ENG1060: COMPUTING FOR ENGINEERS

Lab 2 – Week 3

2020 OCT NOV

Welcome to lab 2. Remember that laboratories continuously build on previously learned concepts and lab tasks. Therefore, it is crucial that you complete all previous labs before attempting the current one.

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 construct, modify and address vectors and matrices
2. To differentiate between regular matrix and element-by-element operations
3. To apply the in-built min/max functions with two outputs
4. To interpret and solve simple problems
5. To practice plotting functions to present results in an appropriate manner

Background:
Engineers collect and create mass amounts of data that require post-processing calculations. MATLAB allows users to perform operations on very large matrices in a straightforward manner. However, it is incredibly difficult to interpret large amounts of data presented in a tabulated/matrix form. Hence, such data is typically presented through plots.

Primary workshops involved:

- Workshop 1: Introduction, variables and matrices
- Workshop 2: Matrix calculations and plotting

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 will 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 2") 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 2 – Assessed questions

TASK 1

[2 MARKS – L02TE]

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.

Min/max functions:

Each group will be assigned either Set A or Set B.

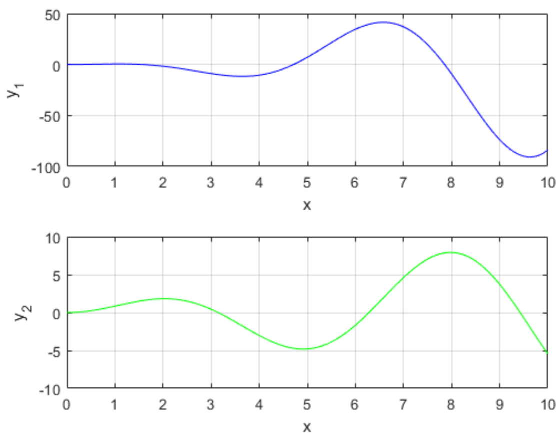
Set A:	$\text{day} = [15 \quad 21 \quad 30 \quad 44 \quad 51]$	$\text{temp} = [24 \quad 37 \quad 34 \quad 30 \quad 20]$
Set B:	$\text{day} = \begin{bmatrix} 11 & 84 & 94 & 74 \\ 51 & 54 & 41 & 14 \end{bmatrix}$	$\text{temp} = \begin{bmatrix} 24 & 37 & 25 & 23 \\ 26 & 19 & 31 & 30 \end{bmatrix}$

Complete the following tasks:

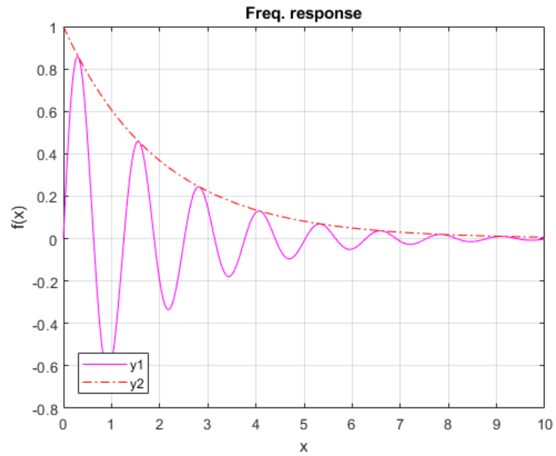
1. Copy the vectors
2. Annotate the output of the following MATLAB commands:
    a. [max_temp, id] = max(temp)
    b. day_of_max_temp = day(id)   (note the odd-looking result for set B)
3. Complete the part relevant to your chosen set.
    a. Set A: Consider the following vectors, which contain 100 elements each. Provide the max() function syntax to retrieve the maximum value of X and the corresponding value of C.
    $C = [4 \quad 7 \quad 1 \quad 3 \quad 9 \quad \cdots]$
    $X = [10 \quad 31 \quad 40 \quad 11 \quad 32 \quad \cdots]$
    b. Set B: Provide the syntax to obtain the **single** maximum value of the temp matrix (i.e. 37) using the max function
4. Discuss the task and explore any misunderstandings.
5. 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.
6. Have a demonstrator assess your understanding.

