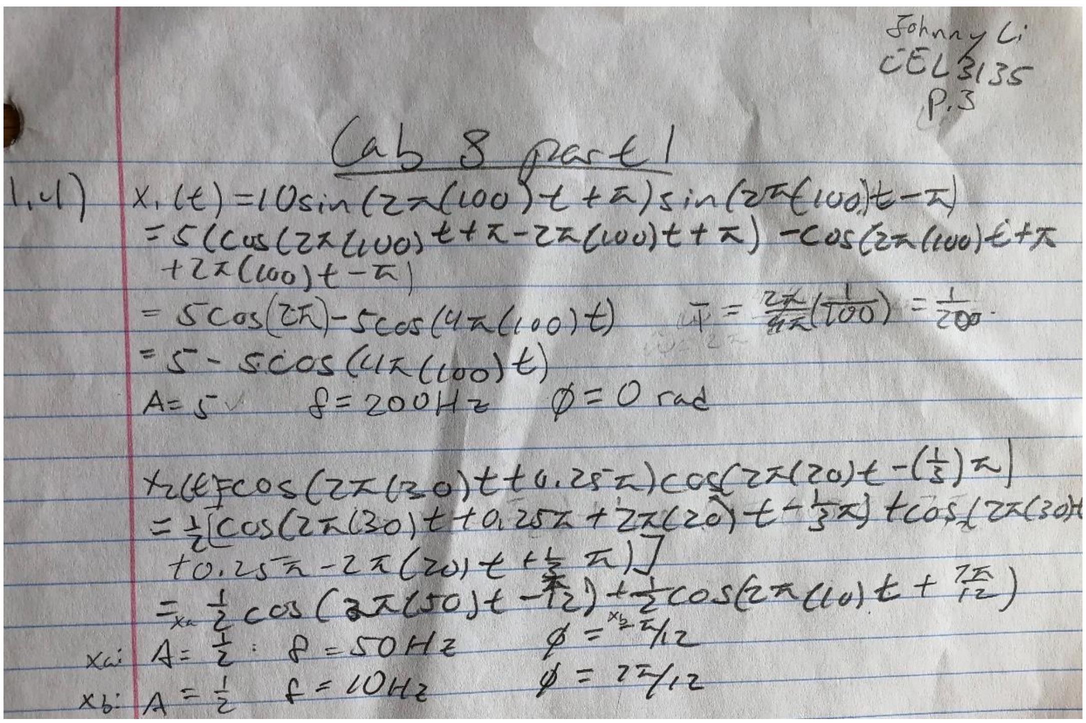
```
diary on
format compact
%Johnny Li
%EEL3135 Fall 2018
%Lab 8 Part 1

%1.4

%Rewrite the following signals, by hand, as a sum of sinusoids.
%Identify the amplitude, frequency, and phase of each sinusoidal component.
%x1(t)=10sin(2pi(100)t+pi)sin(2pi(100)t+pi)
%x2(t)=cos(2pi(30)t+0.25pi)cos(2pi(20)t-(1/3)pi)
```



Johnny Li
EEL3135
P.3

Lab 8 part 1

1.4) $x_1(t)=10\sin(2\pi(100)t+\pi)\sin(2\pi(100)t-\pi)$

$=5(\cos(2\pi(100)t+\pi-2\pi(100)t+\pi)-\cos(2\pi(100)t+\pi+2\pi(100)t-\pi)$

$=5\cos(2\pi)-5\cos(4\pi(100)t)$ $\qquad \frac{2\pi}{4\pi}(\frac{1}{100})=\frac{1}{200}$

$=5-5\cos(4\pi(100)t)$

$A=5$ $\quad f=200Hz$ $\quad \phi=0$ rad

$x_2(t)=\cos(2\pi(30)t+0.25\pi)\cos(2\pi(20)t-(\frac{1}{3})\pi)$

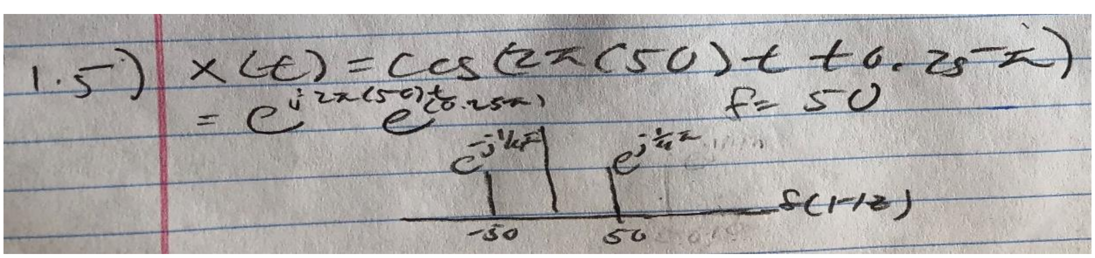
$=\frac{1}{2}[\cos(2\pi(30)t+0.25\pi+2\pi(20)t-\frac{1}{3}\pi)+\cos(2\pi(30)t+0.25\pi-2\pi(20)t+\frac{1}{3}\pi)]$

