MONASH University

MONASH
ENGINEERING
ENG1060

MATRIX CALCULATIONS AND PLOTTING

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Slides by Tony Vo

Assisted by Tham Lai Kuan

GROUP OF EIGHT AUSTRALIA

HOUSEKEEPING

- Peer Assisted Study Sessions (PASS)
  - Begins in Week 3

Monday: 3:30-5:30pm (MYT) / 6:30-8:30pm (AEDT) Meeting ID: **891 2853 2133** Password: **941880** https://monash.zoom.us/j/89128532133?pwd=VVVOenhDbW5xZ3h6ZFRZR1dieVhldz09	Tuesday: 12-2pm (MYT) / 3-6pm (AEDT) Meeting ID: **852 2658 1851** Password: **933340** https://monash.zoom.us/j/85226581851?pwd=d0YxeWVHd0tudnplanFRYWU2ZGJRUT09

- Labs start this week
  - Check for zoom link based on your allocated lab group in Moodle, i.e. under Week 2
  - Complete special consideration application if you are unable to attend a lab https://connect-forms.apps.monash.edu/students/special-consideration/

HOUSEKEEPING

- **Lab Participation Details**

  -Under weekly section in Moodle

Post-class: Lab 1 participation & submission

Submit your lab individual tasks by firstly answering the questions in Google Form and secondly submitting a single ZIP lab file . Your lab mark and feedback will be provided by the end of the following week.

[Lab Group-]

1) Attend your lab using Zoom link below:

- https://monash.zoom.us/j
- **Meeting ID:**
- **Password**: 1060

2) Answer the lab questions in Google Form below :

- Google Form Link Here

3) Submit a single ZIP lab file:

Laboratory 1

HOUSEKEEPING

- Prepare for your labs
  - Labs 1-2 are now available on Moodle/Gdrive
    - Feel free to work ahead of schedule
  - Most labs have 5 assessed tasks (1 team task + 4 individual tasks)
    - Most labs start with a team task (late arrivals will forfeit team task marks)
  - Attempt the individual questions before the lab

HOUSEKEEPING

- Marking
  - Team task will be marked during the lab session
  - Individual tasks:
    - Submit answers using Google Form and then submit a single ZIP m-file solutions before 9am MYT or 12pm AEDT of the following Friday (download and check your submission)

Post-class: Lab 1 participation & submission

Submit your lab individual tasks by firstly answering the questions in Google Form and secondly submitting a single ZIP lab file . Your lab mark and feedback will be provided by the end of the following week.

[Lab Group-1]

1) Attend your lab using Zoom link below:

- https://monash.zoom.us/j[redacted]
- **Meeting ID:** [redacted]
- **Password**: 1060

2) Answer the lab questions in Google Form below :

- Google Form Link Here

3) Submit a single ZIP lab file:

Laboratory 1

HOUSEKEEPING

- Lab solutions are released after the deadline of lab submission
  - This accommodates students with special consideration

- Academic integrity, plagiarism and collusion
  - https://www.monash.edu/students/admin/policies/academic-integrity

- Demonstrators will guide you with your practice
  - Regulate the level of help you are receiving
  - They may be unable to debug your code in time
  - Do not rely too heavily on your demonstrators or friends
    - This often leads to students failing the exam hurdle
  - You are in charge of your own learning, be proactive!

ENG1060

USEFUL RESOURCES

- Resources
  - ENG1060 functions summary
  - ENG1060 supplementary notes
  - MATLAB common errors guide
  - MATLAB online resources

[Moodle-Student] ENG1060-Oct-Nov-2020 > Resources

Name ↑

- Assignment upload instructions.pdf
- ENG1060_functions_summary
- MATLAB common errors guide
- MATLAB Online Resources.pdf
- Supplementary_notes_ALL.pdf