Plotting:

Plot A:
$y_1 = x^2 \cos(x)$ and $y_2 = x \sin(x)$



Plot B:
$y_1 = \exp(-0.5x)\sin(5x)$ and $y_2 = \exp(-0.5x)$



Each group will be assigned either Set A or Set B. Complete the following:

1. Annotate or provide code that generates the following components, where applicable:
   a. A vector x, which starts from 0 to 10 with 0.01 increments
   b. The vectors y_1 and y_2
   c. Subplot figures
   d. Plotting y_1 and y_2 against x with correct line and colour specifications
   e. The grid
   f. The axis labels and title
   g. The legend and location
2. Discuss the task and explore any misunderstandings. Also, browse the work of other teams related to the other set and ensure that you have understood it as concepts from all sets may be required for the individual tasks.
3. Have a demonstrator assess your understanding

TASK 2
[4 MARKS – GF]

Two water waves, w_1 and w_2 meet and result in w_3 on a river position for $0 \le x \le 15$ with increment of 1

$$w_1 = 4\cos\left(x + e^{-x^2}\right)$$
$$w_2 = 5\sin\left(3x + \frac{\pi}{2}\right)$$
$$w_3 = w_1 + w_2$$

1. Plot w_1 against x as a dashed blue line, plot w_2 against x as a dash-dotted red line, and plot w_3 against x as a solid black line on the same figure. Ensure you label your axis and provide a legend and title for the plot.
2. Repeat Step 1 by using x-increment of 0.01 by creating another new figure. Ensure you label your axis and provide a legend and title for the plot.

TASK 3

[4 MARKS – GF]

The item ID, cost and quantities of several items are shown in the table below.

Item ID	Cost per item ($)	Quantity
17	330	1
30	450	35
35	50	15
51	89	4
77	140	4
90	590	9

1. Create the above table as a 6-by-3 matrix (numerical values only, ignore the header).
2. Plot the cost per item against the item ID as blue diamonds and label the plot accordingly.
3. Append a 4^{th} column containing the total cost for each item ID.
4. Use MATLAB's max() function to determine the maximum total cost and the corresponding item ID.
5. Sum the total costs of all the item IDs.

TASK 4

[5 MARKS – GF]

The horizontal and vertical force components are denoted as h and v respectively, and applied to an object which result in

$$Axial\ force, c = hsin\theta + vcos\theta$$
$$Shear\ force, s = hcos\theta - vsin\theta$$

For both $50 \leq h \leq 200$ and $25 \leq v \leq 100$ with 10 linearly spaced points, use $\theta = 0, 15°, 30°, 45°, 60°, 75°, 90°$ to plot a figure with c as x-axis and s as y-axis. Use legend to label for all θ cases. Don't forget axes labels and title.

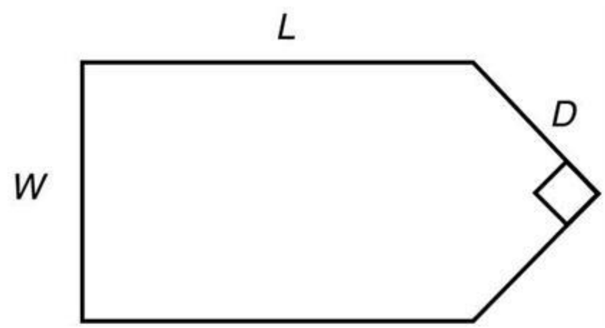
Hint: Use regular matrix multiplication

Hint: If inputs to plot() are 2D matrices, MATLAB takes each column as separate inputs

TASK 5

[5 MARKS – GF]

A fence is required around a field is shaped as shown below. It consists of a rectangle of length *L* and width *W* and a right triangle that is symmetrical about the central horizontal axis of the rectangle. Suppose the width is known (in metres), and the enclosed area *A* is known (in square metres).



1. Use pen and paper to determine the equations for the total area and perimeter in terms of the width *W*, and length *L*.
2. Use MATLAB to plot the perimeter against the width as a black solid line, assuming the width to be between 7 to 20 metres and the area to be 111 m^2.
3. Use the min() function to determine the minimum perimeter required to fence off the 111 m^2 area. Print the corresponding length and width required, and mark the minimum point on the previous plot with a blue diamond.