$=\frac{1}{2}\cos(2\pi(50)t-\frac{\pi}{12})+\frac{1}{2}\cos(2\pi(10)t+\frac{7\pi}{12})$

x_a: $A=\frac{1}{2}$ $\quad f=50Hz$ $\quad \phi=-\pi/12$

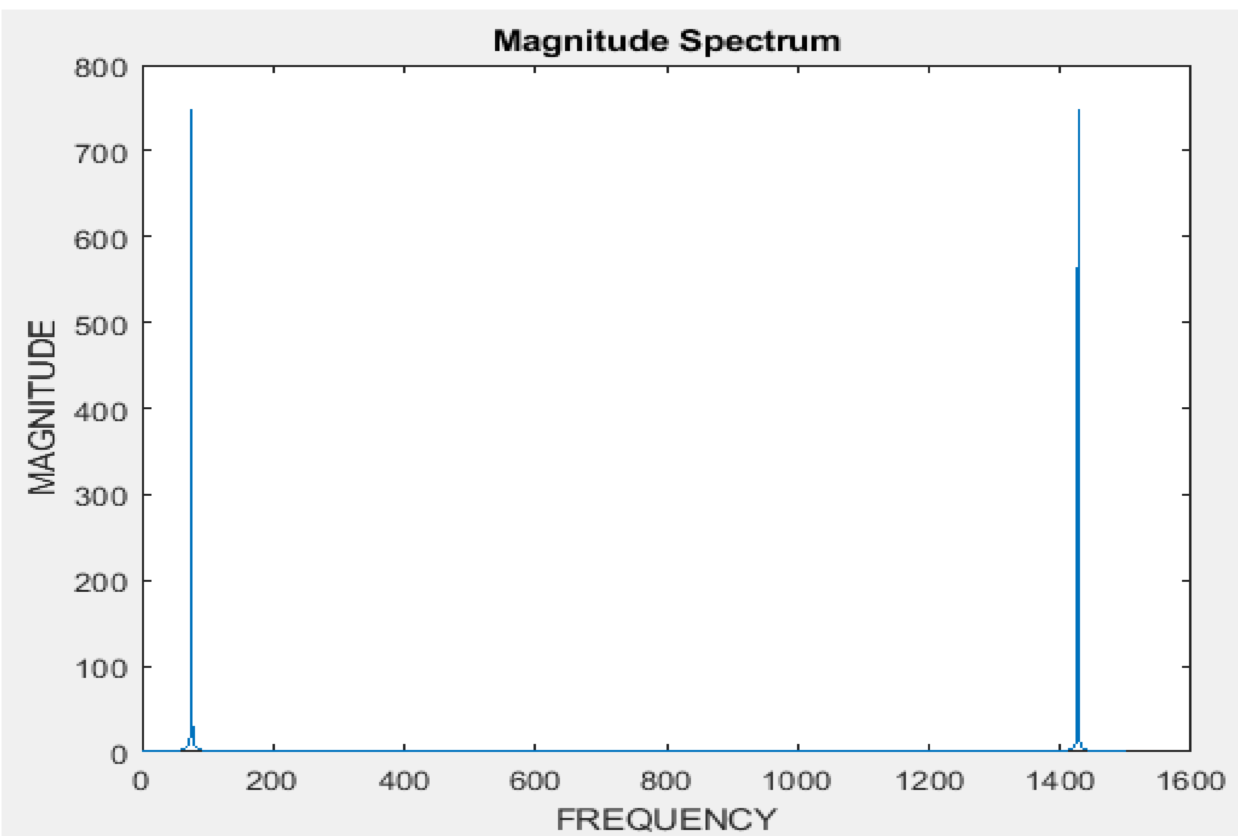
x_b: $A=\frac{1}{2}$ $\quad f=10Hz$ $\quad \phi=7\pi/12$

```
%1.5

%Plot the continuous-time frequency spectrum of this signal by hand.
%x(t)=cos(2pi(50)+0.25pi)
```

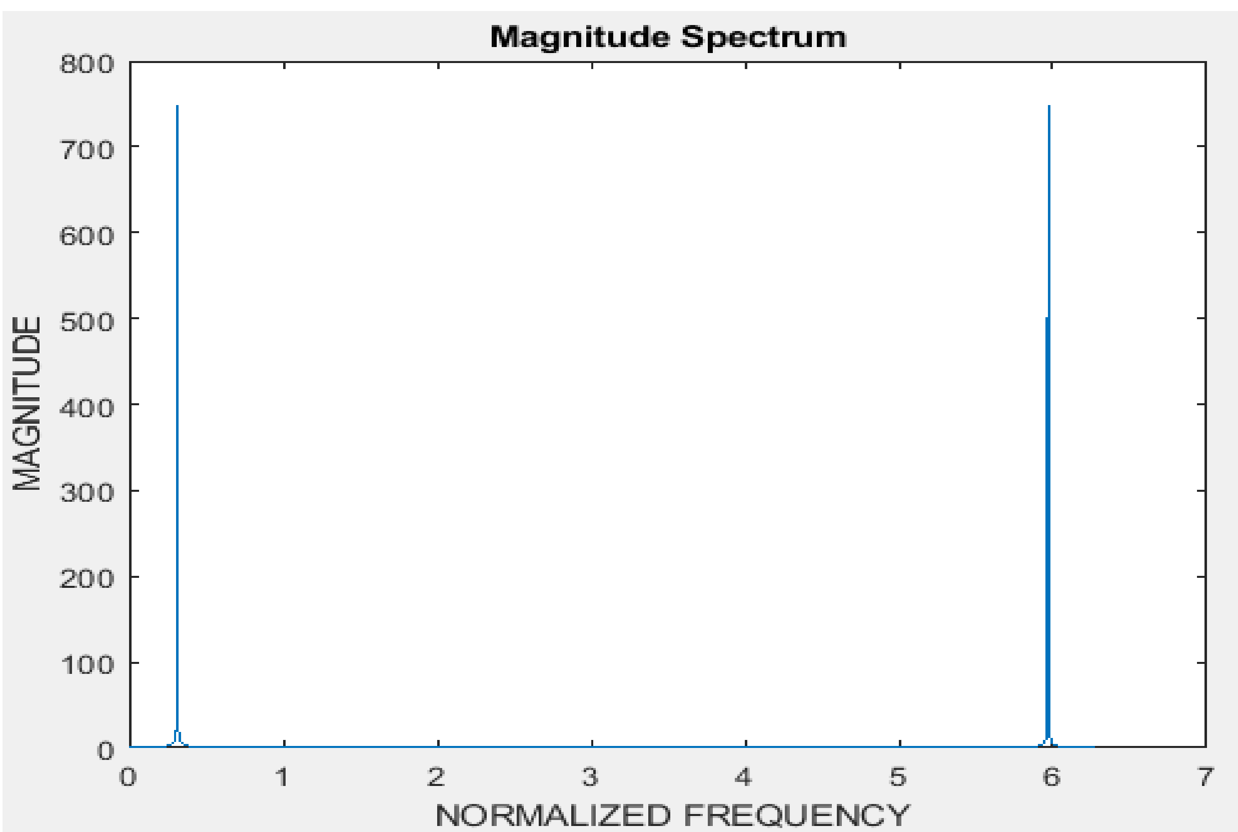



```
%1.5.1

%Define the variable fs for the sampling frequency, and assign it 1000
%samples/second.
```

