Laboratory 8 – Programming With Matlab
Assign Week of November 19, 2012
Due Week of November 26, 2012

I — Introduction:

In the last laboratory exercise you learned how to handle general vector and matrix problems with MATLAB. It also turns out that MATLAB can be used as a very convenient software system for general programming. For large-scale programming (e.g., commercial software applications), languages such as C++ are more often used, however, MATLAB is a convenient program that can readily be used for managing the smaller problems most engineers need to solve routinely. MATLAB is very flexible: it also contains statistics and unstructured data analysis functions, and much more functionality, which has made it an important software tool for engineering students and practicing engineers.

II — Problem Statement:

Part 1: Section 30.6 in the 7th Edition of the textbook (page 836) shows how to write a simple function that takes two numbers as inputs and then outputs their product (*i.e.,* $a = x \cdot y$). Reproduce this function in MATLAB. (In Part 2, you will modify the output to return x times y^2.)

Part 2: Modify the code generated in Part 1 so that the new code takes input numbers, written as vectors, and multiplies one by the square of the other, element-by-element (*i.e.,* $a = x \cdot y^2$), and then writes the input and output vectors as vertical columns in a table with titles. Write your code so that it produces the same output for horizontal and vertical input vectors: in other words, the output should be vertical column vectors regardless of whether the input vectors are vertical or horizontal. The code should check if the lengths of the input vectors are the same and terminate the calculation with an explanatory message to the user if they are not the same. Provide demonstrations with vectors of x and y to show your program meets the requirements listed above.

(You may find the 'size' and 'length' commands helpful for deciding whether a vector is vertical or horizontal, and for finding how many elements it contains.)

Part 3: Write a MATLAB script file to plot the following piecewise function

$$\begin{cases} 1.5\sqrt{4x} + 10 & x \geq 9 \\ \dfrac{38}{11 - x} & 0 \leq x \leq 9 \\ \dfrac{38}{11} + \sin x^2 & x < 0 \end{cases}$$

for $-40 \leq x \leq 30$. Your code should make use of a "for" loop, a counter (index) and "if" statements. In an appendix of your report, include your code, and the plot created by the program. The plot should have the axes labelled and a title that includes your name, *i.e.,* your name should appear in the title of the plot.

Part 4: For your automobile, you wish to determine the fuel efficiency, in miles per gallon (MPG), and fuel consumption in L/100 km. Over six months you record the distance travelled and fuel consumed each month. These records are listed below in the table.

- Write a MATLAB function that returns the fuel consumption in units of L/100 km from input values of distance travelled and the fuel used each month.
- When run, the MATLAB function shall automatically re-produce the table below with the fuel efficiency and fuel consumption calculated for each month.
- The MATLAB function shall automatically produce a separate output for the calculated average values for the fuel efficiency and fuel consumption over the six-month period. (*i.e.,* replace the '???' in the sentences after the table with the calculated values.)
- All calculated output should be reported to the correct number of significant figures.
- Use the plot button in 'Workspace' to produce a graph of fuel consumption versus month. The axes should be labelled and your name should appear in the title (Click on "Insert" in the Figure window and find 'X Label' etc., in the dropdown box). Click on 'Edit > Copy the figure' and paste the plot into an appendix to your laboratory report.

(**1 US gal = 3.785L, 1 mile = 1.61 km)**

Month	Distance (km)	Fuel (L)	MPG	L/100 km
1	2545	216		
2	2305	184		
3	1951	162		
4	2853	234		
5	1984	171		
6	2553	209		

The average fuel efficiency is ??? MPG.
The average fuel consumption is ??? L/100 km.

Part 5: Consider a piston, connecting rod, and crank for an internal combustion engine.

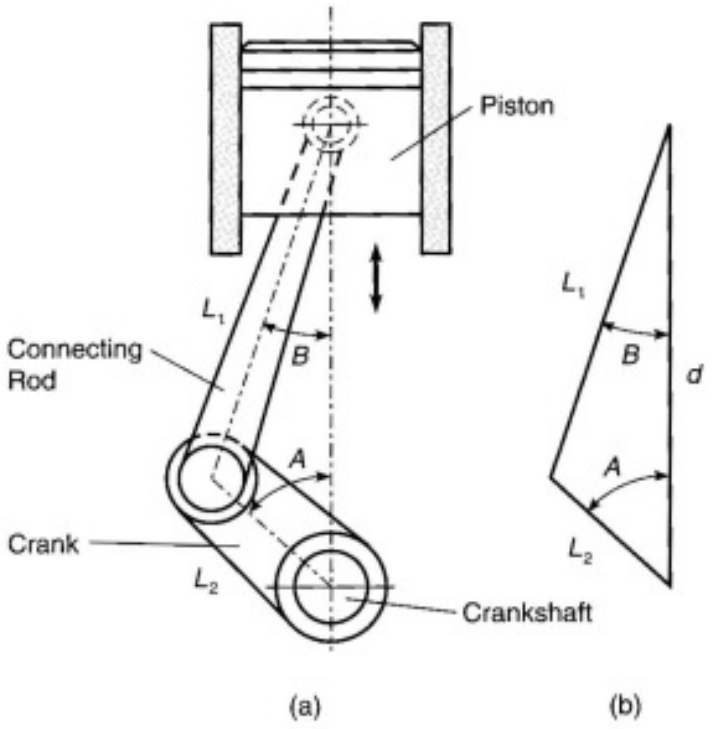

Figure 2. A crankshaft

When combustion occurs, the piston is pushed down. This motion causes the connecting rod to turn the crank, which causes the crankshaft to rotate. You are to construct a MATLAB function to compute the distance d traveled by the piston for given input values of the lengths L_1 and L_2 and the angle A. Because the mechanism's motion is symmetrical about $A = 0$, you need to consider only angles in the range $0° \le A \le 180°$. Figure 1(b) shows the geometry of the motion, from which the following expression for d may be written:

