ENG1060: COMPUTING FOR ENGINEERS

Lab 1 – Week 2

2020 OCT NOV

Welcome to the introductory lab.

Preparation:
Ensure that you:

1. Have a laptop with MATLAB installed.
2. Check your group on the News Forum in Week 2 after allocations have closed. A Zoom invitation and Google Calendar invite will be provided.

Self-study:
Students are expected to attempt these questions during their own self-study time, prior to this lab session. There may be questions that require functions not covered in the workshops. Remember to use MATLAB's built-in help for documentation and examples.

Learning outcomes:

1. To identify the main components of the MATLAB interface
2. To recall and describe various in-built MATLAB functions
3. To translate simple mathematics into MATLAB code
4. To construct, modify and address vectors and matrices
5. To demonstrate the use of m-files

Background:
Engineers rely heavily on the use of computers and programs to perform calculations quickly and accurately – much quicker than if a human were to perform them manually. Additionally, computers have the capacity to store and recall large amounts of data. The data is typically structured as a matrix, which is the basic data element that MATLAB uses. MATLAB (MATrix LABoratory) excels in the manipulation and operation of matrices.

Primary workshops involved:

- Workshop 1: Introduction, variables and matrices

Assessment:
This laboratory comprises **2.5%** of your final grade. The questions are designed to test your recollection of the workshop material and to build upon important programming skills. You will be assessed on the quality of your programming style as well as the results produced by your programs during your laboratory session by the demonstrators. Save your work in **m-files** named ***lab1t1.m***, ***lab2t2.m,*** etc. Inability to answer the demonstrator's questions may result in zero marks, at the demonstrator's discretion.

Team tasks begin at the start of the lab session so please ensure you arrive on time to form your groups. Students who arrive late will not be able to participate in the team tasks as teams will have already formed and will therefore forfeit all associated marks. These tasks will be assessed during class.

Lab submission instructions

Follow the instructions below while submitting your lab tasks.

Team tasks:
The team tasks are designed for students to test and demonstrate their understanding of the fundamental concepts specific to that lab. These tasks will occur at the start of the lab and will be assessed on the spot. Demonstrators will advise on how these will be conducted. Most team tasks do not require the use of MATLAB but MATLAB should be used for checking purposes.

Individual tasks:
The individual tasks are designed for students to apply the fundamentals covered in the team tasks in a variety of contexts. These tasks should be completed in separate m-files. There is typically one m-file per task unless the task requires an accompanying function file (lab 3 onwards). Label the files appropriately. E.g. lab6t1.m, lab6t2.m, eridium.m, etc.

Deadline:
The lab tasks are due next Friday at 9am (MYT) or 12pm (AEDT). Late submissions will not be accepted. Students will need to apply for special consideration after this time.

Submission:
Submit your lab tasks by:

1) Answering questions in Google Form, and
2) Submitting one .zip file which include all individual tasks.

The lab .zip file submission links can be found on Moodle under the weekly sections, namely Post-class: Lab participation & submission. The submission box ("Laboratory") will only accept one .zip file. Zipping instructions are dependent on the OS you are using.

Your zip file should include the separate m-files for the individual tasks including function files.

It is good practice to download your own submission and check that the files you have uploaded are correct. Test run your m-files that you download. You are able to update your submission until the deadline. Any update to the submission after the deadline will be considered late.

Grade and feedback:
The team will endeavour to grade your lab files by Tuesday of the following week. Grades and feedback can be viewed through the Moodle Gradebook, which is available on the left side pane on the ENG1060 Moodle site.

Lab 1 – Assessed questions

TASK 0

[ICEBREAKER ACTIVITY]

Ensure that you have joined in your allocated colour group. Spend some time to introduce yourself with the following before starting the Task 1:

1. Your name
2. Your degree and intended specialisation(s)
3. A hobby, interest or a place you'd rather be besides here

TASK 1

[2 MARKS – L01TI]

Note: Team tasks are designed for students to recall material that they should be familiar with through the workshops and practice of the individual questions prior to this lab session.

Students will be split into groups of 3-5 for the team tasks. Students in each group must explain aspects of the question below to receive the marks. Ensure that everyone has equal learning opportunities. Additionally, ask your table for help if you need it - leave no student behind! You will be required to explain and discuss your work.

MATLAB interface	**MATLAB in-built commands**	**Common error messages**
• Command window • Editor • Workspace • Directory	• Close all; clear all; clc; • linspace() or : (colon operator) • round(), fix() • ceil(), floor() • mod() or rem() • log() or log10() • sin() or acosd()	• Undefined function or variable 'x' • Index exceeds matrix dimensions • Subscript indices must either be real or positive integers or logicals

Complete the following and use MATLAB to aid demonstration if required.