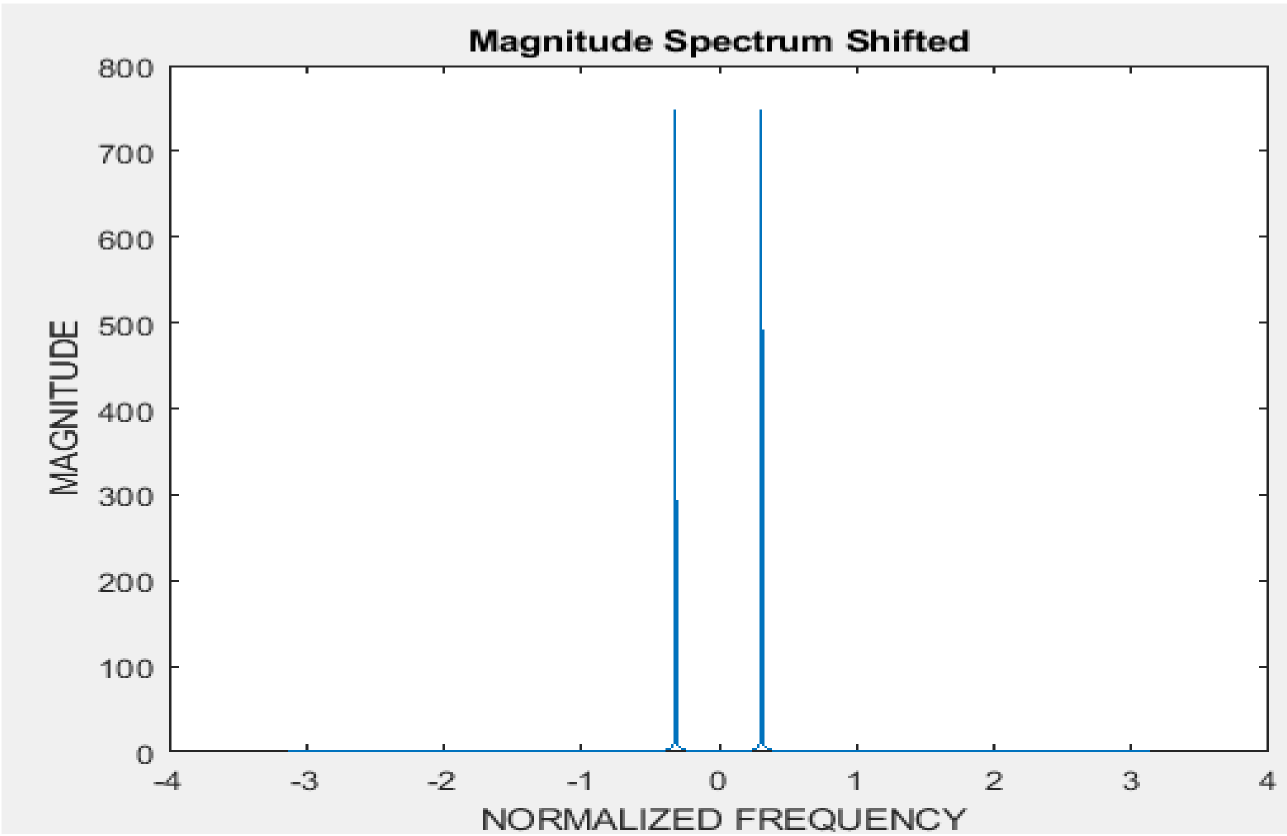
```
fs=1000;

%1.5.2

%Construct a time vector using this sampling frequency that is exactly 1500
%samples long, starting at zero.
tt=0:1/fs:1.5;

%1.5.3

%Define x(t) as the vector x.
xx=cos(2*pi*50*tt+0.25*pi);

%1.5.4

%Run the fft(x) function on x.
X=fft(xx);

%1.5.5.1

%Create a new vector that stores the values of abs(X) and plot it.
%Plot Magnitude
plot( abs(X) )
ylabel("MAGNITUDE")
xlabel("FREQUENCY")
title("Magnitude Spectrum")
```



