DE2-Electronics: Tutorial Sheet 1

Author: **Benedict Greenberg**
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Signals in Time and Frequency Domains
Electronics 2 - Design Engineering
Imperial College London

Contents

Runtime commands

```
clc
clear all
format compact % condenses the outputs in the command window
close all % closes all existing open figures

% For debugging:
% set(0,'DefaultFigureVisible','off'); % suppresses plots after this point
```

Question 1

1.* Sketch each of the following continuous-time signals. For each case, specify if the signal is causal/non-causal, periodic/non-periodic, odd/even. If the signal is periodic specify its period.

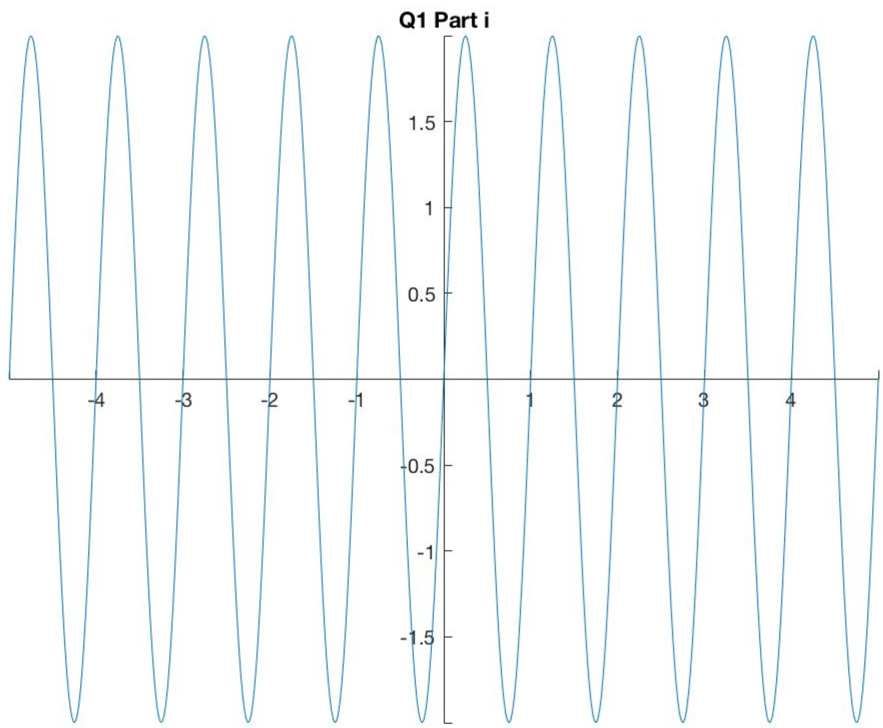
(i) $x(t) = 2\sin(2\pi t)$

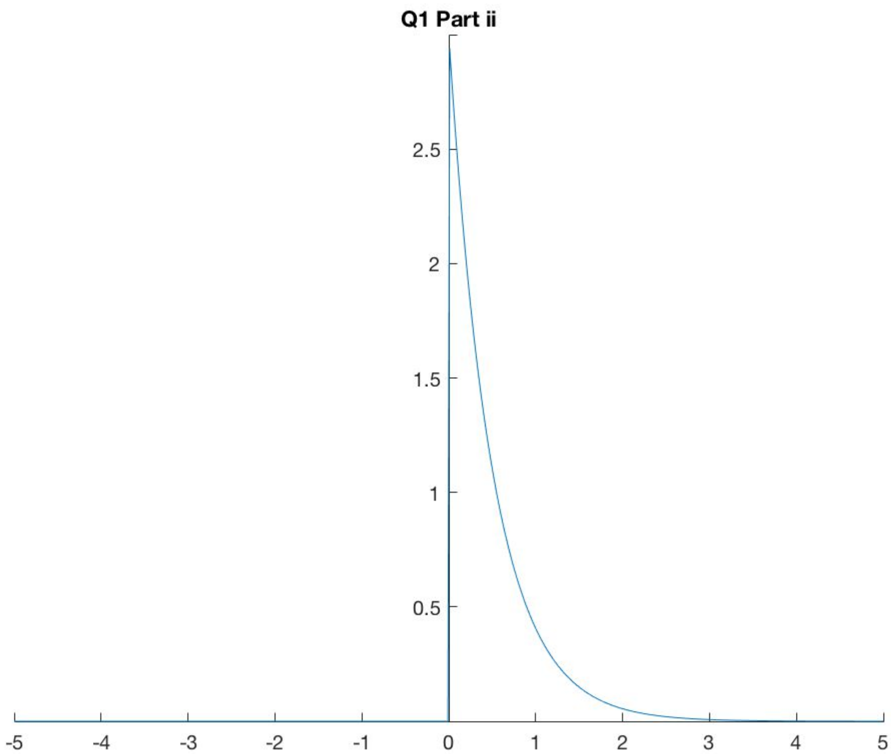
(ii) $x(t) = \begin{cases} 3e^{-2t}, & t \geq 0 \\ 0, & t < 0 \end{cases}$