26	1 - Introduction, variables and matrices	tand()	Tangent of argument in degrees	tand(X) is the tangent of the elements of X, expressed in degrees. For odd integers n, tand(n*90) is infinite, whereas tan(n*pi/2) is large but finite, reflecting the accuracy of the floating point value of pi.
27	1 - Introduction, variables and matrices	who	List current variables	lists the variables in the current workspace
28	1 - Introduction, variables and matrices	whos	List current variables, long form	whos is a long form of WHO. It lists all the variables in the current workspace, together with information about their size, bytes, class, etc.
29	2 - Matrix calculations and plotting	axis()	Control axis scaling and appearance.	axis([XMIN XMAX YMIN YMAX]) sets scaling for the x- and y-axes on the current plot.
30	2 - Matrix calculations and plotting	eye()	Identity matrix	eye(N) is the N-by-N identity matrix. eye(M,N) or eye([M,N]) is an M-by-N matrix with 1's on the diagonal and zeros elsewhere. eye(SIZE(A)) is the same size as A.

1. Syntax errors

A syntax error occurs when the calling syntax you use for a function is incorrect, or when you provide the function with inputs that are of the wrong shape, size, and/or type, or are otherwise not valid for the function in question. A typo could be considered as a syntax error.

a. Matrix operation errors

Error using *
Incorrect dimensions for matrix multiplication. Check that the number of columns in the first matrix matches the number of rows in the second matrix. To perform elementwise multiplication, use '.*'

If matrix A has dimensions (r1,c1) and matrix B has dimensions (r2,c2), A*B will return an error if c1 ≠ r2. Ensure that your matrices are defined correctly by inspecting the size of the matrices in the Workspace.

Error using .*
Matrix dimensions must agree.

If **matrix** A has dimensions (r1,c1) and **matrix** B has dimensions (r2,c2), A.*B will return an error if r1 ≠ r2 AND c1 ≠ c2.

If **vector** A has dimensions (r1,c1) and **matrix** B has dimensions (r2,c2), A.*B will return an error if r1 ≠ r2 OR c1 ≠ c2.

FEEDBACK & THOUGHTS

- Remember to provide your thoughts/feedback via General + Lab Forum in Moodle.
- Refer to News forum in Moodle for important ENG1060 announcements.
- Please check your student email constantly.

IN THIS WORKSHOP

1. Basic plotting and chart formatting
    a. Axes titles and limits
    b. Legend
    c. Line and marker formatting
    d. Chart title
    e. Grid
    f. Hold on/off
    g. New figure
    h. Data point markers
2. Min, max and indices
3. Subplots
4. Logarithmic plots

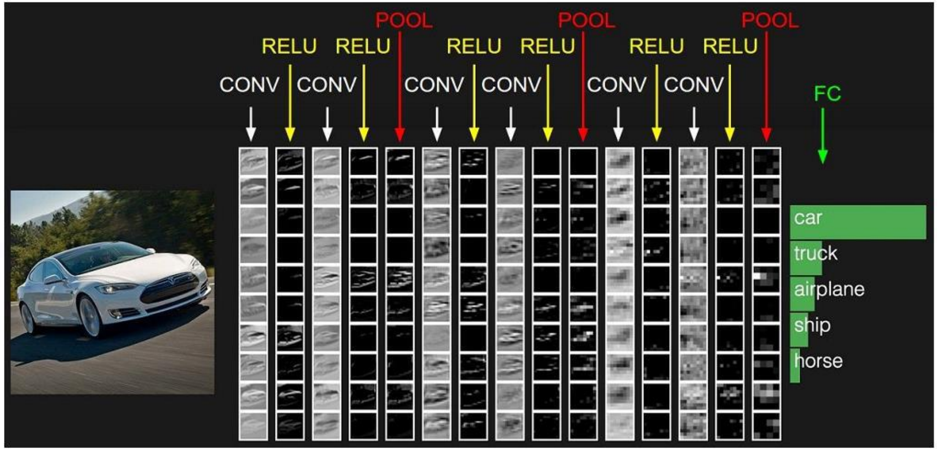
WHY USE MATRICES?

