ENG1060: COMPUTING FOR ENGINEERS

Lab 3 – Week 4

2020 OCT NOV

Welcome to lab 3. 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 2: Matrix calculations and plotting
- Workshop 3: Functions, commenting, debugging and strings

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 includes 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 3") 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.

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

Lab 3 – Assessed questions

TASK 1
[2 MARKS – L03TE]

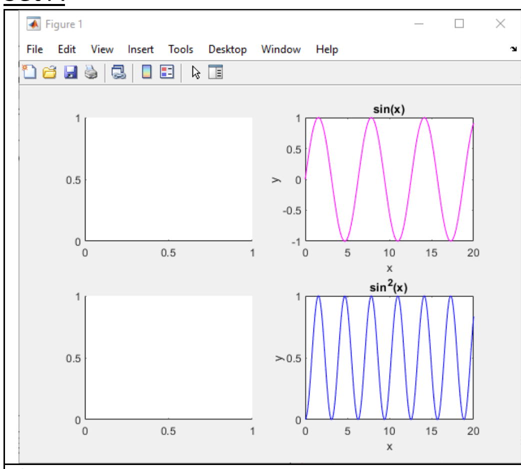
Note: Team tasks are designed for students to recall material that they should be familiar with through the workshops and practice of the individual questions prior to this lab session.

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.

<u>Subplots and fprintf:</u>
Each group will be assigned either Set A or Set B.

Complete the following:
1. [For Set A] Fill out the missing syntax needed to create the figures below
   [For Set B] Complete the single-line syntax to recreate each of the three statements ensuring the proper use of the width, precision and format specifications.
2. Discuss the task and explore any misunderstandings.
3. 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.
4. Have a demonstrator assess your understanding.

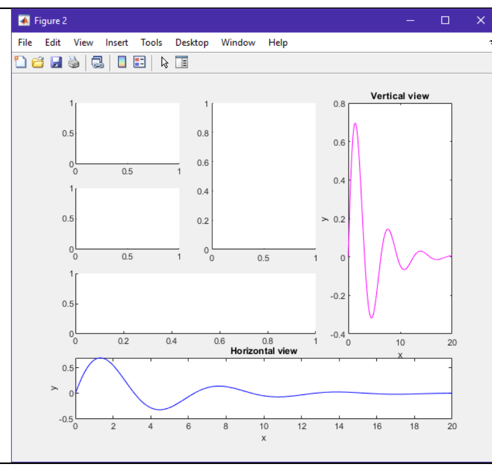
<u>Set A</u>




```
% create x vector
x = 0:0.01:20;

% plotting sin(x) in top right cell
<missing syntax>
plot(x, sin(x),'m')
title('sin(x)')
xlabel('x'); ylabel('y');

% plotting sin^2(x) in bottom right cell
<missing syntax>
plot(x, sin(x).^2,'b')
title('sin^2(x)')
xlabel('x'); ylabel('y');
```




```
% create x vector
x = 0:0.01:20;

% plot right-most plot
<missing syntax>
plot(x, exp(-0.25*x).*sin(x),'m')
title('Vertical view')
xlabel('x'); ylabel('y')

% plot bottom plot
<missing syntax>
plot(x, exp(-0.25*x).*sin(x),'b')
title('Horizontal view')
xlabel('x'); ylabel('y')
```

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

Set B

	Output	Command
1.	`How delicious is 3.14159265?`	fprintf('How delicious is %<missing syntax>',pi)
2.	`Placeholder uses               15 spaces`	fprintf('Placeholder uses %<missing syntax> spaces\n',15)
3.	$$$: 7 $$$: 10 $$$: 15	fprintf('$$$: %<missing syntax>', <missing syntax>)

Functions:

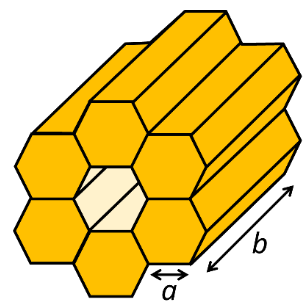
Each group will be assigned either Set A, B or C.