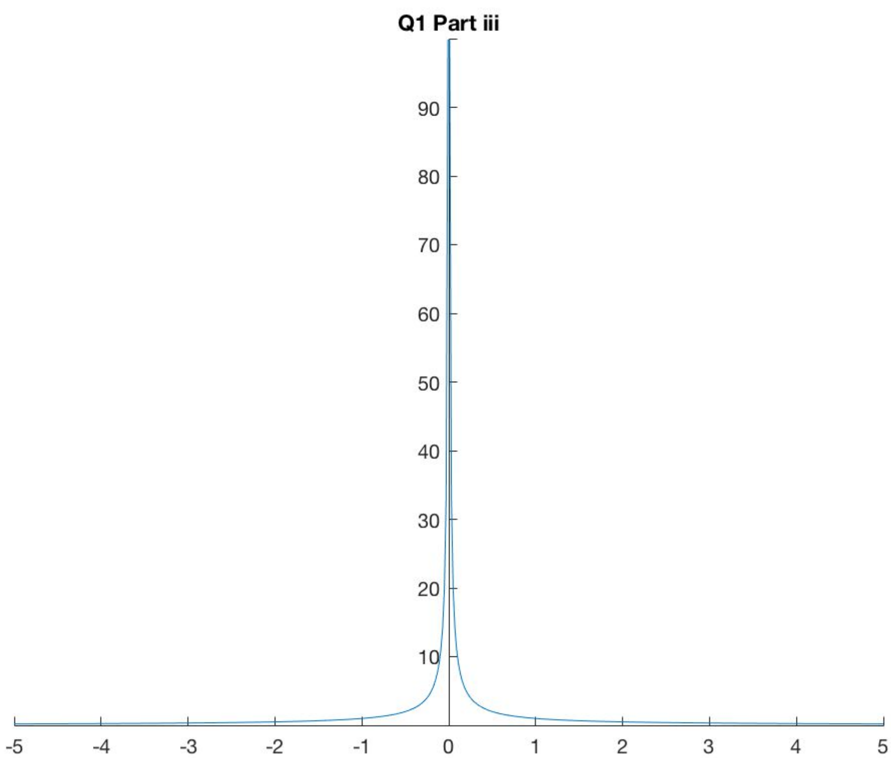
(iii) $x(t) = 1/|t|$

```
N = 500; t0 = -5; tf = 5; % opening time parameters
t = linspace(t0,tf,N); % arbitrary t values

x1 = 2*sin(2*pi*t); % part i

x2 = zeros(1,length(t)); % part ii
for i = 1:length(t)
    if t(i) >= 0
        x2(i) = 3*exp(-2*t(i));
```

```
    else
        x2(i) = 0;
    end
end

x3 = 1./abs(t); % part iii

figure; plot(t,x1); originAxes(); title('Q1 Part i')
figure; plot(t,x2); originAxes(); title('Q1 Part ii')
figure; plot(t,x3); originAxes(); title('Q1 Part iii')

% are signals: causal, periodic, odd/even
```







Part (i) shows a non-causal, periodic (T= 1 sec), odd function.

Part (ii) shows a causal, aperiodic function which is neither even/odd.

Part (iii) shows a non-causal, aperiodic, even function.

Question 2

2.* Sketch the signal

$$x(t) = \begin{cases} 1-t, & 0 \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

Now sketch each of the following and describe briefly in words how each of the signals can be derived from the original signal $x(t)$.