- Matrices are used everywhere in engineering and science
  - We deal with large and complex problems
  - Humans are incapable of retaining a lot of information and we're slow!
  - Instead we use computers to store data in matrices

- Examples:
  - Audio processing: 2 minute audio contains 5,777,100 data
  - Image processing: 10 Megapixels colour image contains 2592 × 3872 × 3 = 30,108,672 data
  - Video processing: High speed video (1280 x 1024, 1000 fps) contains 1,310,720,000 data per second

MATRIX EXAMPLE

- Image example: Image recognition using Deep Neural Network
  - i.e. Each image is 480 × 420 pixels × 3 channels (604800 pixels)
  - If there are 100000 images, 6×10^{10} values need to be processed.



MIN, MAX AND INDICES

- Determine the minimum/maximum value of a vector and its index (aka address, location, element number, etc.)

$$day = [33, 56, 71, 86, 99]$$
$$trees = [18, 70, 63, 40, 16]$$

- Determine the maximum amount of trees observed, and the corresponding day.

ENG1060

PLOTS

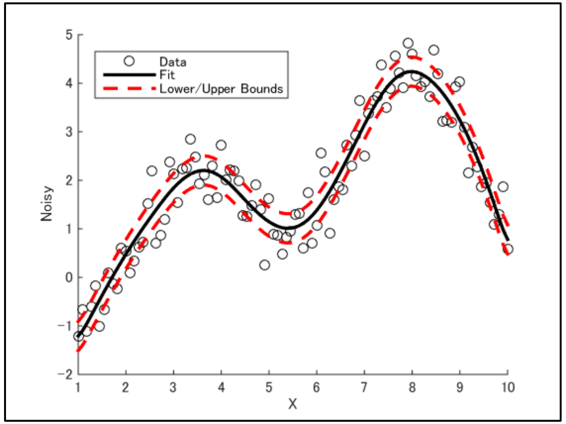
- Visualising the data allows you to interpret more information more quickly
  - Easier to characterise trends

- Syntax?

Specifier	Marker
o	Circle
+	Plus sign
*	Asterisk
.	Point
x	Cross
s	Square
d	Diamond
^	Upward-pointing triangle
v	Downward-pointing triangle
>	Right-pointing triangle
<	Left-pointing triangle
p	Pentagram
h	Hexagram

Specifier	Color
y	yellow
m	magenta
c	cyan
r	red
g	green
b	blue
w	white
k	black

Specifier	Line Style
-	Solid line (default)
--	Dashed line
:	Dotted line
-.	Dash-dot line

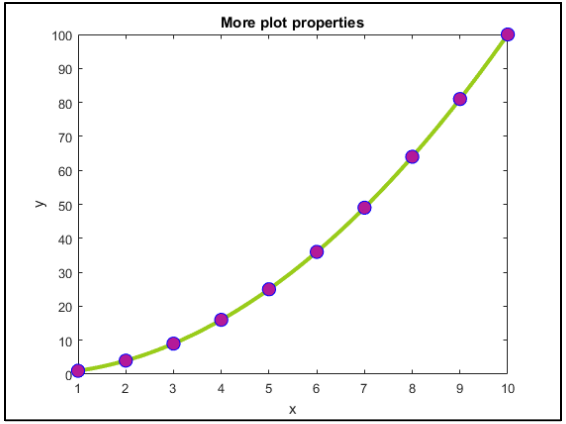


MORE PLOTTING ARGUMENTS

```
clear all; close all; clc;
x = 1:0.1:10;
y = x.^2;

plot(x,y,'color',[0.6, 0.8, 0.1],'linewidth',3)
xlabel('x')
ylabel('y')
title('More plot properties')
```

```
hold on
x2 = 1:10;
y2 = x2.^2;
plot(x2,y2,'o','Markersize',10,'Markerfacecolor', ...
    [0.7, 0.1, 0.6] ,'Markeredgecolor','blue')
```



[15 MINS]

ACTIVITY: AIRFOIL

AIRFOIL_TEMPLATE.M

MATLAB commands:

