```
% BME671L Lab #4: dlmread, switch, error, yticks, yticklabels, text,
%                   greek letters, varargin, nargin

% Your name: Ravitashaw Bathla

% LABEL ALL AXIS WHERE APPROPRIATE

% NOTE: This lab may contain some longer commands that span more than
% a standard page. Your published PDF MUST contain all of your script.
% Use the '...' to break a single command into multiple lines if
% necessary.
close all, clear all
```

Q1: Use the 'dlmread' command to read the spectrum from the file 'lab4_spectrum.txt'. This is a spectrum from a real periodic signal. Extract the first column into a frequency vector, freq, and the second column into a vector of phasors, X.

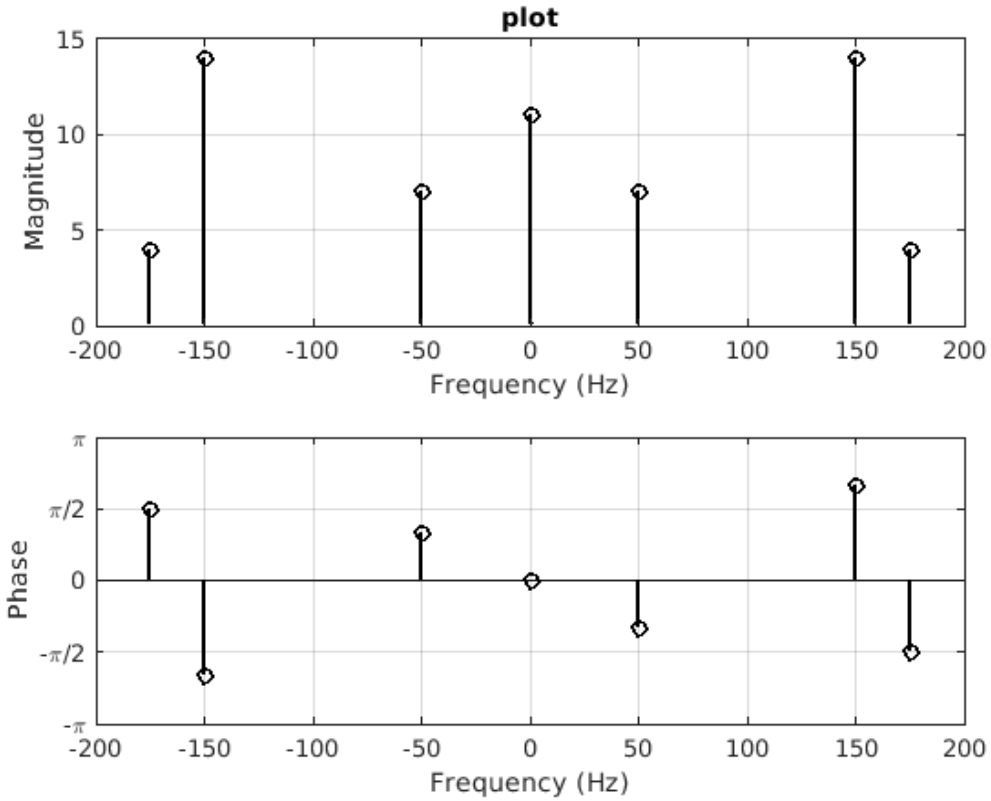
```
freq = dlmread('lab4_spectrum.txt', ' ', [0, 0, 6, 0])
X = dlmread('lab4_spectrum.txt', ' ', [0, 1, 6, 1])
```

```
freq =

  -175
  -150
   -50
     0
    50
   150
   175


X =

   0.0000 + 4.0000i
  -7.0000 -12.1244i
   3.5000 + 6.0622i
  11.0000 + 0.0000i
   3.5000 - 6.0622i
  -7.0000 +12.1244i
   0.0000 - 4.0000i
```

Q2: We will be plotting a lot of spectra. To be more efficient, write a function that will plot spectra, label axis, set ranges, ect., so that you can plot spectra with a single function call:

```
s = 'f';
figure(1), clf
plot_spectra(freq, X, s)

% where the vector freq holds frequencies, X holds the phasors, and s
% is a character 'f' or 'w' for frequency in Hz or rad/s,
% respectively. Your functions should:
%   * use 'switch command' to label the x-axis with either frequency
```

```
%    (Hz) or with the lowercase greek letter omega (rad/s).
%   * if the argument s is not 'f' or 'w' the function should give an
%       error message: "Third argument should be either 'f' or 'w'.
%       STOP"
%   * use subplot plot the magnitude (top) and phase (bottom) spectra
%   * label the y-axes either 'magnitude' or  'phase'
%   * plot the spectra in black with a linewidth of 1.5
%   * add grid lines
%   * adjust the phase y-axis so that the yticks are at
%       [-pi -pi/2 0 pi/2 pi] and correspondingly labeled using the
%       greek letter pi
% TEST your function using freq and X assuming freq is in Hz

% ********************************************************************
%   SHOW YOUR SPECTRUM TO THE TA TO RECEIVE CREDIT FOR THE LAB
% ********************************************************************
```