(i) $x(t+3)$

(ii) $x(t/3)$

(iii) $x(t/3+1)$

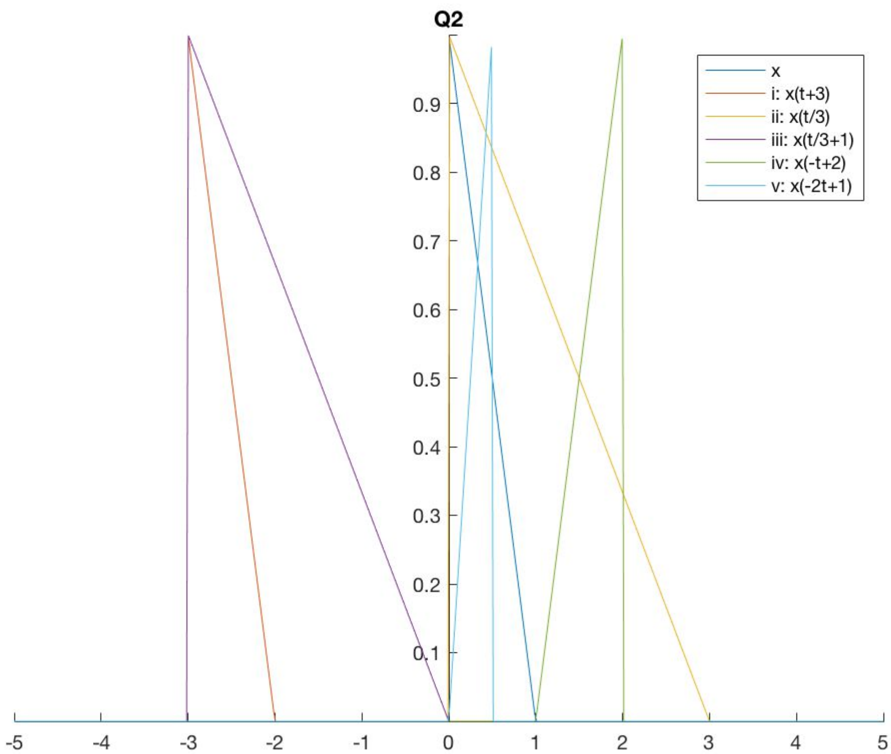
(iv) $x(-t+2)$

(v) $x(-2t+1)$

Use the same values for *t* as in previous question.

See **q2** function in appendix.

```
x = q2(t);
x1 = q2(t+3);
x2 = q2(t/3);
x3 = q2(t/3+1);
x4 = q2(-t+2);
x5 = q2(-2*t+1);

figure(4); plot(t,x,t,x1,t,x2,t,x3,t,x4,t,x5); originAxes(); title('Q2')
legend('x','i: x(t+3)','ii: x(t/3)','iii: x(t/3+1)','iv: x(-t+2)','v: x(-2t+1)')
```



Part (i) translation left by 3.

Part (ii) expansion in x by factor 3.

Part (iii) expansion in x factor 3 followed by translation left by 3

Part (iv) reflect in y axis and shift right by 2

Part (v) reflection in y axis, compress by factor 2, and shift right by half.

Question 3

3.** Sketch each of the following signals. For each case, specify if the signal is causal/non-causal, periodic/non-periodic, odd/even. If the signal is periodic specify its period.