Note: Try solving/rearranging the equations by hand before putting them into MATLAB
Note: You may want to use the built-in function 'min' with two outputs

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 2 – 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

Create a logarithmically spaced vector called **X** between 1 and 1000 using 50 points.

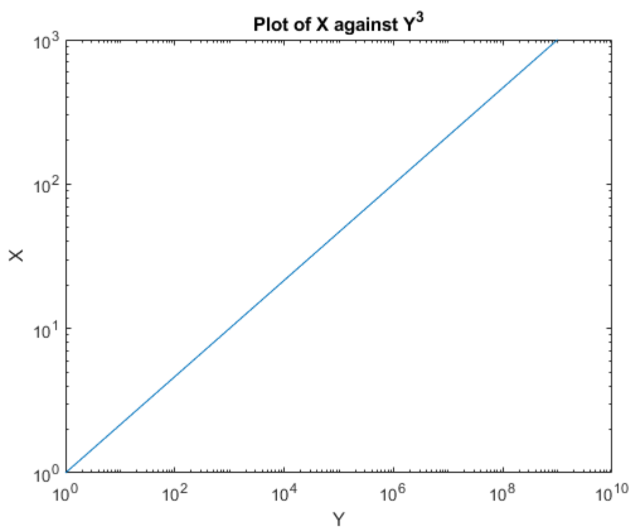
A. Calculate **X**(30)-**X**(45)

B. Calculate **X**(30-45). Is the result as expected?

C. On logarithmically-scaled axes, plot **X** against **Y** where **Y** = **X**^{3}. What does the gradient of this plot represent?

SOLUTION

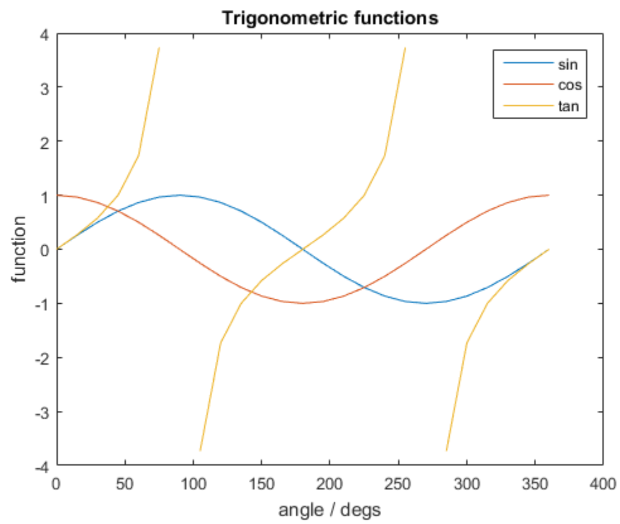
```
A. A = -434.5351
B. % Error since X(30-45) = X(-15).
C. % Gradient of plot = 1/3, is rate of increase of X with Y.
```



TASK 2S

Set up a matrix of angles in the first column from 0 to 360 in steps of 15 degrees, sines in the second column and cosines in the third column. Then add tangents to the fourth column. Plot the sines, cosines and tangent values as a function of degrees on the same figure, remembering to include a legend.

SOLUTION



TASK 3S

The following code is supposed to evaluate the function

$$f(x) = \frac{x^2 \cos(\pi x)}{(x^3 + 1)(x + 2)}$$

for $x \in [0,1]$ (using 200 points). Correct the code and check this by evaluating the function at x=1 using f(200) which should be -1/6.

```
x = linspace(0,1);
clear all
g = xˆ3+1;
H = x+2;
z = x.ˆ2;
y = cos xpi;
f = y*z/g*h
```

SOLUTION

```
% copied code from question, noted where corrections were made

x = linspace(0,1,200); % mistake in n points
% clear all - mistake clearing variables
g = x.^3+1; % should use element-by-element
H = x + 2;
z = x.^2;
y = cos(x*pi); % needs brackets and multiplication symbol
f = y.*z ./( g.*H ); % needs brackets for denominator, element-by-element operations, h
not the same as H defined earlier

fcheck = f(end) % should be -1/6
err = abs(fcheck - (-1/6)) % should be 0 to be correct


% END OF SCRIPT
```

```
fcheck =    -0.1667
err =      0
```

TASK 4S

The following data is the mass and associated terminal velocities of a number of jumpers.