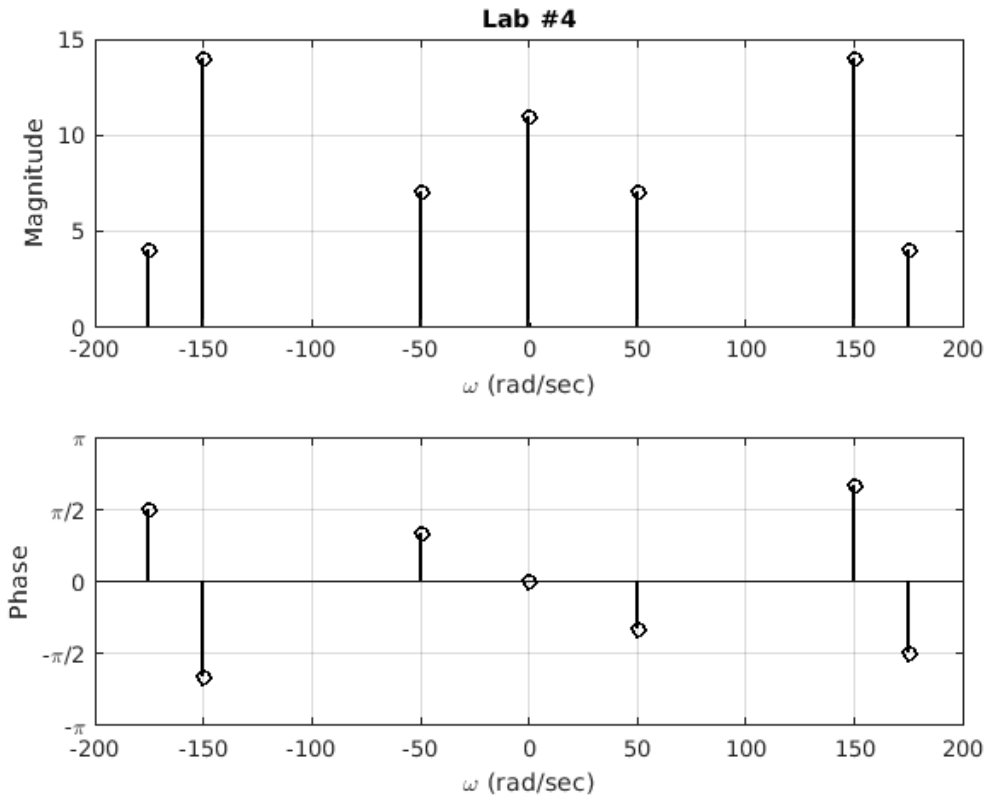
Q3: A few questions about the spectrum: * What is the fundamental frequency of the signal? YOUR ANSWER: 25

```
%   * Describe the symmetry you observe in the magnitude plot.
%       YOUR ANSWER: The spectrum is symmetric from k=0 or f=0.
%       The magnitude of the spectrum for each spectrum is symmetric
 as well
%       for positive and negative values of frequency.

%   * Describe the symmetry you observe in the phase plot.
```

```
%       YOUR ANSWER: No the phase plot is not symmetric as the phase
 will be
%       negative for a conjugate pair. So, the phases are inverted and
 the
%       symmertry is not observed. However, the DC signal has only one
%       value (no time component) therefore it appears symmetric.

%   * Fill in the blank:
%     This symmetry will be present for all _____ signals
%       YOUR ANSWER: DC
```

Q4: We may want to add a title to the top plot. Modify your function to take an optional fourth argument, which is a specified title i.e.: plot_spectra(freq,X,s,'plot title');

```
% TEST how your function deals with the fourth argument using freq and
% X with the title 'Lab #4'. This time assume frequency is in rad/s.
s = 'w';
figure(2), clf;
plot_spectra(freq,X,s,'Lab #4')
```



Q5: Add comments to the beginning of the function so that the command 'help plot_spectra' (separate .m files) or 'help lab4>plot_spectra' (if the function is in the same script) prints information about your function. This should include what it does, how to call it, and the inputs.

```
help plot_spectra
```