Complete the following:

1. Copy-paste the image of the structure
2. List the number of $a \times b$ segments that comprise the side surface of the structure
3. Write the total surface area SA and volume V equations
4. Write the function file that determines the surface area and volume given inputs a and b.
5. Write the syntax needed to call the function file in the m-file, naming the outputs out1 and out2. Provide the results of out1 and out2 if $a = 3$ and $b = 4$.
6. Ensure you understand user-defined functions as you'll be using them for the rest of the semester.
7. Have a demonstrator assess your understanding

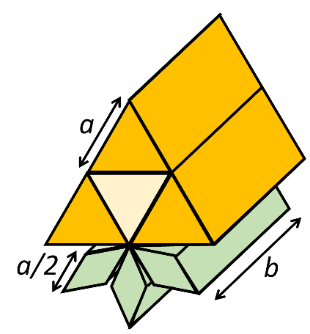
Set A: Sallydron – its cross-section is comprised of 6 hexagonal prisms (the centre is hollow). The edges of the hexagon are of length *a*, and the prism is of length *b*. The total cross-sectional area *CS* is

$$CS = 9\sqrt{3}a^2$$



Set B: Decorated Triforce - its cross-section is comprised of three equilateral triangles of length *a* (the centre is hollow), and three diamonds with side lengths *a*/2. The structure is extruded by length *b*. The total cross-sectional area *CS* is given by

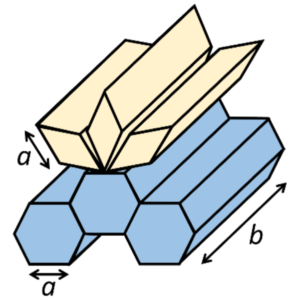
$$CS = \frac{3}{4}a^2\left(\sqrt{3} + 1\right)$$



 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

Set C: Never-before-seen legendary Pokemon (create a name for it!)- its cross-section is comprised of three hexagons and three diamonds. The structure is extruded by length *b*. The total cross-sectional area *CS* is given by

$$CS = 3a^2\left(\frac{3\sqrt{3}}{2} + 1\right)$$



 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

Remember good programming practices for all tasks even if not specifically stated. This includes, but is not limited to:

- using clc, close all, and clear all, where appropriate
- suppressing outputs where appropriate
- labelling all plots, and providing a legend where appropriate
- fprintf statements containing relevant answers

TASK 2

[4 MARK]

A geometry study using hypercycloid-like pattern can be described by the following equations.

$$x = (a-b)cos^2(\theta) + bcos^2\left(\frac{(a-b)}{b}\theta\right)$$

$$y = (a-b)sin^3(\theta) - bsin^3\left(\frac{(a-b)}{b}\theta\right)$$

Let $a = \pi$, $b = 1$ and create an equally-spaced vector for θ with 1000 values ranging from 0 to 50π. Create a 2-by-1 subplot figure with the following specifications:

- [Top subplot] Plot y against θ and x against θ on the same subplot. Remember to provide a legend.
- [Bottom subplot] Plot y against x as a continuous line coloured with the following RGB (red-green-blue) colours [0.0353, 0.6941, 0.8588]. Make the axis of this subplot square in size. Provide a title.

Note: check the axis() documentation for information on how to make the axis box square in size
Note: check the plot() documentation for information on how to use RGB colours

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

TASK 3

[4 MARKS]

The average atmospheric pressure on Earth is approximated as a function of altitude by the relation

$$P_{atm} = 101.325(1 - 0.02256z)^{5.256}$$

Where P_{atm} is in kPa and z is in km.

A. Create a **function** that computes the outputs P_{atm} provided z is known.
B. Create a separate m-file which produces a z vector from 0 to 12km with increments of 25m. Plot P_{atm} against z as a red dashed line, remembering to label your plot. Turn the grid on.
C. On the same plot you should mark with blue circles the pressure values for Perisher Valley (z=1740m), Hotham heights (z=1700m), Canberra (z=660m), Yamdrok Lake (z=4441m), Lipulekh Pass (z=5334m), Jejudo (z=1950m), Mount Hyjal (*z*=11337m) and the top of Mount Everest (z=8848m).

Optional: use text() to label each point with the location name.

TASK 4

[5 MARKS]

A petroleum tank is made up of a cylindrical part and conical top. The radius of cylindrical part and the base radius of cone are same, and are denoted by r. Similarly, both the cylindrical part and cone have same height h and so the tank has a total height of $2h$.