1. Explain the purpose of each item in the 'MATLAB interface' list
2. Provide a short example (and output) of the commands in the 'MATLAB in-built commands' list
3. Write a short example code that would generate the errors in the 'common error messages' list. You may use the "MATLAB common-errors guide" provided in the 'Resources' folder on the ENG1060 GDrive.
4. Have the demonstrator assess your understanding.

TASK 2

[2 MARKS – L01TJ]

Note: Team tasks are designed for students to recall material that they should be familiar with through the workshops and practice of the individual questions prior to this lab session.

Students will be split into groups of 3-4 for the team tasks. Students in each group must explain aspects of the question below to receive the marks. Ensure that everyone has equal learning opportunities. Additionally, ask your table for help if you need it - leave no student behind! You will be required to explain and discuss your work.

Vectors and matrices:

Each group will be assigned either vector A or matrix B.

Vector A

$$A = [100 \quad 90 \quad 80 \quad 70 \quad 60 \quad 50 \quad 40 \quad 30 \quad 20 \quad 10]$$

Complete the following:

1. Draw the vector and write its dimensions
2. Write syntax to create the similar vector two different ways
3. Write syntax to extract every 3rd element starting with the 1st element and the output
4. Write syntax to concatenate 5 rows of vector A to form matrix K.
5. Assume that A is a column vector, write syntax to concatenate 5 columns of vector A to form matrix K.
6. Discuss the task and explore any misunderstandings.
7. Browse the work of other teams related to the other set(s) and ensure that you have understood it as concepts from all sets may be required for the individual tasks.
8. Have a demonstrator assess your understanding.

Matrix B

$$B = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \\ 10 & 11 & 12 \end{bmatrix}$$

Complete the following:

1. Draw the matrix and write its dimensions
2. Write syntax to create the matrix
3. Write syntax to extract the number 9
4. Write syntax to extract elements common to the 2nd and 4th rows & the 2nd and 3rd columns
5. Discuss the task and explore any misunderstandings.
6. Browse the work of other teams related to the other set(s) and ensure that you have understood it as concepts from all sets may be required for the individual tasks.
7. Have a demonstrator assess your understanding.

TASK 3

[2 MARKS]

The capacitance of capacitors connected in series and in parallel (C_s and C_p) can be calculated as follows:

$$\frac{1}{C_s} = \sum_{i=1}^{N} \frac{1}{C_i} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots.$$

$$C_p = \sum_{i=1}^{N} C_i = C_1 + C_2 + \cdots,$$

What is the total capacitance of seven capacitors with equally spaced capacitance values ranging from 0.1 F to 100 F if they are all connected in series, and if they are connected in parallel?

TASK 4

[2 MARKS]

Consider *x* = -299:999 and calculate the function:

$$f(x) = \frac{x\cos(x)}{(x^2+1)(x+2)}$$

Then determine the product of the of $f(-179) \times f(146) \times f(999)$. Note that these correspond to the 121st, 446th, and last values of the $f(x)$ result vector.

Hint: Do not use *f*(*x*) as the variable name!

TASK 5

[GF]

The walls of blood vessels in the microcirculation are being subjected to shear stress due to blood flow. Mathematically, the shear stress per volumetric flow rate exerted on the microcirculation-based blood vessel walls can be calculated using the Hagen-Poiseuille equation given as:

$$\frac{\tau_w}{Q} = \frac{4\mu}{\pi R^3}$$

where τ_w represents the wall shear stress (dyn/cm^2), *R* (cm) is the radius of the blood vessel, *Q* (cm^3/s) is the volumetric flow rate of blood and μ (dyn.s/cm^2) is the apparent viscosity of blood. The m-file below is supposed to calculate the total shear stress exerted on the walls of a blood vessel of diameter 50 μm due to blood flow at a volumetric flow rate of 9.81 × 10^{-6} cm^3/s. The apparent viscosity of blood is 0.03 dyn.s/cm^2. However, the m-file contains errors.