`plot(…)`

`figure`

`xlabel(…) & ylabel(…)`

`axis([XMIN XMAX YMIN YMAX])`

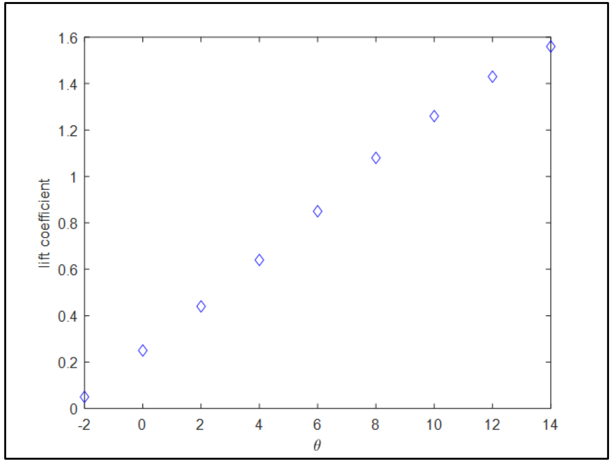
`legend(…,…,…)`

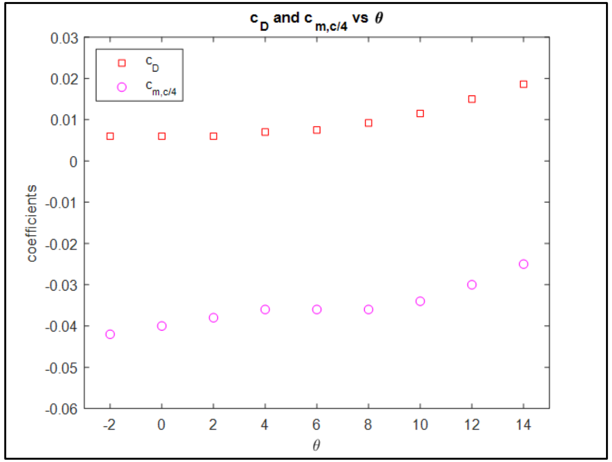
`title(…)`

Mr ENG1060 has obtained some experimental data for the NACA 2412 airfoil. He is looking to plot the data.

Activity involves:

1. Plotting empirical data
2. Adding:
   a. Marker formatting
   b. Axes titles and limits
   c. Legend
   d. Chart title





[15 MINS]

ACTIVITY: AIRFOIL

AIRFOIL_TEMPLATE.M

MATLAB commands:

```
plot(…)
figure
xlabel(…) & ylabel(…)
axis([XMIN XMAX YMIN YMAX])
legend(…,…,…)
title(…)
```

1. Plot the c_L (lift, y-axis) against θ (angle, x-axis) as blue diamonds. θ ranges from -2 to 14 in increments of 2.

2. In a new figure, plot c_D against θ as red squares and $c_{m,c/4}$ against θ as magenta circles
   a. Limit the x-axis to -3 and 15
   b. Limit the y-axis to -0.06 and 0.03
   c. Add a legend in the northwest corner
   d. Add a chart title

Colour	Description
y	yellow
m	magenta
c	cyan
r	red
g	green
b	blue
w	white
k	black

Marker	Description
o	Circle
+	Plus sign
*	Asterisk
.	Point
x	Cross
s	Square
d	Diamond
^	Upward-pointing triangle
v	Downward-pointing triangle
>	Right-pointing triangle
<	Left-pointing triangle
p	Pentagram
h	Hexagram

[20 MINS]

ACTIVITY: DENSITY

DENSITY_TEMPLATE.M

Equations:

$$\rho = -8.5016 \times 10^{-6} T_c^{\,2} + 6.5622 \times 10^{-5} T_c + 0.99987$$