The surface area and the volume of cylindrical part are given by

$$A_{cyl} = 2\pi rh \qquad\qquad V_{cyl} = \pi r^2 h$$

The surface area and the volume of conical top part are given by

$$A_{con} = \pi r\sqrt{r^2 + h^2} \qquad\qquad V_{con} = \frac{1}{3}\pi r^2 h$$

The total cost C to construct the tank comprises cylindrical part and conical part which cost \$400 and \$600 per square meter of surface area, respectively.

A. Write a **function** that accepts r and V as input arguments and computes the total cost C and h as outputs.
B. Write an m-file that uses the function in part A that determines the minimum C and the corresponding r and h values, given $V = 500$ m^3. Print this information to the command window.

   Note: You will need to guess the range of r values with increment of 0.001 that incorporates the minimum cost. You can plot the C against r to confirm the result.

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

TASK 5
[5 MARKS]

The exponential function e^x can be approximated using a Taylor/Maclaurin series

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!}$$

a) Write a **function** file that takes x as the input and calculates the approximation of e^x using the first six terms of the series. i.e. $n = 0$ to $n = 5$. Your function should work for either a scalar or vector inputs. As a check, the approximation should return 42.8667 for $x = 4$.

b) The hyperbolic function $\tanh(x)$ is defined as

$$\tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}}$$

Write an m-file that uses the function file you wrote in part (a) to calculate $\tanh(x)$ for $x = [1, 5, 25, 60]$

Calculate the error (absolute difference) between your approximated $\tanh(x)$ and the MATLAB's built in tanh() function. Use the following example fprintf() statement to print the values of the approximated tanh, the MATLAB's tanh and the absolute error for every input x.

```
fprintf("x: %.2f, Approximated tanh: %.2f, MATLAB's tanh: %.2f, Absolute error: %.2f\n",
[x;tanh_approx;tanh_real;error])
```

Example output below.
x: 5.00, Approximated tanh: ???, MATLAB's tanh: ???, Absolute error: ???
x: 25.00, Approximated tanh: ???, MATLAB's tanh: ???, Absolute error: ???
…

2 marks deducted for poor programming practices (missing comments, unnecessary outputs, no axis labels, inefficient coding, etc.)

END OF ASSESSED QUESTIONS

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

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

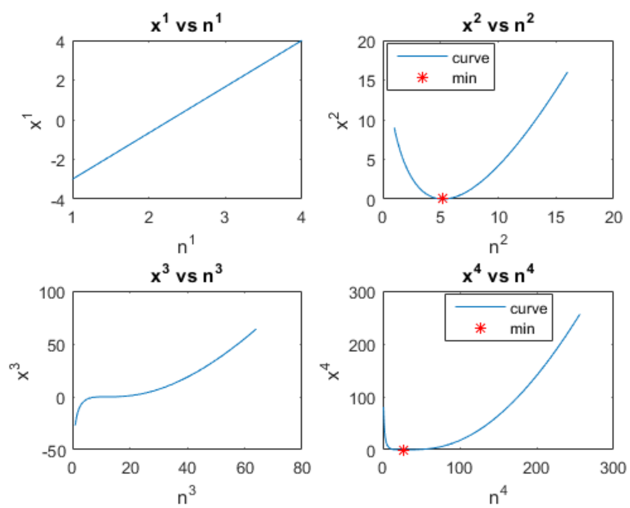
Lab 3 – Supplementary questions

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

Consider x^y and n^y where n is from 1 to 4 with 123 points and x is -3 to 4 with 123 points. Create a 2x2 subplot arrangement, where each subplot panel has y=1, y=2, y=3 and y=4. Find the minimum in each plot (if it exists) and mark it with a red asterisk.

SOLUTION




```
For n=2, min(x^n) = 2.6874E-04 @ n^n = 5.1924
For n=4, min(x^n) = 7.2224E-08 @ n^n = 26.9612
```