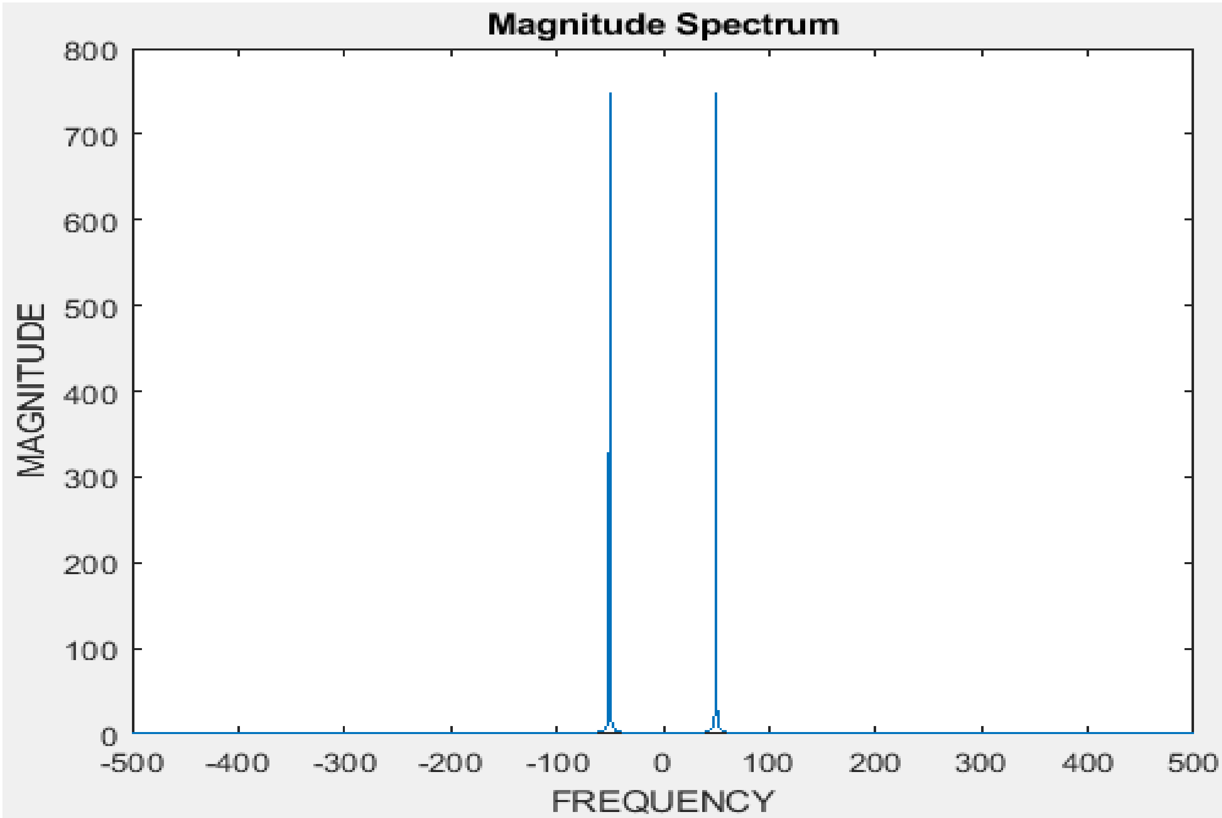
```
%1.5.5.2

%Question: What's different about it?
%The MatLab plot has two congruent peaks on the positive frequency spectrum
%and has a much larger magnitude than the hand plotted spectrum.


%1.5.5.3

%Question: What is the index corresponding to the left peak?
magn=abs(X);
find(magn>700)
ans =
          76        1427
%The index corresponding to the left peak is equal to 76.

%Question: What is the value of the magnitude spectrum everywhere else?
%The value of the right peak, at 1427, is equal to the left peak which are
%the only nonzero values, everywhere else has a magnitude of zero


%1.5.5.4

%Plot FFT output against normalized radian frequency.
ww = 0:(2*pi/length(X)):(2*pi-1/length(X));
plot(ww,abs(X));
```



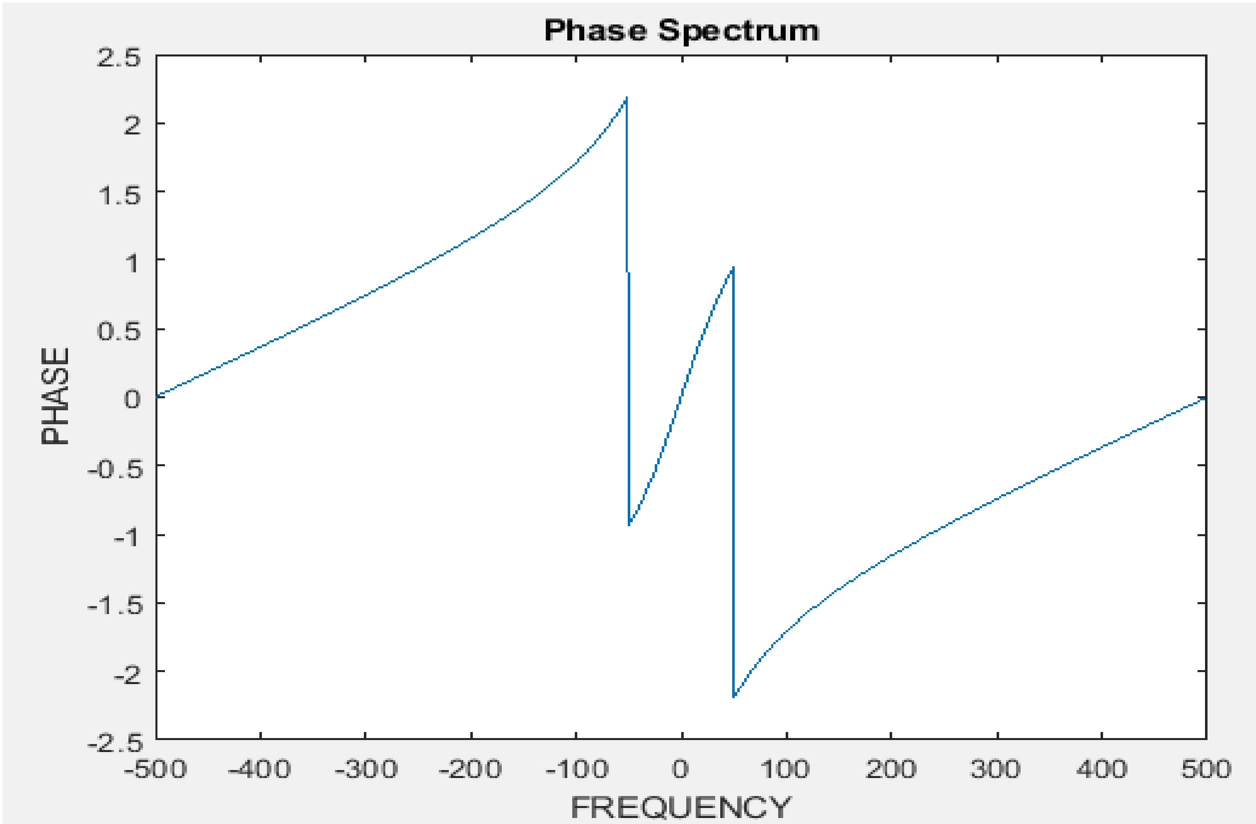
```
%1.5.5.5

%Plot the shifted FFT output against normalized radian frequency:
ww = 0:(2*pi/length(XX)):(2*pi-1/length(XX));
plot(ww,abs(XX));
```




```
%1.5.5.6

%Plot the FFT of X against the Hertz frequencies of the bins.
ww = -pi:(2*pi/length(X)):(pi-1/length(X));
freq=(fs*ww)/(2*pi);
plot(freq,abs(X))
ylabel("MAGNITUDE")
xlabel("FREQUENCY")
title("Magnitude Spectrum")
```

