Notes on using MATLAB

MATLAB is an interactive program for numerical methods, with graphing capability. These notes describe some useful functions and syntax. The following sites have more extensive tutorials:
http://www.engin.umich.edu/caen/technotes/CAEN705_Matlab.html
http://www.math.mtu.edu/~msgocken/intro/intro.html
http://www.math.unh.edu/ mathadm/tutorial/software/matlab/
http://www.mines.utah.edu/gg_computer_seminar/matlab/matlab.html

The command for starting MATLAB depends on your system configuration (you can often start MATLAB on UNIX systems by typing `matlab`). To obtain help from within MATLAB, type `help`; this provides a list of available functions. Supply the function name for information about a particular item (e.g. `help plot`). For demonstration of a few commands, type `demo`. To terminate a MATLAB session, type `quit`.

Formats for printing numbers.

- **format short** 3.1416
- **format short e** 3.1416e+00
- **format long** 3.14159265358979
- **format long e** 3.141592653589793e+00

There is only one data type in MATLAB, complex matrices. Vectors and scalars are special cases. Matrices can be created as follows, \( A = [1, 1, 1; 1, 2, 3, 4]. \) This creates a 2×4 matrix \( A \) whose first row is (1,1,1,1) and whose second row is (1,2,3,4). The dimensions of a matrix \( A \) can be found by typing `size A`.

To create a vector, type `x=[1,2,3,4]`. The system responds with:

\[
x = \\
1 2 3 4
\]

The commas are optional, `x=[1 2 3 4]` gives the same result. If an assignment statement ends with a semicolon, then the result is not displayed. Thus if you type `x=[1 2 3 4];`, nothing will be displayed. You can then type `x` to display the vector. The length of a vector \( x \) is obtained from `length(x)`. Indices for vectors and matrices must be positive integers. Thus, \( A(1.5,2) \) and \( x(0) \) are not allowed. There is a special syntax for creating a vector whose components differ by a fixed increment. Thus, `x=[0.2 .4 .6 .8 1]` can be created by typing `x=0:.2:1`.

Built-in functions.

- `pi` 3.1415....
- `zeros(3,3)` 3×3 matrix of zeros
- `eye(5)` 5×5 identity matrix
- `ones(10)` vector of length 10 with all entries =1
- `abs(x)` absolute value
- `sqrt(x)` square root, e.g. `i=sqrt(-1)`
- `real(z), imag(z)` real, imaginary parts of a complex number
conj(z) complex conjugate
atan2(y,x) polar angle of the complex number x + iy
\sin(x), \cos(x) trig functions
\sinh(x), \cosh(x) hyperbolic functions
\exp(x) exponential function
log(x) natural logarithm
gamma(n) gamma function = (n-1)!
bessel (a,x) bessel function of order a at x

Example of a loop.
    for i = 1:4
        x(i) = i;
    end

Example of a conditional.
    if a==0;
        x = a+1;
    elseif a < 0;
        x = a-1;
    else;
        x = a+1;
    end

Plotting.
plot(x,y) linear plot, uses defaults limits, x and y are vectors
grid draw grid lines on graphics screen
title('text') prints a title for the plot
xlabel('text') prints a label for the x-axis
ylabel('text') prints a label for the y-axis
axis([0, 1, -2, 2]) overrides default limits for plotting
hold on superimpose all subsequent plots
hold off turns off a previous hold on
clg clear graphics screen
mesh 3-d plot; type help mesh for details
contour contour plot; type help contour for details
subplot several plots in a window; type help subplot for details

Example. To plot a Gaussian function, type the following lines:
    x = -3:.01:3;
    y = exp(-x.*x);
    plot(x,y)

Matrix functions.
\text{x} = \text{A}\backslash\text{b} \quad \text{gives the solution of} \ \text{Ax=b}
[l,u] = lu(A) \quad \text{LU decomposition of} \ A
[v,d] = eig(A) \quad \text{eigenvalues in} \ \text{d}, \ \text{eigenvectors in} \ v
[u,s,v] = svd(A) \quad \text{singular value decomposition}
 chol(A) Cholesky factorization
 inv(A) inverse of a square matrix
 rank(A) matrix rank
 cond(A) condition number
 *, + matrix product and sum
 .* , .+ element by element product and sum
 , transpose, e.g. A'
 ^ power, e.g. A ^ 2
 .^ element by element power, e.g. A.^ 2

m-files.

An m-file is a file that contains a sequence of MATLAB commands. Some m-files are built into MATLAB. A user can create a new m-file using an editor. For example, an m-file called fourier.m could be created containing the lines:

```matlab
% % Plot a trigonometric function.
% x = 0:.01:1;
y=sin(2*pi*x);
plot(x,y)
```

In this case, typing `fourier` would produce a plot of a sine curve. (Note: % in an m-file denotes a comment line.) In order to pass arguments to and from an m-file, the word “function” must be on the first line. For example:

```matlab
function [x,y] = fourier(n,xmax)
% % Plot a trigonometric function.
% x=0:.01:xmax;
y=sin(n*pi*x);
plot(x,y)
```

Typing `[x,y] = fourier(2,7);` plots a sine curve. After execution, the vectors `x` and `y` are available for further calculations.

Useful commands.

```matlab
type dft lists the contents of the m-file dft.m
save A stores a matrix in a file called A.mat
save saves all variables in a file called matlab.mat
load temp retrieves all the variables from file temp.mat
print prints the current graphics window
```