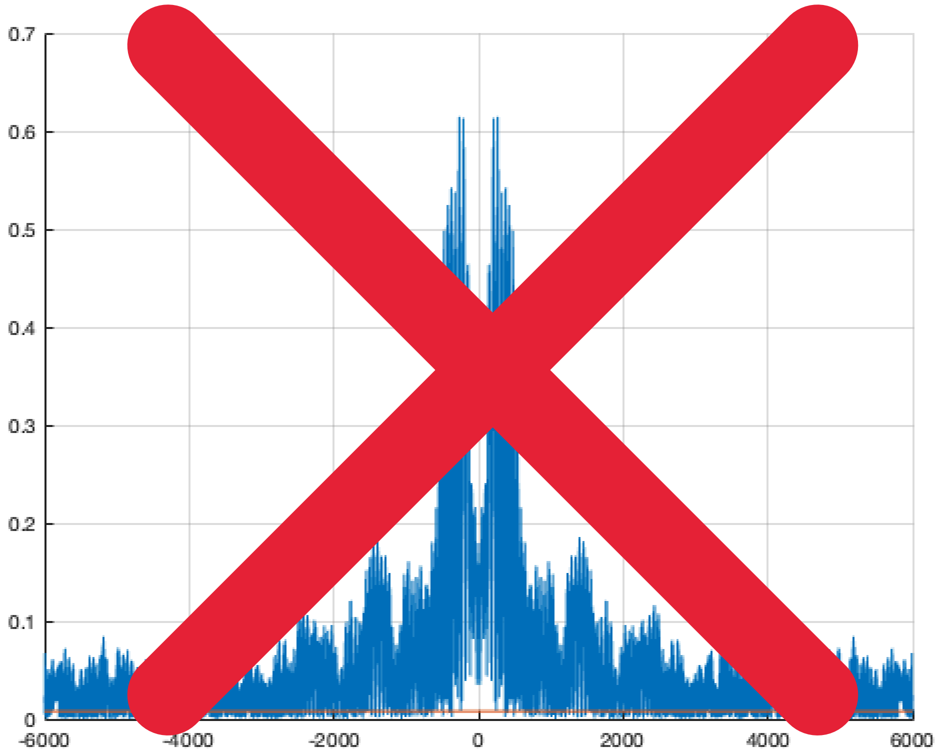
```
cuttoff1 = 0.05*max(s1);
cuttoff2 = 0.05*max(s2);

width1 = [];
width2 = [];

for ii = 1:length(s1)
    if s1(ii) >= cuttoff1
        width1 = [width1, t2(ii)];
    end
end

for jj = 1:length(s2)
    if s2(jj) >= cuttoff2
        width2 = [width2, t2(jj)];
    end
end

fprintf('The bandwidth spans from %f. Hz to %f. Hz\n', width1(1),
 width1(length(width1)));
fprintf('The bandwidth spans from %f. Hz to %f. Hz\n', width2(1),
 width2(length(width2)));
```

```
% Output:
%The bandwidth spans from -1057.650000. Hz to 1057.650000. Hz
%The bandwidth spans from -1040.800000. Hz to 1040.800000. Hz
```

The bandwidth spans from -3999.800000. Hz to 3999.800000. Hz
The bandwidth spans from -4000.000000. Hz to 3999.950000. Hz

Question 12

```
fs = 12000;
t = (0:1/26.66666664:fs/2)';

N = length(t);
t2 = (-(fs/2):(fs/(N)):12000/2-12000/N)';

s1 = fftshift(abs(fft(doubleArray)));
s2 = fftshift(abs(fft(doubleArray2)));

figure();
hold on
plot(t2,s1);
plot(t2,s2)
grid on
hold off

% Answer: The amplitude of the spectra at frequencies of about 4000Hz
 are
% approxmiately 10-20 units.  It is not important to capture these
 frequencies
% in the cochlear implant program because these frequencies are beyond
 the
% range of human hearing.  This can be seen in the attached graph, as
 the
% amplitude of frequencies beyond 4000Hz is not significant to the
 broader
% spectra
```