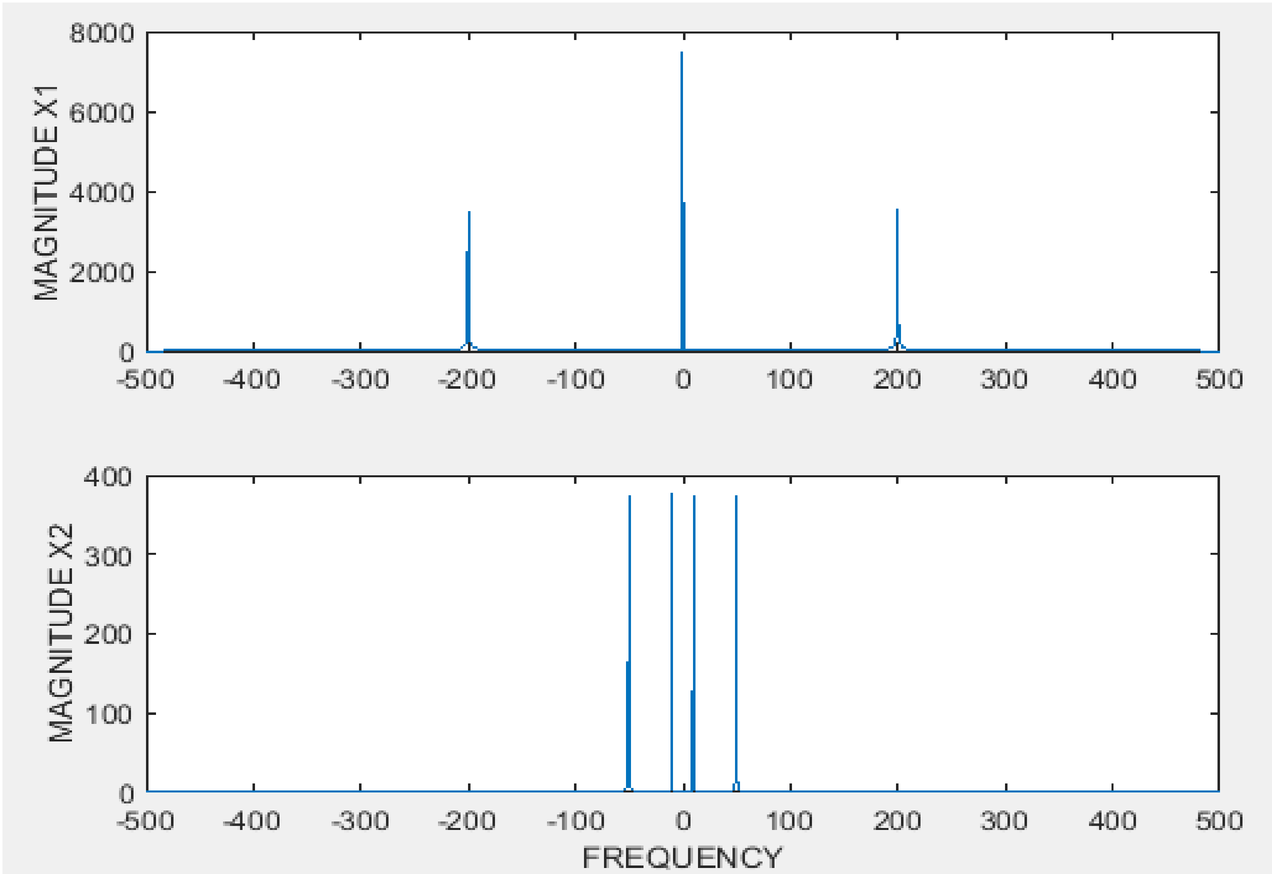



```
%Question: What are the frequencies matching the peaks?
magn=abs(fftshift(X));
freq(find(magn>700))
ans =

  -50.2998   49.6336
%The frequencies matching the peaks are around -50 Hz for the left peak and
%50 Hz for the right peak.


%1.5.6

%Plot the phase spectrum of the signal against Hertz frequency.
fs=1000;
tt=0:1/fs:1.5;
xx=cos(2*pi*50*tt+0.25*pi);
X=fft(xx);

ww = -pi:(2*pi/length(X)):(pi-1/length(X));
freq=(fs*ww)/(2*pi);
plot(freq,angle(fftshift(X)))
ylabel("PHASE")
xlabel("FREQUENCY")
title("Phase Spectrum")
```