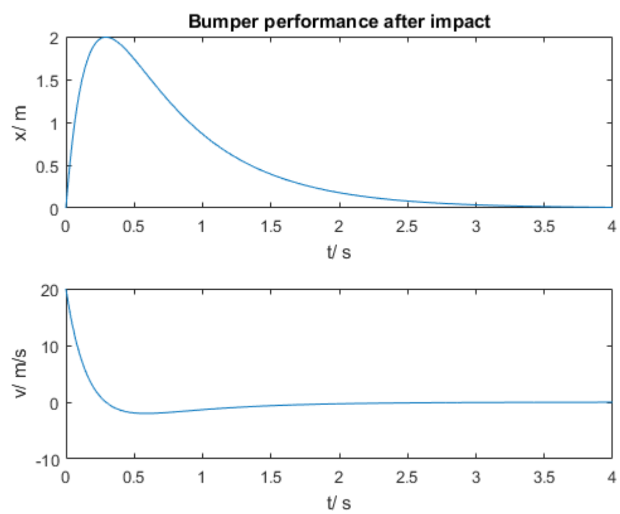
TASK 2S

A railroad bumper is designed to slow down a rapidly moving railroad car. After a 20,000 kg railroad car travelling at 20 m/s engages the bumper, its displacement x (in meters) and velocity v (in m/s) as a function of time t (in seconds) is given by:

$$x(t) = 4.219(e^{-1.58t} - e^{-6.32t})$$
$$v(t) = 26.67e^{-6.32t} - 6.67e^{-1.58t}$$

Plot the displacement and the velocity as a function of time between 0 and 4 seconds on separate sub plots.

SOLUTION



 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

TASK 3S

Write a function that converts degrees F to degrees C. The equation for conversion is given by:

$$C = 5(F - 32)/9$$

Test your function with the following vector, F = [0 32 64 128 256 512]

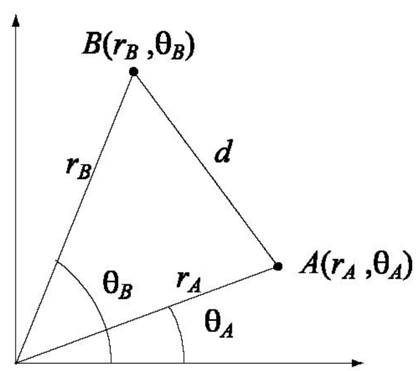
SOLUTION

```
0.00F converts to -17.78C
32.00F converts to 0.00C
64.00F converts to 17.78C
128.00F converts to 53.33C
256.00F converts to 124.44C
512.00F converts to 266.67C
```

TASK 4S

The distance between two points in polar coordinates can be calculated using the Law of Cosines:

$$d = \sqrt{r_A^2 + r_B^2 - r_A r_B \cos(\theta_A - \theta_B)}$$



Write a function that calculates the distance between two points in polar coordinates given the radii and angles of the points. Use a separate m-file to calculate the distance between point A(3, π/3) and point B(4, 3π/4).

SOLUTION

```
Coord A = [3.00 1.05rad]
Coord B = [4.00 2.36rad]
Distance = 4.6791
```

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

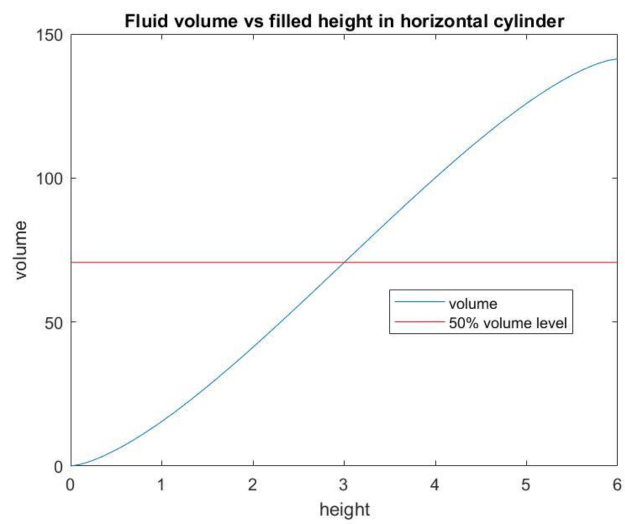
TASK 5S

The volume V of liquid in a hollow horizontal cylinder of radius r and length L is related to the depth of the liquid h by

$$V = \left[r^2 \cos^{-1}\left(\frac{r-h}{r}\right) - (r-h)\sqrt{2rh - h^2}\right] L$$

Create a separate m-file to call the function to calculate the volume for specified heights for a cylinder of r=3 and L=5. Then plot the result. On the same figure, plot the 50% volume threshold as a red line. Ensure you include a legend and label your plots.