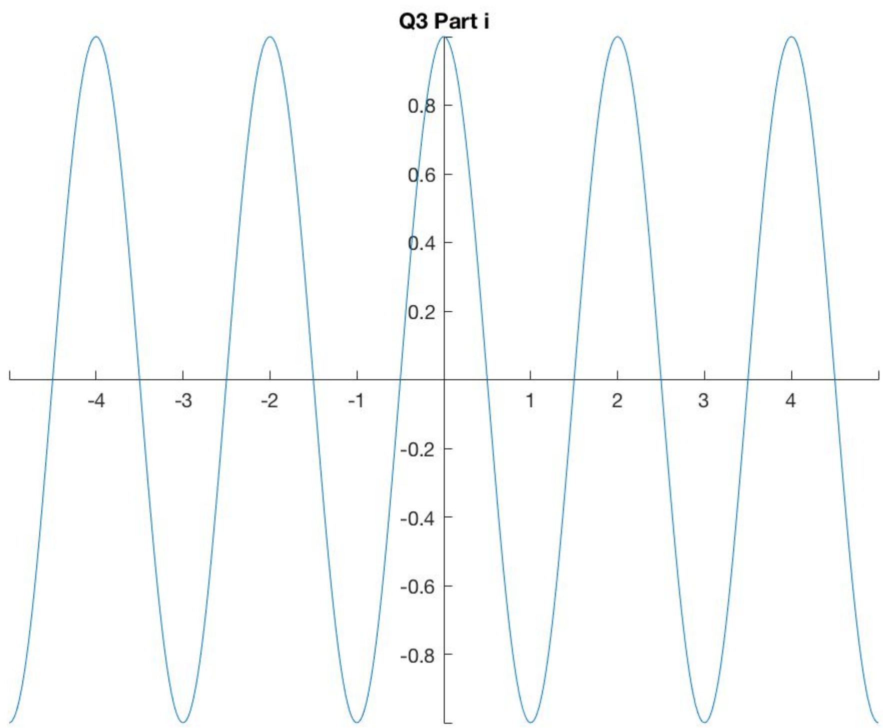
(i) $x[n] = \cos(n\pi)$

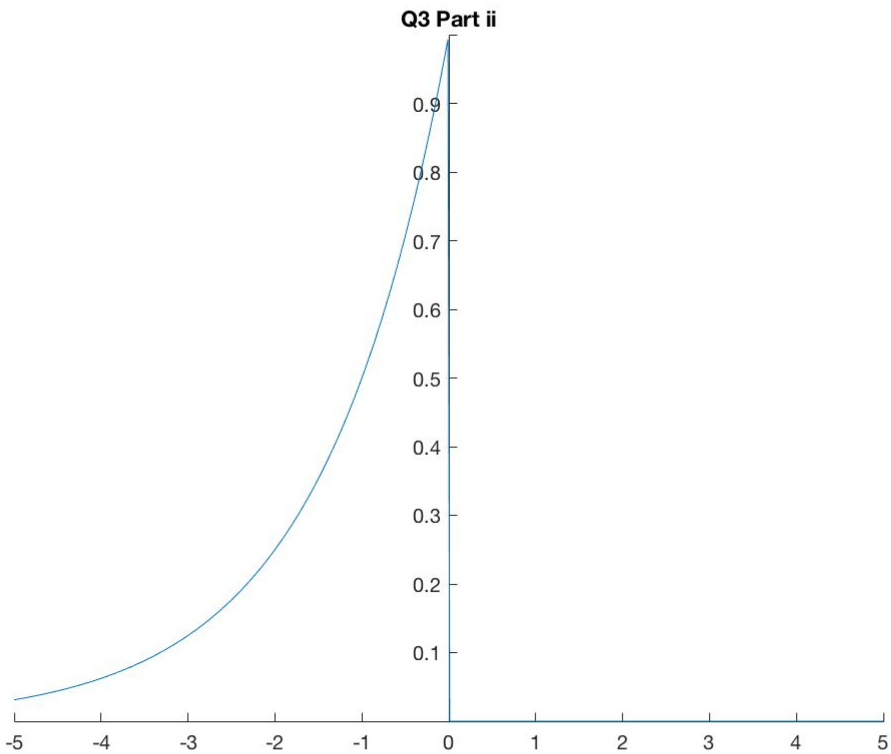
(ii) $x[n] = \begin{cases} 0.5^{-n}, & n \le 0 \\ 0, & n > 0 \end{cases}$

Use the same values for *t* as in previous question.

```
x1 = cos(t*pi); % part i

x2 = zeros(1,length(t)); % part ii
for i = 1:length(t)
    if t(i) <= 0
        calc = 0.5^(-t(i));
```

```
        x2(i) = calc;
    else
        x2(i) = 0;
    end
end

figure; plot(t,x1); originAxes(); title('Q3 Part i')
figure; plot(t,x2); originAxes(); title('Q3 Part ii')
```





Part (i) is a non-causal, periodic (T= 2 sec), even function.

Part (ii) is a non-causal, aperiodic function neither even/odd.

Question 4

4.* Sketch the spectrum of the time domain signal.