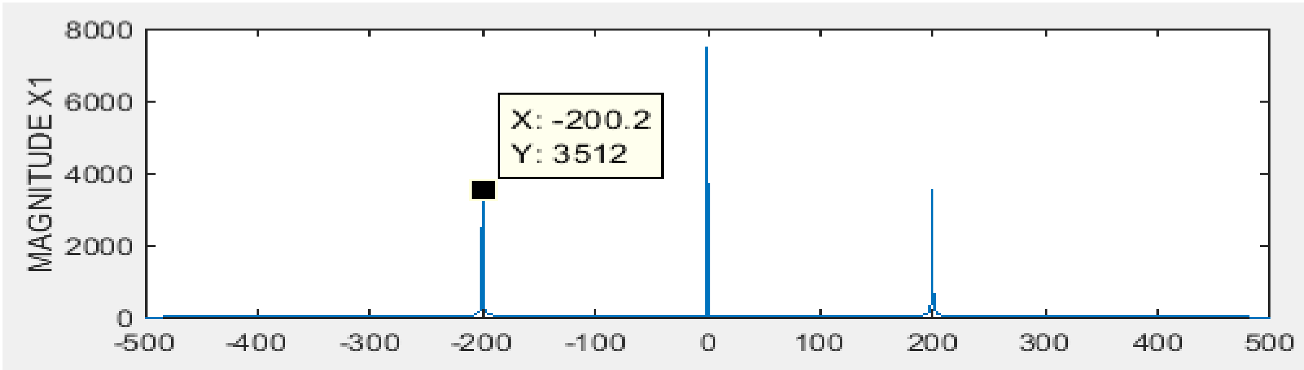



```
%Question: What are the phases of the peaks?
%The phases peaks are at the same frequency as the magnitude peaks.
phase = angle(X);
phase(find(ceil(freq) == -50))
ans =
    -0.7853
%The left peak has the phase -0.7853.
phase(find(ceil(freq) == 50))
ans =
    0.7853
%The right peak has the phase 0.7853.

%Question: Does this match what you would expect, and why?
%Yes, it is expected that the peak of the phases also occurs at the same
%frequency as the peak of the magnitude. By observation, the phase peaks
%are the local max making them respective peaks. The resulting value equals
%hand calculated value as 0.25*pi=0.7854.


%1.5.7

%Determine the exact magnitude of the peak.
fs=1000;
tt=0:1/fs:1.5;
xx=cos(2*pi*50*tt+0.25*pi);
X=fft(xx);
y=max(abs(X))
y =
```

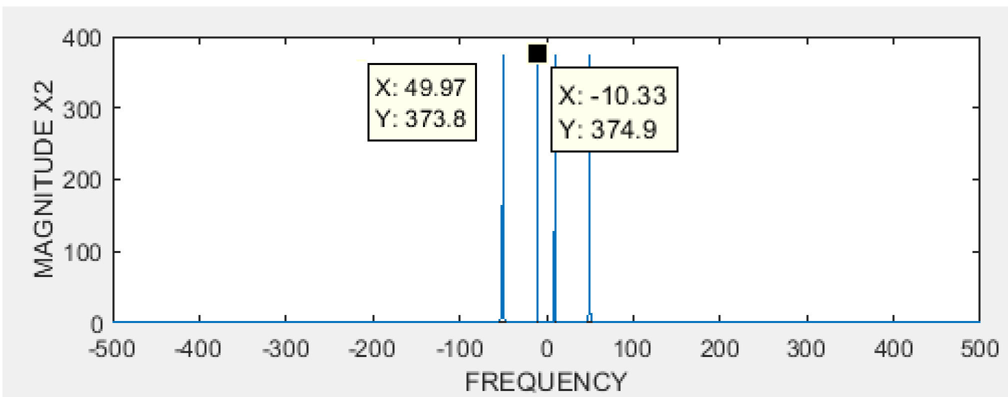
```
  747.4175
%Magnitude of the right and left peaks are equal, being 747.4175.


%1.6.1

%Using the same sampling frequency and duration, create the vectors x1 and
%x2, storing 1500 samples of the signals.
fs=1000;
tt=0:1/fs:1.5;
x1=10*sin((2*pi*100)*tt+pi).*sin((2*pi*100)*tt-pi);
x2=cos((2*pi*30)*tt+0.25*pi).*cos((2*pi*20)*tt-(1/3)*pi);

%1.6.2

%Plot the magnitude spectrum of x1 and x2 against Hertzian frequency.
fs=1000;
tt=0:1/fs:1.5;
x1=10*sin((2*pi*100)*tt+pi).*sin((2*pi*100)*tt-pi);
x2=cos((2*pi*30)*tt+0.25*pi).*cos((2*pi*20)*tt-(1/3)*pi);

X1=fft(x1);
X2=fft(x2);

%Convert to Frequency
w1 = -pi:(2*pi/length(X)):(pi-1/length(X));
freq1=(fs*w1)/(2*pi);
w2 = -pi:(2*pi/length(X)):(pi-1/length(X));
freq2=(fs*w2)/(2*pi);

%Magnitude X1
subplot(2,1,1)
plot( freq1,abs(X1) )
ylabel("MAGNITUDE X1")
%Magnitude X2
subplot(2,1,2)
plot( freq2,abs(X2) )
ylabel("MAGNITUDE X2")
xlabel("FREQUENCY")
```



