Spring 2018

Lab 1 - MATLAB as a Calculator

Objectives: To learn how to use MATLAB as a calculator, in particular:

- How to enter numbers
- How to use variables
- How to do arithmetic and use scientific functions
- How to use scripts and basic input/output

1. **Getting Started with MATLAB**

   (a) In Windows, go to the Start menu and find MATLAB. Select it and wait for MATLAB to start.

   (b) Arrange the windows so that you can both see this document and the MATLAB window. We'll be working primarily in the Command Window in MATLAB, so if you need space, you can close the other panes and resize the window.

   (c) Command Window:

   - Before you begin all lab assignments, start by typing *diary lab*0x (where x is the lab number) to begin recording your session. This is critical since you will be required to show this file to get credit for your lab.
   - To get MATLAB to do things, you type commands into the command window and when you hit return, MATLAB executes the command and displays the result. Try typing $7 + 9$ then hit Enter.
   - If you make a mistake MATLAB will give an error message and it will try to locate the mistake. Try typing $7 + (9 - 6$ and hit Enter.
   - You can use the left-right arrow keys to edit a command before you hit enter. You can use the up-down arrow keys to go review previous commands. Try using the up arrow to return to the statement $7 + (9 - 6$, add the closing parenthesis and hit enter.
   - If you want MATLAB to stop executing a command or you want it to just ignore a command you're typing, use control-C (ctrl-C).

2. **Calculation Basics**

   (a) Numbers use the digits $0 - 9$, decimal point ., sign $-$, like -17.4886. For scientific notation, use e, like $1e - 4$ for 0.0001. For complex numbers use i, like $4.7 - 3.2i$. Be careful to not use spaces, because, as we'll see later, MATLAB also works with lists of numbers and uses the space as a separator. Type these numbers into the command window:

   i. the year you were born
   ii. the speed of light (300,000 km/s; use scientific notation)
   iii. a complex number in the form of your birth month + your birth day * i (e.g., Dec 15 = 12 + 15i)
   iv. your favorite negative number

   (b) Variable names must begin with a letter and use letters, upper and lower case, numbers and the underscore. Variables are case sensitive so 'A' is different from 'a'. There are a few reserved words, but not many and MATLAB will give you an error message if you try to use one. Unfortunately, you can create variables that override some built-in functions. Type these variables into the command window:

   i. x = 22
   ii. X = 89
   iii. y = 58
   iv. check your session variables by typing *who* and *whos*
   v. clear the variable X by typing *clear X*

vi. again check your session variables by typing *who* and *whos*

vii. pi

viii. pi = 45

ix. pi

x. clear pi

(c) Variable names should be descriptive so that they are meaningful but they shouldn't be too long. Type these variables into the command window:

i. pressure = 35

ii. velocity = 56

iii. thisVariableIsVeryLongAndItWouldBeFrustratingToTypeThisOverAndOverAgain = 45

iv. clear all variables in this session by typing *clear*

(d) Basic arithmetic operations use the same characters as your calculator. Use parenthesis: (and), to group terms, otherwise normal precedence holds. Try these:

i. 3456 + 455

ii. 566 * (5675 - 2344)

iii. x = 1/2

iv. y = 1/5

v. $z = x + y$, $w = x - y$, $v = x * y$, $u = x/y$, $t = z * w/(v * u)$, $s = t^2$

(e) Basic scientific functions are *sin*, *cos*, *tan*, *sind*, *cosd*, *tand*, *log* (natural log), *exp*, *log*10, *round*, *floor*, *ceil*, and *factorial*. There are many other built-in functions but these are the major ones. (If you do not understand the purpose of a function or want more information, you can type 'help functionName' into the MATLAB console or simply Google 'matlab functionName'. For example, if you want to know more about *sind* you would type 'help sind' into the console or Google 'matlab sind'.) Evaluate the following:

i. set $\theta = 45$ degrees, then evaluate $\sin\theta$, $\cos\theta$, $\tan\theta$

ii. set $\theta = \pi/2$, then evaluate $\sin\theta$, $\cos\theta$, $\tan\theta$

iii. $\ln 7$, e^3, $\log 1000$

iv. round 3.14159 to the hundredths place

v. round down 43.66 and 9.28

vi. round up 43.66 and 9.28

vii. evaluate 24!