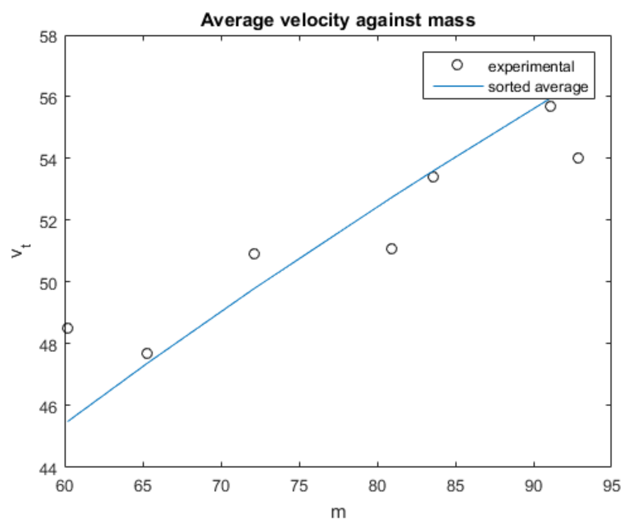
m	83.6	60.2	72.1	91.1	92.9	65.3	80.9
v_t	53.4	48.5	50.9	55.7	54	47.7	51.1

Plot this data as circles. The drag coefficient can be calculated using

$$c_d = \frac{gm}{v_t^2}$$

Calculate the drag coefficients and find the average. Then rearrange the above equation to calculate the predicted average terminal velocity of each jumper using the averaged drag coefficient. Plot the predicted velocities as a continuous line on the same figure as the raw data.

SOLUTION




```
cdmean =    0.2854
```

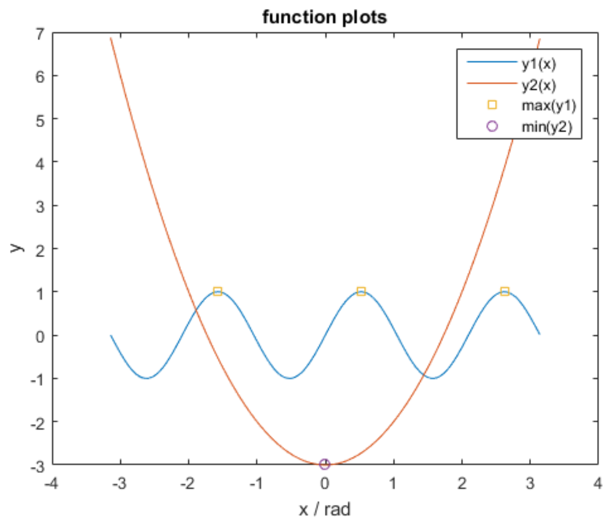
TASK 5S

Plot the following functions on the same plot for x values between -π to π with a spacing of 0.01.

$$y_1 = \sin(3x)$$
$$y_2 = x^2 - 3$$

Mark all of the maxima for y_1 with squares and mark the minimum of y_2 with a circle. You will need to use the max function multiple times.

SOLUTION



Lab 2 – Exam-type questions

These questions are provided 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. Consider the following matrices:

$$A = [90 \quad 70 \quad 50 \quad 30 \quad 10\,] \qquad B = \begin{bmatrix} 8 \\ -7 \\ -11 \\ 21 \\ 33 \end{bmatrix} \qquad C = [1 \quad 2 \quad 3 \quad 4 \quad 5]$$

$$D = \begin{bmatrix} 4 & 9 & 1 & 6 & 15 \\ 11 & 3 & 2 & 8 & 6 \end{bmatrix}$$

a) List **four** different syntax to create the vector **A** in MATLAB. Each syntax should be limited to one line.

b) Provide the output of **X=A*B**

c) Provide the output of **Y=B.*C**

d) Provide the syntax to extract the **2nd, 3rd, and last columns of D** to create a 2-by-3 submatrix.