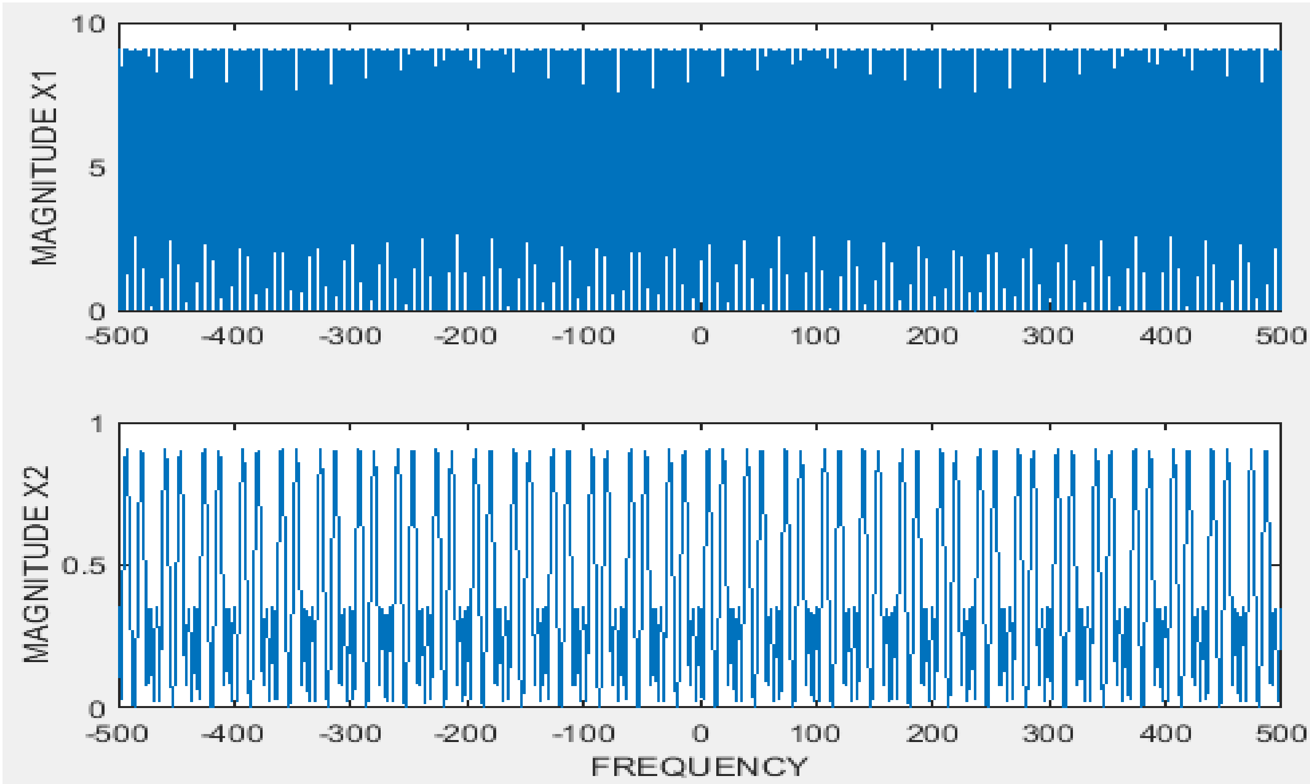

```
%Comment on the appearance of each spectrum.
%For the spectrum of X1, there are 3 peaks, 1 being the dc value and 2 from
%the single sinusoidal- a real and complex. The dc valued peak is naturally
%located at 0 as based on the sum of sinusoids function: 5-5cos(4pi(100)t).
%For the spectrum of X2, there are 4 peaks, from the two sinusoidal- a real
%and complex each as based on the sum of sinusoids function: 1/2cos(2pi(50)t-
3*pi/12)+1/2cos(2pi(10)t+7*pi/12).


%Question: Do you notice any differences in the number of peaks for these
%signals?
%The spectrum of X1 has 3 peaks while the spectrum of X2 has 4 peaks.


%1.6.3

%Using MATLAB, find the frequencies, amplitudes, and phases of the
%sinusoidal components of x1 and x2.
%From the spectrum plot the location of the peaks determine the function's
%frequency as in the spectrum of X1 the frequency is 200 Hz for the
%sinusoid and zero for the dc value which is tested to be true as done by
%hand as noted with 5-5cos(4pi(100)t)= 5-5cos(2pi(200)t).
```