Copy-paste the following code into an m-file and run it. Identify all the errors and take note of how you have resolved these errors.

```
clear all; close all; clc

tao/Q = 4*mu/pi*R^3
Q = 9.81*10e-6
R = 50
mu = 0.03
```

TASK 6

[3 MARKS]

The sound pressure level (SPL, measured in units dB) of an acoustic wave is a measurement used to judge the 'loudness' of sounds. Humans will begin to feel pain if subjected to sounds with $SPL \gtrsim 90$dB, with permanent damage being sustained to the eardrum at $SPL \gtrsim 160$dB. The sound pressure level in dB is related to the sound pressure p in Pa through

$$p = p_0\, 10^{0.05\, SPL}$$

where $p_0 = 20$ μPa is the reference background pressure of air. Calculate the SPL of the following noises:

a) Mosquito buzz from 3m away in a quiet room ($p \approx 20$ μPa)
b) Jet engine noise from 1m away ($p \approx 11.25$ Pa)
c) "Karen": "I've walked all of Braaahton" ($p \approx 20$ kPa)

TASK 7

[5 MARKS]

Construct the following matrices in MATLAB and find:

$$A = \begin{bmatrix} 8 & 7 & 9 & 5 & 7 \\ 9 & 6 & 0 & 5 & 5 \\ 3 & 6 & 0 & 2 & 3 \\ 4 & 6 & 0 & 8 & 9 \\ 2 & 1 & 2 & 1 & 2 \end{bmatrix} \qquad B = \begin{bmatrix} 38 \\ -10 \\ 44 \\ -7 \\ 53 \end{bmatrix}$$

1. Transpose of matrix **A** (**A**^{T})
2. Find the product: A^T x B.
3. Sort the result of A^T x B in descending order.
4. Find the square of matrix A (not element-by-element).
5. Form a 3 x 4 matrix from **A** comprising of elements from 3rd, 4th and 5th rows & 2nd, 3rd, 4th and 5th columns.
6. Form a 3 x 4 matrix from **A** comprising of elements from 2nd, 3rd, and 4th rows & 1st, 2nd, 3rd & 4th columns.
7. Compute the absolute difference between steps #5 and #6.
8. Compute element by element square of step #7 matrix.

TASK 8

[4 MARKS]

The area of a triangle is

$$Area = \frac{1}{2} \times base \times height$$

Find the area of a set of triangles whose base and height vary from 3m to 7m and 10m to 16m respectively, with a spacing of 1m. Your answer should be a 2D matrix as shown in the figure below.

Area	10	11	…	16
3				
4				
…				
7				

Your answer matrix

END OF ASSESSED QUESTIONS

The remainder of this document contains supplementary and exam-type questions for extended learning. Use your allocated lab time wisely!

Lab 1 – Supplementary questions

These questions are provided for your additional learning and are not assessed in any way. You may find some of these questions challenging and may need to seek and examine functions that are not taught in this unit. Remember to use the help documentation. Coded solutions will not be provided on Moodle. Ask your demonstrators or use the discussion board to discuss any issues you are encountering.

TASK 1S

Calculate the values of the following expressions

A. $p(x) = x^2 + 3x + 1$ at $x=1.3$
B. $y(x) = \sin(x)$ at $x=30°$
C. $f(x) = \tan^{-1}(x)$ at $x=1$
D. $g(x) = \sin(\cos^{-1}(x))$ at $x=3/2$

SOLUTION

```
A. p = 6.5900
B. y = 0.5000
C. f = 0.7854
D. g = 0.0000 + 1.1180i        % Explain why.
```

TASK 2S

There are 739 apples to be packed and shipped in boxes that each contain a maximum of 54 apples. Calculate how many apples will remain unpacked if only full boxes can be shipped.

SOLUTION

```
rem_apples =    37
```

TASK 3S

A sphere has a radius of 24cm. A rectangular prism has sides of a, $a/2$ and $a/4$.

A. Determine the length a of a prism which has the same volume as the sphere
B. Determine the length a of the prism which has the same surface area as a sphere.

SOLUTION

```
A. vol_sph =    5.7906e+04
   a_eqvol =    77.3756
   vol_prism =    5.7906e+04    %cm^3 - checking if same as vol_sph

B. sa_sph =    7.2382e+03
   a_eqsa =    64.3128
   sa_prism =    7.2382e+03     %cm^3 - checking if same as sa_sph
```

TASK 4S

Verify the following identity using $x=\pi/12$.

$$\tan(3x) = \frac{3\tan(x) - \tan^3(x)}{1 - 3\tan^2(x)}$$

SOLUTION

```
func_LHS =    1.0000
func_RHS =     1
err =   1.1102e-16
```

TASK 5S

There are eight pints in a gallon, and 2.11 pints in a litre. The volume of a tank is given as 2 gallons and 4 pints. Convert this volume into litres.