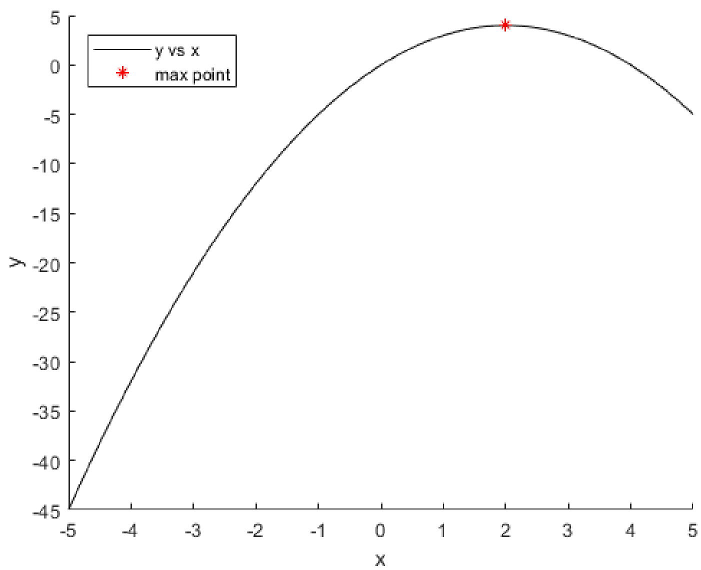
e) Provide the output of **max(D)**

2. Describe what element-by-element operations are and list all element-by-element MATLAB operators.

3. Consider a 50-by-50 matrix containing 2500 unique values. Provide the syntax to output the smallest number in that matrix.

4. Describe the line specifications for the following function: **plot(t, v, 'ms-')**

5. **Complete and correct** the following table to reproduce the figure shown below. Limit your code to one line for line numbers that are require filling.



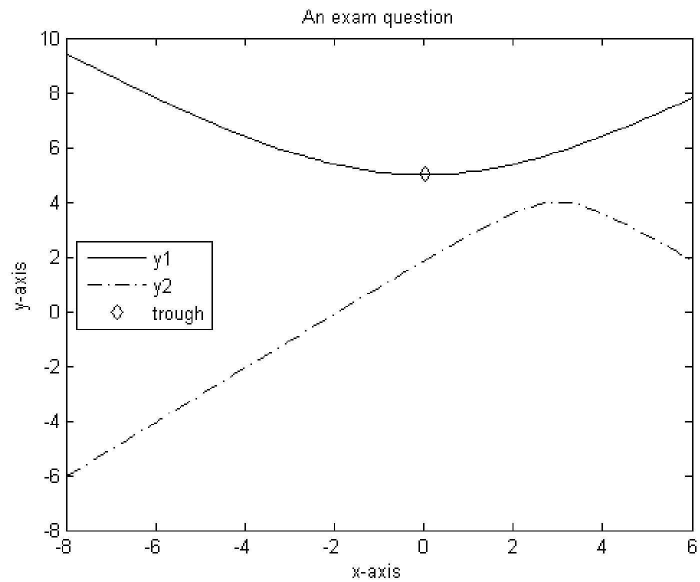
1	`clear all; close all; clc;`
2	`%% plotting`
3	`x = -5:0.1:5;`
4	`y = -x^2 + 4*x;`
5	
6	
7	
8	
9	`xlabel('x')`
10	
11	`legend('y vs x', 'max point')`

6. Write a MATLAB script that reproduces the figure below. The vector **x** is comprised of **83 equally spaced points with limits of -8 to 6 (inclusive)**. The equations **y1** and **y2** are defined as:

$$y1 = \sqrt{x^2 + 25}$$

$$y2 = -\sqrt{(x-3)^2 + 1} + 5$$

The **minimum (trough) of y1** is marked with a **diamond symbol**.



Ensure the following:

- Clear all variables before defining any.
- Clear the command window.
- Close any previously opened MATLAB windows.
- Proper axis labels, title and legend placement.
- Black coloured lines with appropriate line specifications.
- Marking of the minimum (trough) with a diamond symbol

Note: the default location of the legend box is northeast.

Using dot points, describe the steps needed to reproduce the figure below. You will need to use the max function multiple times.