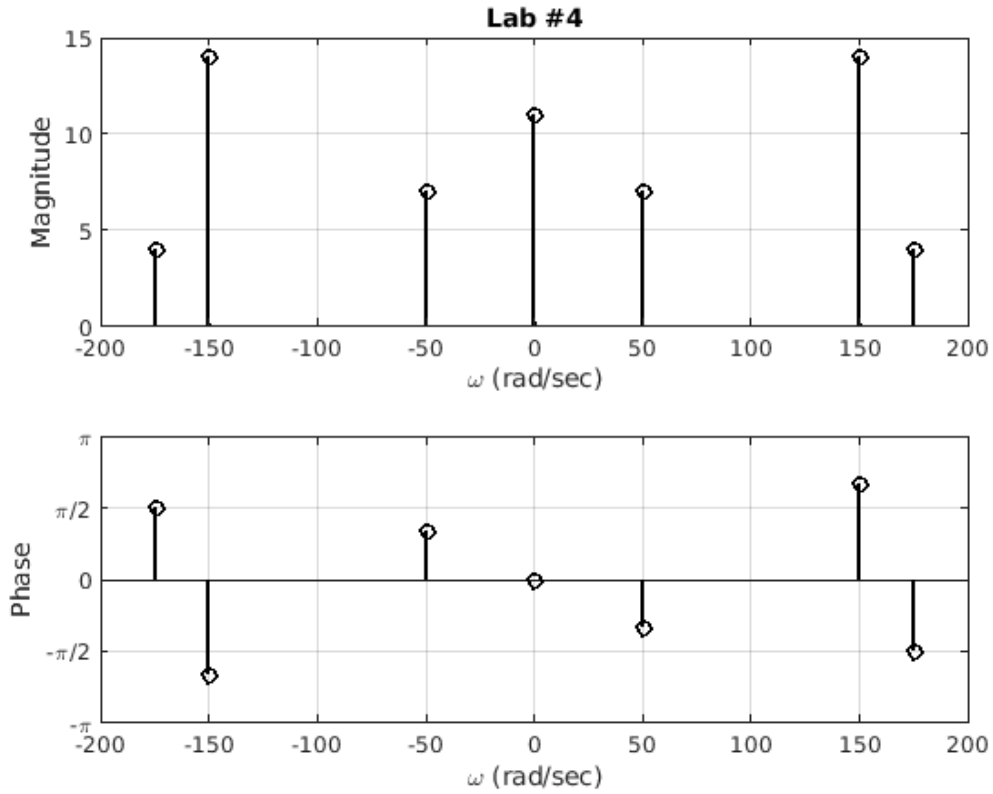
```
--- plot_spectra not found. Showing help for plot_spectra1 instead.
 ---
```

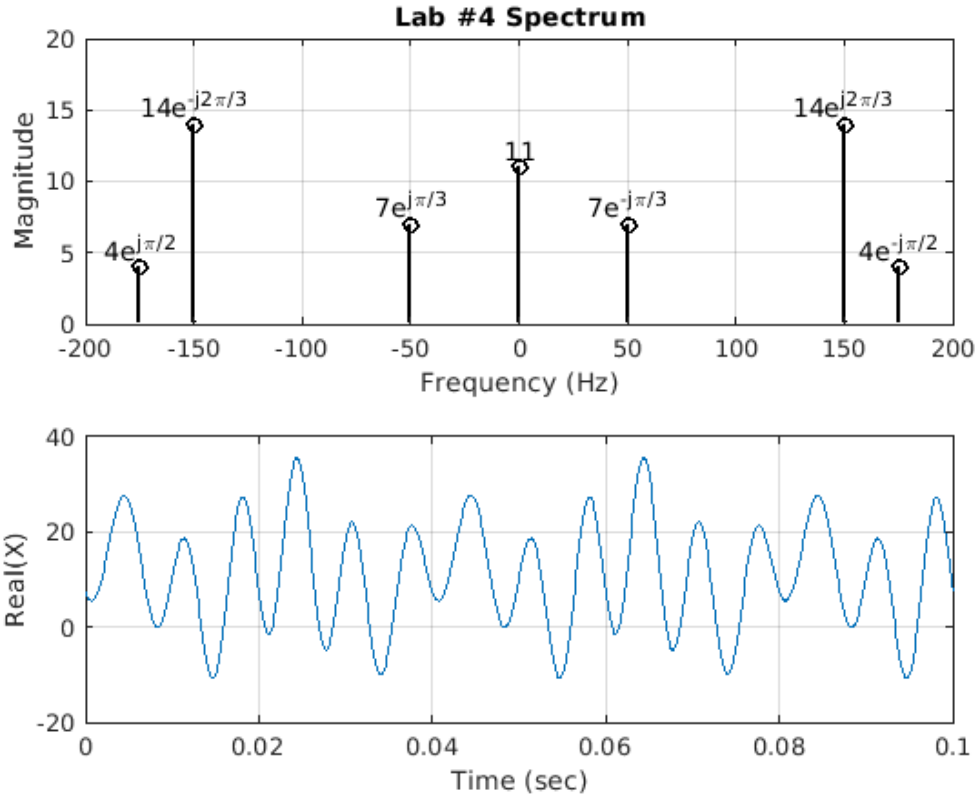
```
    plot_spectra  plots the amplitude and phasor of a spectrum.

    plot_spectra(freq, X, s)  plots the spectrum for freq (a vector),
 X (a
    vector of complex numbers) and s value can be either 'f' or 'w' to
    specify the unit of frequency for x-axis label. If any other value
 is
    provided, the function throws an error

    plot_spectra(freq, X, s, plot_title)  plots the spectrum for freq
 along
    with a title of the plot as passed in plot_title.

    Input
    freq = Vector of Frequency in Hz or rad/sec
    X = Vector of Complex Number for each given freq
    s = char specifying unit of freq, `f` for Hz and `w` for rad/sec
    plot_title = (optional) Plots the graph with input title
```