SOLUTION

```
tot_vol_litres =    9.4787
```

TASK 6S

The spread of a computer virus through a computer network can be modelled by

$$N(t) = 20e^{0.15t}$$

where $N(t)$ is the number of computers infected and t time in minutes.

A. Determine how long it takes for the number of infected computers to double.
B. Determine how long it takes for 1,000,000 computers to be infected.

SOLUTION

```
   A. dt_a =    4.6210
   B. dt_b =   72.1319
```

TASK 7S

An environmental engineer has determined that the cost C, of a container tank will be based on the radius r of the tank, which is given by

$$C = \frac{32430}{r} + 428\pi r$$

Calculate the costs for r=10, 20, 30, 40 and 50.

SOLUTION

```
c = 1.0e+04 *
    1.6689    2.8514    4.1419    5.4595    6.7879
```

TASK 8S

Water freezes at 32°F and boils at 212°F on the Fahrenheit scale. Use the following formula to convert temperatures of 10°C, 20°C, 30°C, 37°C (normal human temperature), 40°C and 50°C to Fahrenheit temperatures

$$F = \frac{9C}{5} + 32,$$

where *F* and *C* represent Fahrenheit and Celsius temperatures, respectively.

SOLUTION

```
temps_f =    50.0000   68.0000   86.0000   98.6000  104.0000  122.0000
```

TASK 9S

Six people stand on a pier. From heaviest to lightest, they weigh 100lbs, 130lbs, 160lbs, 190lbs, 220lbs and 250lbs. The pier is rated hold 400kg. Check if this pier can safely hold these 6 people.

SOLUTION

```
wkg =   45.4545   59.0909   72.7273   86.3636  100.0000   113.6364
w_all =  477.2727
Pier will collapse!
```

TASK 10S

The volume *V*, of a hollow sphere is given by

$$V = \frac{4\pi}{3}(r_0^3 - r_i^3),$$

where r_i and r_o represent the inner and outer radius, respectively. Calculate the volume for the following (r_i, r_o) pairs. Determine which pair has a volume greater than 420 units^3.

- (r_i, r_o) = (3, 5)
- (r_i, r_o) = (4, 5.5)
- (r_i, r_o) = (5, 5.75)
- (r_i, r_o) = (5.1, 6)

SOLUTION

```
ri =    3.0000    4.0000    5.0000    5.1000
ro =    5.0000    5.5000    5.7500    6.0000
V =   410.5014  428.8274  272.7295  349.1315
```

TASK 11S

A few biomedical students are designing a device that will monitor a person's heart rate while on a treadmill. A simple calculation of the target heart rate (THR) for a moderately active person is given by

$$THR = \frac{6}{10}(220 - A)$$

where *A* represents the person's age. Calculate the *THR* for ages 10 to 65, in increments of 10.

SOLUTION

```
A =    10    20    30    40    50    60    65
THR =   126   120   114   108   102    96    93
```

Lab 1 – Exam-type questions

These questions are for your additional learning and are not assessed in any way. You may find these type of questions on ENG1060 exams. Solutions will not be provided on Moodle. Ask your demonstrators or use the discussion board to discuss any issues you are encountering. Additionally, you may use the exam collaboration document on Moodle (under the exam section) to share your answers.

Note: If a MATLAB statement returns an error, write down "error".

1. Describe what an m-file is and list its benefits.

2. What is the syntax to calculate the natural logarithm of X?

3. What is the syntax to calculate the cosine of π in degrees?

4. Which one of the following is an invalid variable in MATLAB?
   A. Exam = 8+14;
   B. Union leader = 4^2;
   C. Jack9 = pi + exp([1 2 3]);
   D. S3m1 = [7, 9; 8 4]
   E. Dst_proficiency = [1 : 8]

5. Describe two main environments in the MATLAB interface.

6. Provide the output of Y = sign(-5).

7. List two rules for invalid variable creation in MATLAB.

8. Provide the syntax to clear all variables, close all figure windows and clear the command window.

9. Describe the difference between a traditional m-file and a function file.

10. The terminal velocity U_T, of a sphere of diameter x (m), and density ρ_s (kg/m^3), falling in a stationary fluid of density ρ_f (kg/m^3) and viscosity μ_f (kg/ms) is given by:

$$U_T = \frac{x^2 g(\rho_s - \rho_f)}{18\mu_f}$$

Where g=9.81 is the acceleration due to gravity. Write an m-file in the box below to calculate the terminal velocity of a sphere with a 10 mm diameter and density of 7.86 g/cm^3, falling in a stationary fluid of density 1000 kg/m^3 and a viscosity of 0.001 kg/ms.