(i) $x(t) = \sin(2\pi \times 350t) + 0.35 \times \sin(6283t) + 0.1$

(ii) $y(t) = 1.5 \times \cos(2199t) + \sin(2\pi \times 1000t + \pi/2)$

NOTE: that the sampling frequency of the time domain MUST match the sampling frequency of the frequency domain. If this does not happen then the *fft* function will not correctly match up the time and frequency samples.

```
fs = 8192; % set the sampling frequency
dt = 1/fs; % find dt
t = -5:dt:5; % redefine our time span using set sampling freq

x = sin(2*pi*350*t) + 0.35*sin(6283*t) + 0.1;
y = 1.5*cos(2199*t) + sin(2*pi*1000*t / (pi/2) );
```

In practise we see that the sine wave takes on the form:

$A * sin(2 * \pi * f * t)$

where A is the amplitude, f is the frequency as seen in the spectrum, and t is the time variable.

frequency_magnitude_peaks is an outputted matric that find the peaks of the spectrum and returns each peak in a row. Column 1 corresponds to peak frequency and column 2 corresponds to the peaks magnitude.

```
plot_spectrum(x,8192)
title('Q4 Part i spectrum')

plot_spectrum(y,8192)
title('Q4 Part ii spectrum')
```

Question 5

5.** (Optional Challenge)

It could be interesting to explore generating the signals in 4) in Matlab using the two functions provided in Lab 1 (i.e. sine_gen and plot_spec) to find out in practice the spectrum of the x(t) and y(t).

This was done in Q4.

Appendix - functions

These global functions are placed at the end of the script.

Firstly **originAxes()** set the environment of the plot.

```
function originAxes()
% this sets the axes to pass through the origin, removes the box around the
% plot and sets the background of the figure to white

set(gcf,'color','w');
ax = gca;
ax.XAxisLocation = 'origin';
ax.YAxisLocation = 'origin';
ax.Box = 'off';

end
```

Question 2 utilises a function to save space.

```
function x = q2(t)
% this function is required for question 2
    x = zeros(1,length(t));
    for i = 1:length(t)
        if 0 <= t(i) && t(i) <= 1
            x(i) = 1-t(i);
        else
            x(i) = 0;
        end
    end
end
```

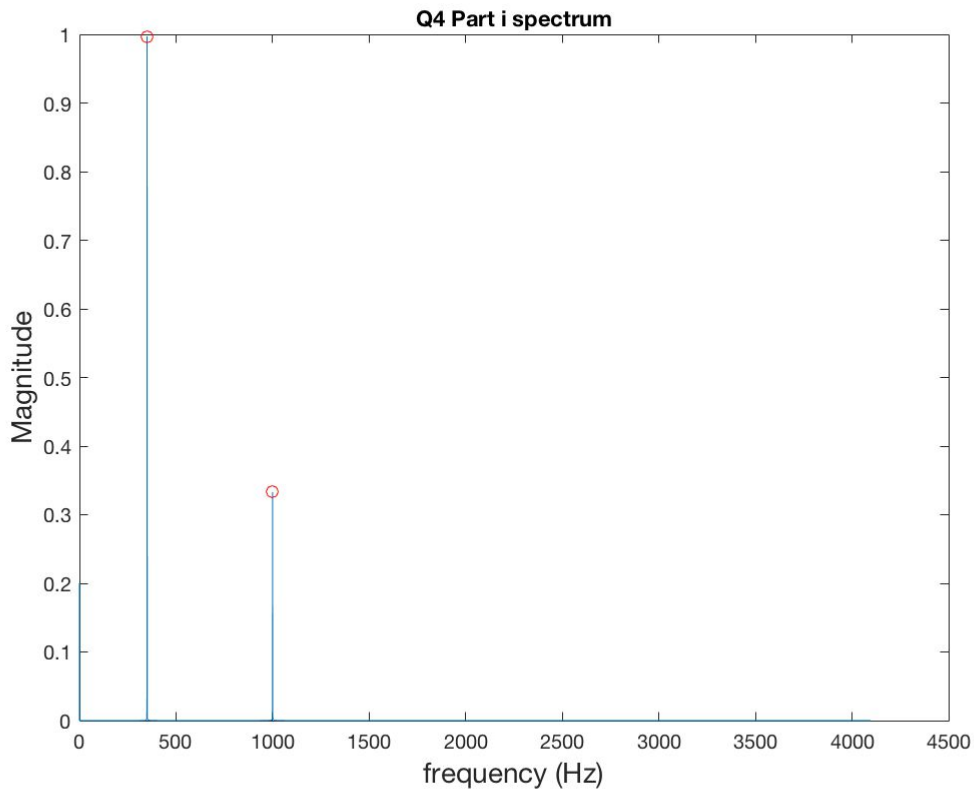
Sine generation function as seen in Lab 1.

```
function [sig] = sine_gen(amp, f, fs, T) % Function to generate a sine wave
%
%     fs = sampling frequency
%     T = duration
%     usage:  signal = sine_gen(1.0, 440, 8192, 1)

    dt = 1 / fs;
    t = 0:dt:T;
    sig = amp*sin(2*pi*f*t);
end
```