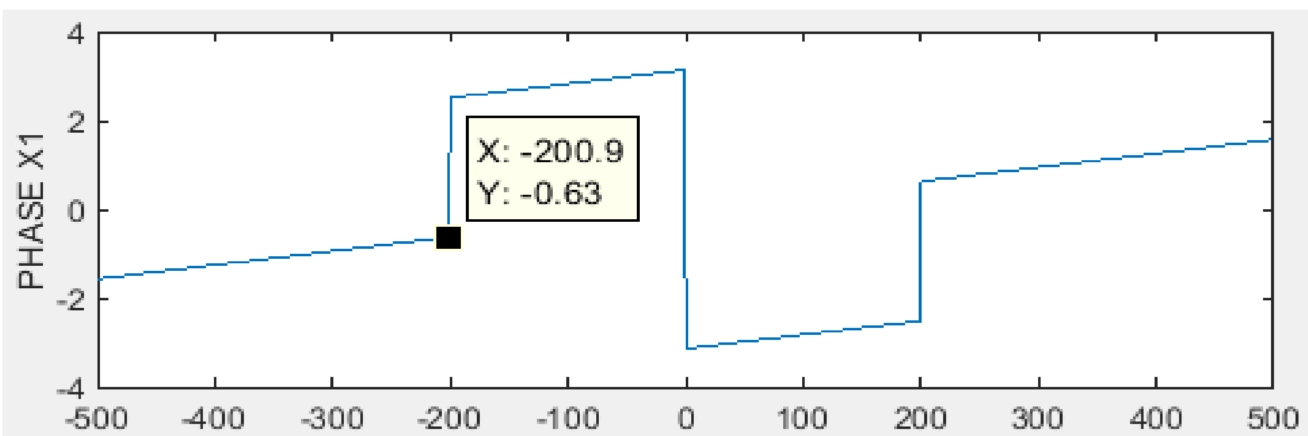
%In the spectrum of X2 the frequency is 10 and 50 Hz for the
%sinusoids which is tested to be true as done by hand as noted with
%1/2cos(2pi(50)t-3*pi/12)+1/2cos(2pi(10)t+7*pi/12).



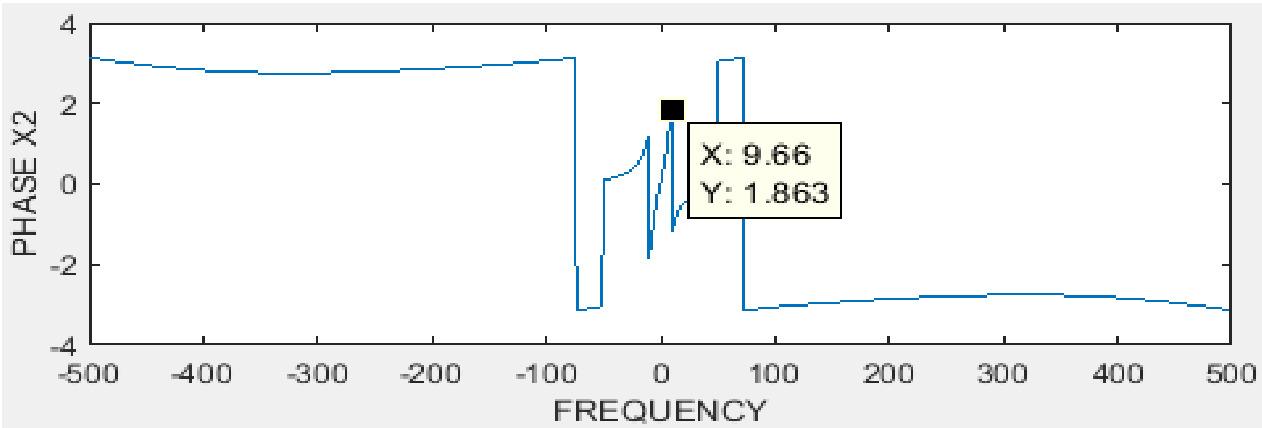
%The amplitude of the sinusoid is half the y-axis max value, going from 0
%to the halfway point. In the plot below the amplitude of X1 is 10/2=5
%and the amplitude of X2 is 1/2=0.5. The plot is of the function x1 and x2.

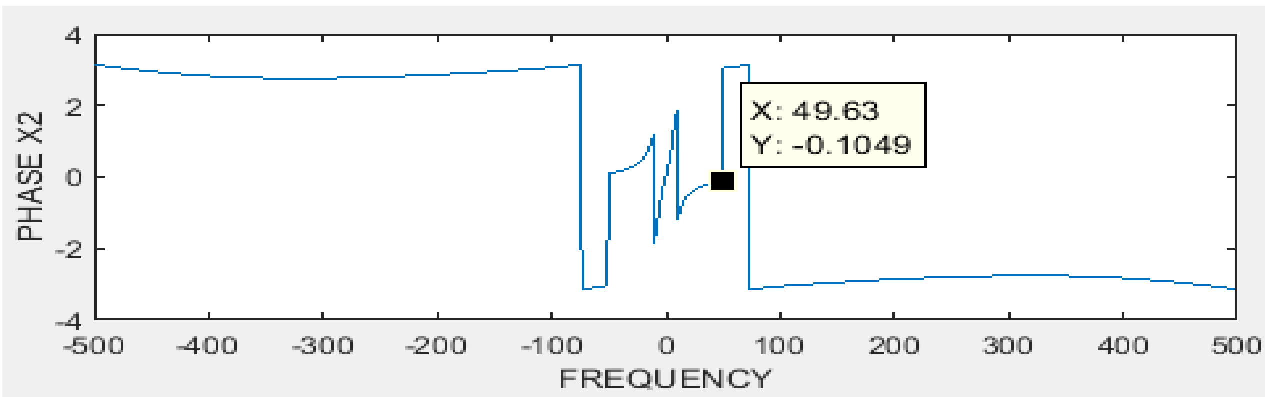


%For the phases, X1 has no phase value as a dc value does not contain a
%phase and at the peak on the frequency 200 Hz, the phase is nearly 0 thus
%be true as done by hand.



%X2 phase is at the frequency of the peaks, the phase for one sinusoid at
%50 Hz is -0.109 which is very close to the hand calculated value of -pi/12
%while for the other sinusoid at 10 Hz has a phase of 1.863 being very
%close to the hand calculated value of 7pi/12.


X: 9.66
Y: 1.863
PHASE X2
FREQUENCY


X: 49.63
Y: -0.1049
PHASE X2
FREQUENCY