Q6: An alternative to having separate magnitude and phase plots is to plot only the magnitude and label each spectral line with the corresponding complex amplitude. Determine the complex exponential representation of the values in X. The values are all common fractions of pi (i.e. pi/3 or 3/4*pi).

```
figure(3), clf
subplot(2, 1, 1);
stem(freq, abs(X), 'k-','LineWidth', 1.5);
z_amp = {'4e^{j\pi/2}', '14e^{-j2\pi/3}', '7e^{j\pi/3}', '11', '7e^{-j
\pi/3}', '14e^{j2\pi/3}', '4e^{-j\pi/2}'};
text(freq, abs(X),
 z_amp, 'VerticalAlignment', 'bottom', "HorizontalAlignment","center");
grid on;
ylim([0 20]);
ylabel('Magnitude');
xlabel('Frequency (Hz)');
title('Lab #4 Spectrum');

t = 0:0.0001:0.1;
subplot(2, 1, 2);
y_t = @(t) 11 + 7*cos(100*pi*t - 1/3*pi) + 14*cos(300*pi*t + 2/3*pi) +
 4*cos(350*pi*t - 1/2*pi);
y = y_t(t);
plot(t, y);
grid on;
ylabel('Real(X)');
xlabel('Time (sec)');

% Create figure with 2 plots:
%   * In the TOP plot show the magnitude spectrum of f and X. Add the
%       complex amplitudes as text elements centered above each
%       spectral line.
% HINT: Cell arrays are a great way to store strings of different
% length. Ex: example = {'this','is','an','example'};
```

```
%
%   * In the BOTTOM plot display the real signal with respect to time
%       that corresponds with this spectrum assuming that freq is in
%       Hz. Plot the signal for t = 0:0.0001:0.1;
```





Q7: Determine the function (sum of cosines) that this spectrum represents.

```
% YOUR ANSWER:
% 11 + 7*cos(100*pi*t - 1/3*pi) + 14*cos(300*pi*t + 2/3*pi) +
 4*cos(350*pi*t - 1/2*pi
```

When you are done:

```
% * Show the indicated result/figure to the TA during the lab period
%       to receive credit
%   * For publishing/grading purposes include your function below
% * upload your script to Sakai
%   * upload a pdf containing your script and outputs.

return
```

YOUR FUNCTION:

```
function plot_spectra(freq, X, s, varargin)
%   plot_spectra  plots the amplitude and phasor of a spectrum.
%
%   plot_spectra(freq, X, s)  plots the spectrum for freq (a vector),
 X (a
%   vector of complex numbers) and s value can be either 'f' or 'w' to
%   specify the unit of frequency for x-axis label. If any other value
 is
%   provided, the function throws an error
```

```
%
%   plot_spectra(freq, X, s, plot_title)  plots the spectrum for freq
 along
%   with a title of the plot as passed in plot_title.
%
%   Input
%   freq = Vector of Frequency in Hz or rad/sec
%   X = Vector of Complex Number for each given freq
%   s = char specifying unit of freq, `f` for Hz and `w` for rad/sec
%   plot_title = (optional) Plots the graph with input title

    switch(s)
    case 'f'
        xunit_str = 'Frequency (Hz)';
    case 'w'
        xunit_str = '\omega (rad/sec)';
    otherwise
         error("Error: Input for third argument must be a either 'f'
 or 'w'");
    end

    if nargin < 4
        plot_title = 'plot';
    else
        plot_title = varargin(1);
    end

    subplot(2, 1, 1);
    stem(freq, abs(X), 'k-','LineWidth', 1.5);
    grid on;
    ylabel('Magnitude');
    xlabel(xunit_str);
    title(plot_title)

    subplot(2, 1, 2);
    stem(freq, atan2(imag(X), real(X)), 'k-','LineWidth', 1.5);
    ylim([-pi pi]);
    grid on;
    yticks([-pi, -pi/2, 0, pi/2, pi]);
    yticklabels({'-\pi', '-\pi/2', 0, '\pi/2', '\pi'});
    ylabel('Phase');
    xlabel(xunit_str);
end
```

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