3. **Putting it Together**

(a) MATLAB is both interactive, i.e. you type expressions in the command window and MATLAB evaluates it; and it is a programming environment where you can save your command(s) in a file and execute them.

(b) All programs in MATLAB are called m-files as their filenames are always of the form filename.m. There is also a built-in M-file editor in MATLAB that helps format your commands.

(c) For your first program, we'll create a simple script. From the File menu in MATLAB, select New: M-File. You should get a new blank window. In the window, type the following exactly:

```
% Author: Justin Bieber (remember that guy?)
% Takes two numbers and adds them together.
% Enter 2 numbers
n1 = input('Enter a number: ');
n2 = input('Enter another number: ');
result = n1 + n2; % sum the two numbers
% display the results
disp('The sum of the two numbers you entered is')
disp(result)
```

(d) Notes: Anything after a % is a comment and to suppress output in the command window add a ; to the end of your statement. As always a program should be labeled with the author's name and the purpose of the program at the beginning. The different parts of the program are also commented as to their function or purpose.

(e) Two new commands: input and disp. Their function is obvious for accepting input from the user and displaying text and results. Note that disp accepts only one argument, i.e., you can't do disp(x,y).

(f) Now, in the command window, type *lab*0101 (this runs the program you typed in). If you don't get error messages then you should see the computer asking you to enter a number. Do so and hit return, enter another number and see if you get the correct result.

(g) If you have any other problems, MATLAB should give you a message trying to point out where the problem is located. Go back to the M-file, make the correction, save it, and run it again.

4. **Where the Rubber Meets the Road**

(a) Create a script called lab0102.m that evaluates the following expressions. Put your name in the script. Label each evaluation with a comment and use appropriate variables.

- Find the volume of the cylinder with diameter 7.2 and height 9.54. $V = \pi r^2 h$.
- With $x = 0.74$ and with $x = 1.99$, evaluate

$$f = \frac{x^5 - 3x^3 + x - 10.5}{x^2 + 0.00456x - 4.2}$$

- With $r_1 = 350$, $r_2 = 275$ and $r_3 = 325$, evaluate:

$$R = \frac{1}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}}$$

  This is the formula for the total resistance of three resistors in parallel.
- For $r = -0.77$ and $\theta = 5\pi/4$, evaluate

$$y = e^2 r\cos(\theta) + e^{4r}\sin(3\theta)$$

- In special relativity, the Lorentz factor is a number that describes the effect of speed on various physical properties when the speed is significant relative to the speed of light. Mathematically, the Lorentz factor is given as:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

  Use 3 x 10^8 m/s for the speed of light, c. Create variables for c and the speed v and from them a variable *lorentz* for the Lorentz factor. What happens if $v = 3$ x 10^8 m/s? How close to 3 x 10^8 m/s can you get? What happens to the Lorentz factor as v approaches c? What happens to the Lorentz factor if v is 5 m/s? Write your answer to these questions as comments in your script.

(b) Write a script like the example script given above so that it accepts a temperature in Celsius and displays the temperature converted to Fahrenheit. ($F = 9/5C + 32$). Call the script lab0103. Run it and convert the following temperatures, -39, 0, 23 and 112. Be sure to comment your code!

(c) Write a script entitled *lab*0104.*m* that converts x and y from cartesian to polar coordinates. The relationship between these two coordinate systems is defined as:

$$x^2 + y^2 = r^2$$
$$x = r\cos\theta$$
$$y = r\sin\theta$$

You will need to use these equations in your script to complete the conversion. Allow the user to enter their x and y values then display the corresponding r and θ to the user. Again, be sure to comment.

(d) You should submit 5 files to your TA for review: your diary file, *lab*0101.*m*, *lab*0102.*m*, *lab*0103.*m* and *lab*0104.*m*. Do not forget to upload all of these files to Canvas!

(e) Once the TA has checked your files you are free to go. Log off of your machine before you leave the lab.