SOLUTION



 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

Lab 3 – 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 function:

```
function S = cartesian(r,a,b)
%convert spherical coordinates to Cartesian coordinates
S = zeros(3,1);
S(1,1) = r*cos(b)*sin(a);
S(2,1) = r*sin(a)*sin(b);
S(3,1) = r*cos(b);
```

a) Provide the input and outputs of the function above

b) Provide the name and extension of the function above

c) Provide the output of **S = cartesian(1,4,4)**

d) Consider a=4, b=5, c=6. Provide the output of **S = cartesian(a,b,c)**

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

e) Consider j=[5, 7], k=[1, 5] and m=[6, 3]. Provide the output of **S = cartesian(j,k,m)**

f) State a benefit in executing **S = zeros(3,1)** in the function

2. The rate of change for the surface height of a liquid inside a storage tank is described by the following equation:

$$\frac{\mathrm{d}y}{\mathrm{d}t} = 3\frac{Q}{A}\sin^2(t) - \frac{Q}{A}$$

where *y* is the surface height, *t* is the time, *Q* is the flow rate and *A* is the cross-sectional area.

a) Write a function file that accepts inputs of Q, A and t, and returns dy/dt. Name your function "surfrate". Ensure that your function accepts vector inputs.

b) Write the code required to **compute dydt using your function**, given a flow rate of 450 m^3/day, a cross-sectional area of A=1250 m^2, at a time of 0.5 days.

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

c) Write the code required to **compute dydt using your function**, for each of the following data sets.

#	*Q* (m^3/day)	*A* (m^2)	*t* (day)
1	400	1250	0.3
2	400	1250	0.9
3	600	1250	0.3
4	600	1250	0.9
5	800	1250	0.3
6	800	1250	0.9

3. Given two points (x_1,y_1) and (x_2,y_2), it is possible to linearly interpolate between these two points to estimate the value of y_3 at x_3.

a) Derive the equation for y3, using x1, x2, y1, y2 as variables. Show all working and confirm that it is one of the following equations

$$y3 = \frac{(y2 - y1)}{(x2 - x1)}(x3 - x1) + y1$$
$$y3 = \frac{(y2 - y1)}{(x2 - x1)}(x3 - x2) + y2$$

 Important: If you are struggling with a task, ensure that you have performed hand-written work (e.g. hand calculations, pseudocode, flow charts) to better understand the processes involved. Do this before asking demonstrators for help and use it to assist with your illustration of the problem.

b) Write a function file that linearly interpolates between two points p1 and p2.

c) The drag coefficient c_D, around a tennis ball was recorded as a function of the Reynolds number *Re*. The data is provided below. Provide code that uses the function written in part (b) to estimate the drag coefficient when *Re* = 10.5 x10^{-4}.

Re (x10^{-4})	2	5.8	16.8	27.2	29.9
c_D	0.56	0.55	0.54	0.5	0.44

d) Justify your reason for the two points used in part (c).

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4. A Cartesian vector can be thought of as representing magnitudes along the *x*, *y* and *z*-axes multiplied by a unit vector (*i*,*j*,*k*). The dot product of two vectors {a} and {b} corresponds to the product of their magnitudes and the cosine of the angle between their tails such that

$$\{a\} \cdot \{b\} = ab\cos(\theta)$$

The cross product yields another vector,

$$\{\mathrm{c}\} = \{\mathrm{a}\} \times \{\mathrm{b}\}$$

which is perpendicular to the plane defined by {a} and {b} such that its direction is specified by the right-hand rule. The help documentation for cross is provided below:

```
cross  Vector cross product.
   C = cross(A,B) returns the cross product of the vectors
   A and B.  That is, C = A x B.  A and B must be 3 element
   vectors.
```

a) Write a function that accepts two vectors *a* and *b*, and returns *c*, the magnitude of *c* and θ. Your function should work with 3-dimensional vectors. i.e. *a* = [6 4 2] and *b* = [2 4 6].

b) Consider *x* = [1 5 3] and *y* = [7 5 9]. Provide code that uses the function in part (a) to calculate *c*, the magnitude of *c* and θ for vectors *x* and *y*.

c) Would the function you wrote in part (a) work with matrices, assuming each row represents a vector? i.e. a = [1 5 3; 2 8 6; 1 5 7] and b = [8 7 3; 2 3 4; 7 0 1]. Provide a brief explanation for why it will or will not work.

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