$$d = L_1 \cos B + L_2 \cos A \tag{1}$$

Thus, to compute d given the lengths L_1 and L_2 and the angle, A, you must first determine angle B. You can do so using the law of sines:

$$B = \sin^{-1}\left(\frac{L_2 \sin A}{L_1}\right) \tag{2}$$

Equations 1 and 2 form the basis of the calculations.

You are to develop and test a MATLAB function that returns the value of d (in **cm**) for input values of lengths L_1 and L_2 (measured in feet) and the angle A (in degrees):

$$d[\text{cm}] = \text{function}(L_1[\text{feet}], L_2[\text{feet}], A[^\circ]) \tag{3}$$

Note that MATLAB angles for trigonometric functions are in radians. Use the following values for the lengths: L_1 = 1.25 ft and L_2 = 0.5 ft. Recall that 1 ft = 30.48 cm.

Run and test your function in the Command Window:

- Produce a vector of angles from 0^o to 180^o in steps equal to the least significant digit of your student number (*i.e.,* the last number).
- Use your function to calculate the corresponding vector of values for *d* at these angles.
- Use the 'plot button' in the Workspace to produce a scatter plot of *d* as a function of the angles.
- Label the axes and write your name in the title of the graph

Part 6: Write a MATLAB program that asks for the input of a number, which will be your student number, and then follows this procedure:

- if the number is even, divide it by 2;
- if the number is odd, multiply the number by 3 and then add 1.

Iterate this procedure until 1 is reached; the program should display the number of iterations that were required to reach one *(i.e.,* 'The number of iterations = '). Your program should use a 'While' loop. This procedure will generate a series of numbers starting with the input number and ending with the number one. The program will reverse this series and plot its logarithm in base 10 versus sequence number. Axes should be labelled and your name and student number should appear in the plot title.

Run your program with your student number as input. In the plot window, use the 'Tools > Basic Fitting' option to produce a line that represents the trend in the plotted data. Comment on the physical relevance of the fitted line.

The commands `rem(x,y)` and `mod(x,y)` might be helpful in determining if a number is even.

III — Steps and Calculations:

Use MATLAB's programming language to perform all the necessary steps to obtain the solutions to each of the questions and problems presented above in Parts 1 to 6. All programs and functions should include comments to explain the codes.

IV — Report Requirements and Deliverables:

- Using the guidelines presented in Laboratory 1, produce a formal laboratory report that summarizes your findings.
- Like laboratory 7, this assignment is more-or-less a series of programming exercises and not a good imitation of a real-life situation. Nonetheless, you should be able to identify a central theme (central objective) to use as a guide for writing your report.
- State briefly the results to all of the problems posed. Discuss the significance of the results in each case.
- Include your MATLAB code and plots for each problem in an appendix(ces).
- In general terms, discuss the usefulness of MATLAB for performing programming tasks. Discuss the difference between MATLAB script files and MATLAB functions. When is it less/more advantageous to use one or the other?

Deliverables Summary *The lab assignment includes the following:*
1. Title page **2. One-page report** **3. A MATLAB program for Part 2 with some input and output demonstrating it works** **4. A MATLAB program and the corresponding plot for Part 3** **5. A MATLAB program, a Table followed by the average values, and the corresponding plot for Part 4** **6. A MATLAB program and the corresponding plot for Part 5** **7. A MATLAB program and the corresponding plot for Part 6** **8. IMPORTANT: Submit your electronic version of your assignment to the specific folder*** **IMPORTANT NOTES:** A. Deliverables 3-7 above should be included in the laboratory report as an appendix. The maximum number of plots per page in the appendix is two. B. All the plots should have labelled axes and a title that includes your name. All programs and functions should include comment statements to explain the code.

***File name: "Lab Session_Student number.doc OR .docx" (e.g. "C3_100812345.doc": it is for C3 Lab session)**

V — Submission and Timing:

Your report is to be submitted to the Teaching Assistant within the first 30 minutes of your next laboratory period. **LATE SUBMISSIONS WILL NOT BE ACCEPTED.**

VI — Marking:

Laboratory submissions will be marked on a 10-point scale: 9-10 (excellent); 7-8 (good); 5-6 (marginal); less than 5 (poor). **Be sure that you are familiar with the University's policy on plagiarism and academic integrity. Your instructors are obligated to report all suspected violations to the Associate Dean's office for investigation (see also chapter 14 at www4.carleton.ca/calendars//ugrad/current_ /regulations).**