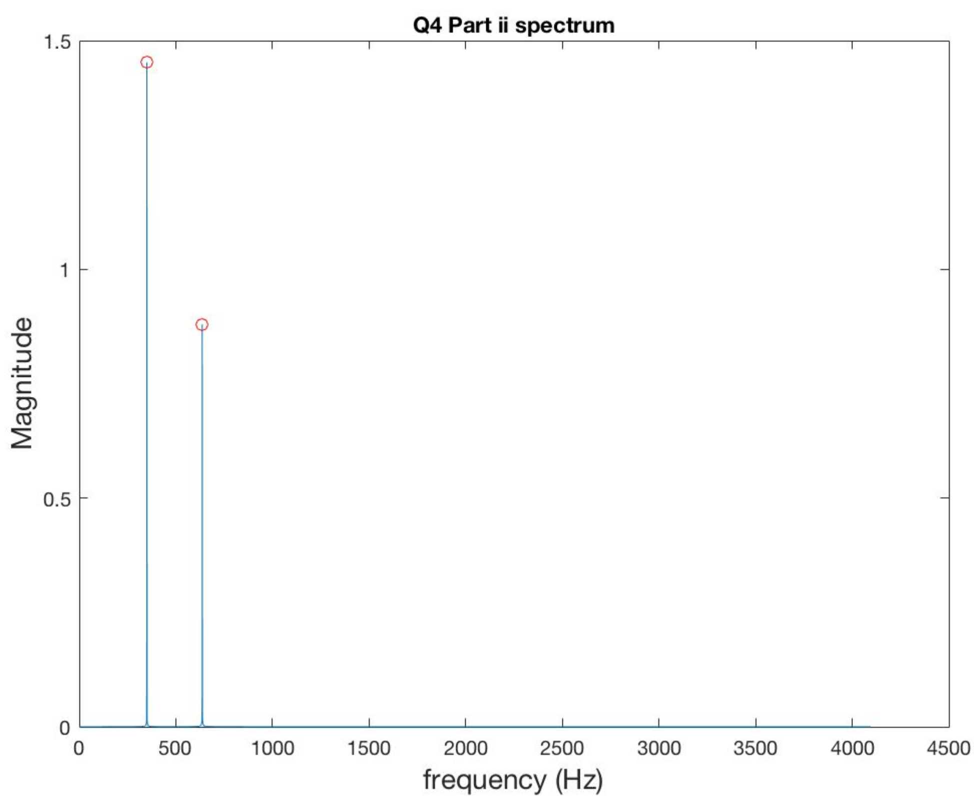
Plotting a spectrum as seen in Lab 1 but with some modifications such as identifying peaks.

```
function plot_spectrum( sig, fs )
% Function to plot frequency spectrum of sig
%   usage:
%           plot_spectrum(sig, 8192)

    magnitude = abs(fft(sig));
    N = length(sig);
    df = fs / N;
    f = 0:df:fs/2;
    Y = magnitude(1:length(f));

    [pks,locs] = findpeaks(Y/(N)*2); % finds peaks in spectrum

    figure % ensures plot is placed on new figure
    plot(f, Y/(N)*2,f(locs),pks,'or'); % plots spectrum and circles peaks
    xlabel('\fontsize{14}frequency (Hz)');
    ylabel('\fontsize{14}Magnitude');

    frequency_magnitude_peaks = transpose([f(locs);pks])
    % peaks are stored in an array where
    % column 1 is frequency
    % column 2 is magnitude at respective frequencies

end
```

```
frequency_magnitude_peaks =
  349.9957    0.9970
  999.9878    0.3330
frequency_magnitude_peaks =
  349.9957    1.4520
  636.5922    0.8798
```



Q4 Part i spectrum
Magnitude
frequency (Hz)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
500
1000
1500
2000
2500
3000
3500
4000
4500



Q4 Part ii spectrum
Magnitude
frequency (Hz)
0
0.5
1
1.5
0
500
1000
1500
2000
2500
3000
3500
4000
4500