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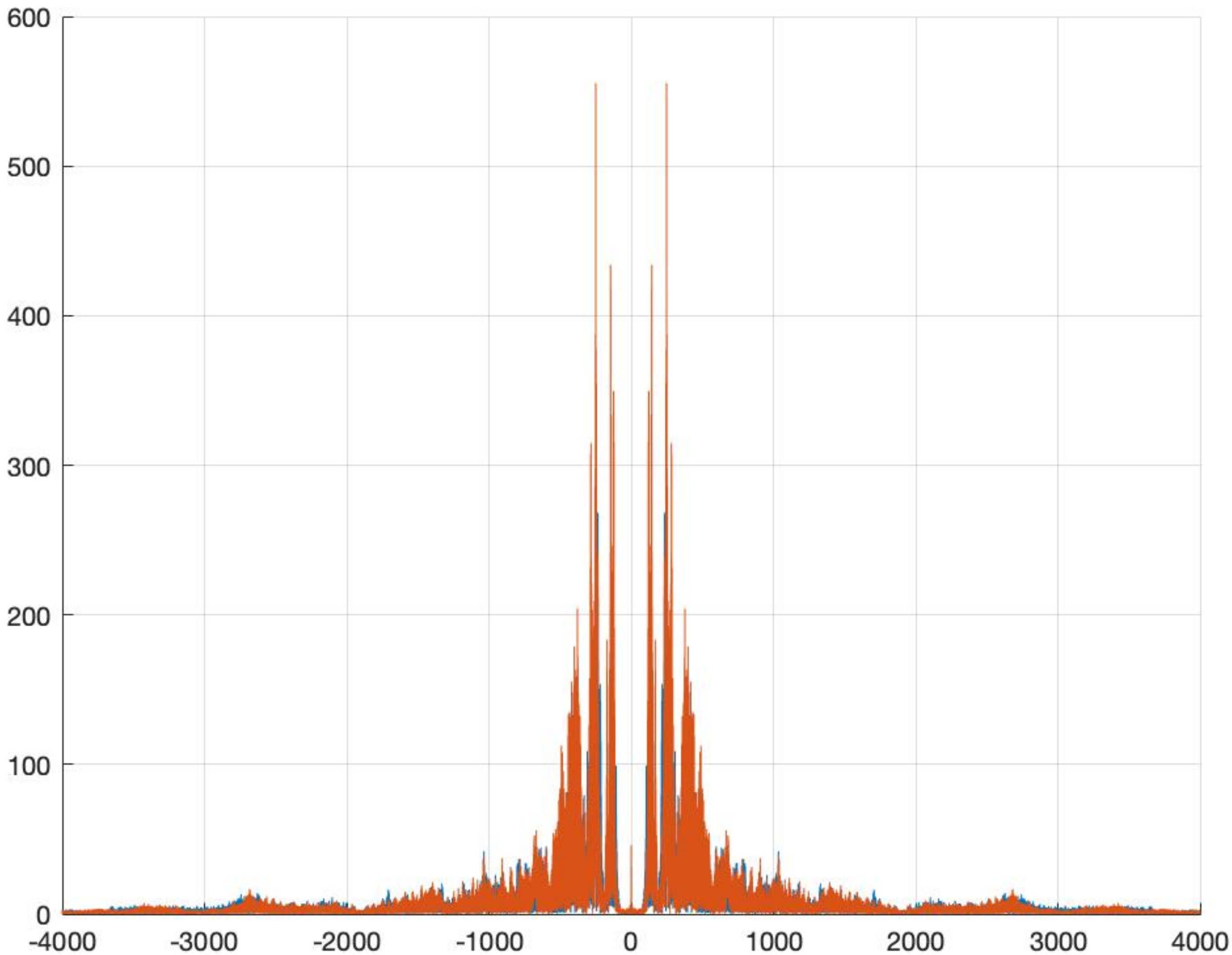
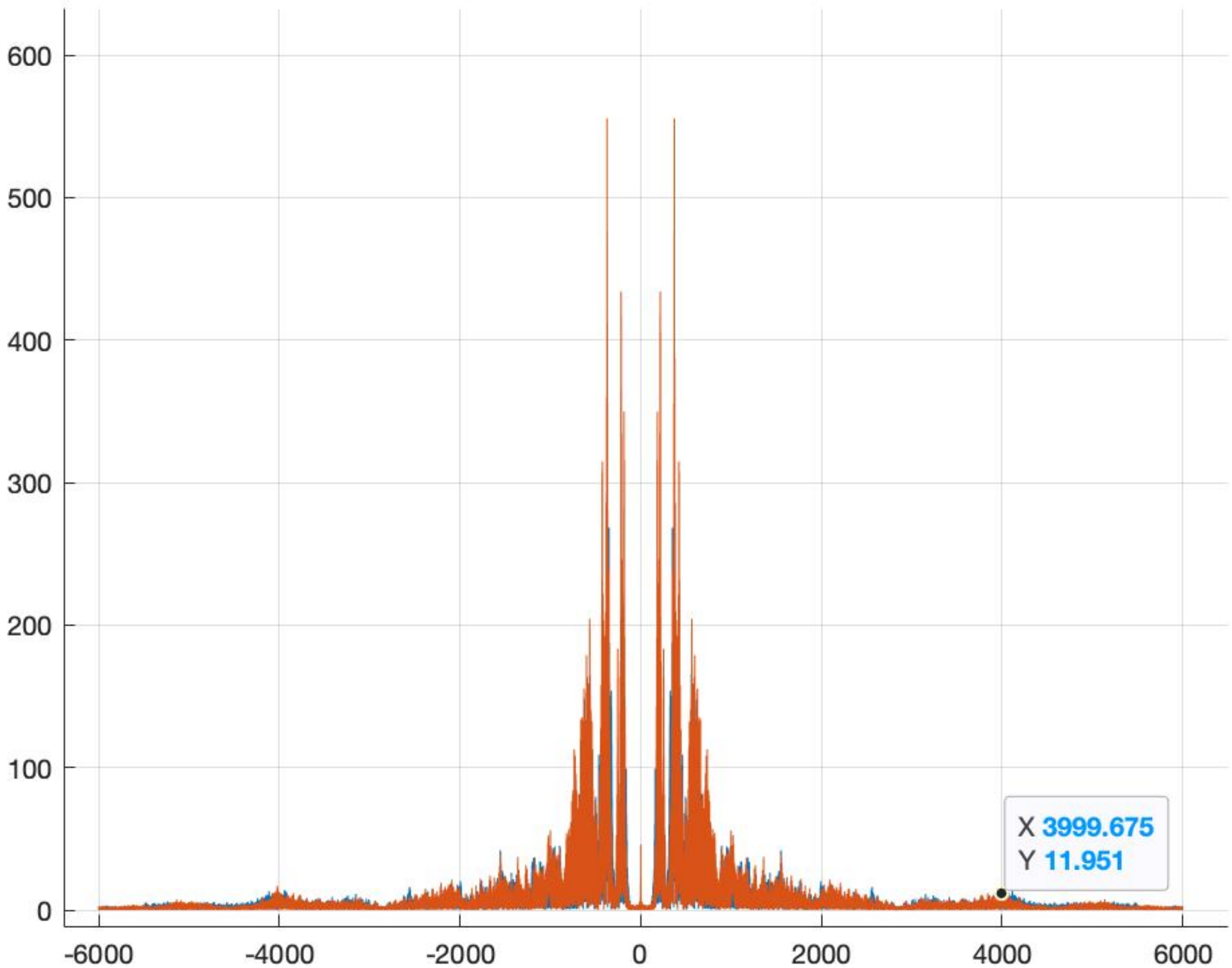
Question 10



600
500
400
300
200
100
0
-4000
-3000
-2000
-1000
0
1000
2000
3000
4000

Question 12



600
500
400
300
200
100
0
-6000
-4000
-2000
0
2000
4000
6000
X 3999.675
Y 11.951