ME417 - Laboratory Exercise #1

Introduction to Matlab

This laboratory exercise is intended to provide a tutorial review of Matlab, which will be used heavily throughout the rest of the course/laboratory. All the exercises in this first assignment can be done entirely in Matlab.

1) Vectors and Matrices: Data entry in Matlab is achieved by separating columns of matrices by spaces, and rows of matrices by semi colons. Thus in order to enter the matrix

$$a = \begin{bmatrix} 1 & 3 & 7 \\ 2 & 5 & 6 \end{bmatrix}$$

one would type

$$a = [1 \;\; 3 \;\; 7; 2 \;\; 5 \;\; 6]$$

Having defined matrices then one can compute algebraic manipulations of them easily in Matlab. Matlab provides a wealth of matrix functions, each of which has online help to describe their operation. Type the following commands to learn about the functions and then carry out the exercises below:

help arith
help inv
help eig ← skip this one (not required)

You can also browse by typing *helpwin*. Look around in the directories *general, ops, lang, elmat, elfun*, and *matfun* to familiarize yourself with what is available in Matlab. Of course we will not be using all of the available tools, but some we will use heavily, and you will build your understanding of Matlab as the course progresses.

Enter the following matrices (note that the imaginary number $j = \sqrt{-1}$ is recognized in Matlab).

$$a = \begin{bmatrix} 1 & 3 & 7 \\ 2 & 5 & 6 \end{bmatrix}$$

$$b = \begin{bmatrix} 4 & 7 & 9 \\ 8 & 1 & 3 \\ 1 & 1 & 1 \end{bmatrix}$$

$$c = \begin{bmatrix} 1-j & 1+j & 3 \\ 2-4j & 8+3j & 6j \\ 0 & 0 & 7 \end{bmatrix}$$

and compute the following quantities

i) bc
ii) $b^{-1}c$
iii) ab
iv) $b+c$
v) ba^T (where a^T denotes the transpose of a)
vi) The eigenvalues of b
vii) The eigenvalues of c

Hint: the transpose operator is the apostrophe (')

skip these parts (not required)

You may find the following commands useful

help diary
help save
help load

2) Polynomials: Matlab facilitates easy manipulation of polynomials, by storing the coefficients as vectors. The polynomial

$$s^3 + 3s^2 - 7s + 8$$

would be stored as the vector

$$p = [1 \;\; 3 \;\; -7 \;\; 8]$$

Evaluating the polynomial and calculating the roots is then straightforward in Matlab. Type the commands

help polyval
help roots

and look in *helpwin* under *polyfun*. Then carry out the following exercises:

i) Evaluate $s^3 + 2s^2 + 4s - 8$ for $s = 1$
ii) Evaluate $s^3 + 2s^2 + 4s - 8$ for $s = 2 - 4j$
iii) Evaluate $s^3 + 4s$ for $s = 2j$
iv) Compute the roots of $2s^3 - 3s^2 + 6s + 7$
iv) Compute the roots of $s^3 - 12s^2$
v) Compute *all* the cube roots of 1

change these to "v" and "vi"

3) Plotting and Printing: Matlab has an array of commands for plotting, labeling/editing plots, and printing. Type the following commands:

help plot
help print

Note that there are "See also" commands suggested at the end of every help menu. You can also look in *helpwin* under *graph2d* (and others). As a simple example the following series of commands generates a plot of a cosine wave:

```
t = 0:0.01:2*pi;
y = cos(t);
plot(t,y);
title('Plot of a cosine wave');
```

Note the first line is used to automatically generate a time vector (see also *linspace* and *logspace*). The semicolons keep the commands silent. Generate and print plots of the following functions. Please include titles and axis labels.

i) $\sin^2(t) - cos(3t)$ for $0 \leq t \leq 2\pi$
ii) $t^3 - 3t^2 - 2t$ for $0 \leq t \leq 5$

Hint: For the exponents, you will need to use the element-by-element operator (.^)

4) Scripts and Functions: Any collection of Matlab commands can be gathered together as a script, saved in an "m-file". For instance save the following commands in a text file called plotit.m

```
numhar = 5;
t = linspace(0,2*pi,300);
y = zeros(1,300);
for ii = 1:numhar
y = y + ((-1)^(ii+1))*(1/(2*ii-1))*cos((2*ii-1)*t);
end
plot(t,y)
title('Harmonic decomposition of a square wave')
```

You can then run this straight from Matlab to build a square wave from its harmonics and plot it. Note that this is a script in that all the variables exist in the workspace. You can also write subroutines, which use local variables. Type *help function* to see the syntax for doing this. Carry out the following programming tasks:

i) Write a script to generate and plot a triangular wave from its harmonics, with the number of harmonics left as a variable to be altered as desired.
ii) Write a function which gives back the sum of the squares of the absolute values of the elements of a matrix, i.e., it evaluates the function

$$f = \sum_{i=1}^{n} \sum_{j=1}^{m} |a_{ij}|^2$$

for any $n \times m$ matrix a. Test your routine on the matrices a, b, c from question 1).

In addition to the above you find out more about Matlab by typing *demo* or *tour*. You can also try the following Websites:

http://www.mathworks.com/
http://www.engin.umich.edu/group/ctm/basic/basic.html

The Mathworks Website is a general reference site, and the latter Website is specifically designed as a tutorial introduction to Matlab.

Summary of Documentation Requirements:

1. Show Matlab commands and answers for i - v (skip vi and vii)

2. Show commands and answers for i - vi

3. Show commands and plots with labels for i and ii

4.
i: Present the m-file with comments, the commands entered into matlab to run it, and three clearly-labeled plots with different values for the number of harmonics.

ii: Show the m-file (containing the function definition) and the results of calling the function for the three matrixes a, b, and c.