$$T_c = \frac{5}{9}(T_F - 32)$$

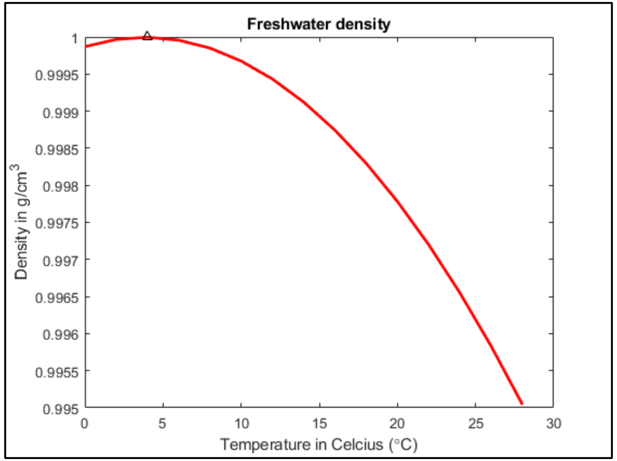
Ms ENG1060 is fishing for an elusive shiny Magikarp, which is said to exist in regions of highest density. The density ρ (g/cm^3) of freshwater can be estimated as a function of temperature T_C (^{o}C)

MATLAB commands:

```
plot(…)
xlabel(…) & ylabel(…)
title(…)
[…,…] = max(…)
```

Activity involves:

1. Plotting data from a model
2. Converting units
3. Adding:
   a. Line formatting
   b. Axis labels
   c. Chart title
4. Finding the maximum point



[20 MINS]

ACTIVITY: DENSITY

DENSITY_TEMPLATE.M

Equations:

$$\rho = -8.5016 \times 10^{-6} {T_c}^2 + 6.5622 \times 10^{-5} T_c + 0.99987$$

$$T_c = \frac{5}{9}(T_F - 32)$$

1. Generate estimates of density for temperatures ranging from 32ºF to 82.4ºF using increments of 3.6ºF

2. Plot density against temperature using a continuous red line with a line width of 2. Label the figure appropriately.

3. Determine the maximum density and corresponding temperature (ºC).

4. On the figure, mark the maximum point with a black upward-pointing triangle

MATLAB commands:

`plot(…)`

`xlabel(…) & ylabel(…)`

`title(…)`

`[…,…] = max(…)`

Colour	Description
y	yellow
m	magenta
c	cyan
r	red
g	green
b	blue
w	white
k	black

Marker	Description
o	Circle
+	Plus sign
*	Asterisk
.	Point
x	Cross
s	Square
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^	Upward-pointing triangle
v	Downward-pointing triangle
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p	Pentagram
h	Hexagram

[20 MINS]

ACTIVITY: BEAM

BEAM_TEMPLATE.M

$$y = \frac{-wx}{24LEI}\left(Lx^3 - \frac{10}{9}L^2x^2 + \frac{25}{81}L^4\right) \quad \text{for } 0 \le x \le \frac{1}{3}L$$

$$y = \frac{-wL}{216EI}\left(2x^3 - 6Lx^2 + \frac{37}{9}L^2x - \frac{1}{9}L^3\right) \quad \text{for } \frac{1}{3}L \le x \le L$$

A simply supported beam that is subjected to a uniformly distributed load w over one-third of its length is shown below. The beam's deflection is given by the equation.

MATLAB commands:

`plot(…)`

`xlabel(…)`

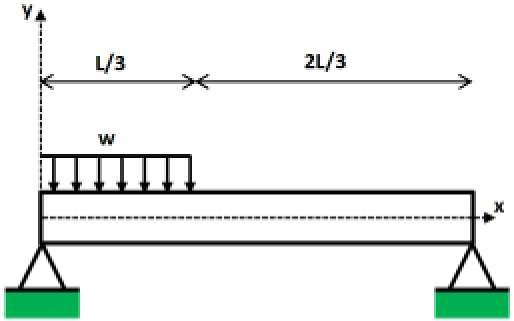
`ylabel(…)`

`title(…)`

`[…,…] = min(…)`

Activity involves:

1. Plotting piecewise data
2. Adding:
    a. Line and marker formatting
    b. Axis titles
    c. Chart title
3. Finding the maximum point
4. Marking coordinates next to a data point



[20 MINS]

ACTIVITY: BEAM

BEAM_TEMPLATE.M

$$y = \frac{-wx}{24LEI}\left(Lx^3 - \frac{10}{9}L^2x^2 + \frac{25}{81}L^4\right) \qquad \text{for } 0 \le x \le \frac{1}{3}L$$

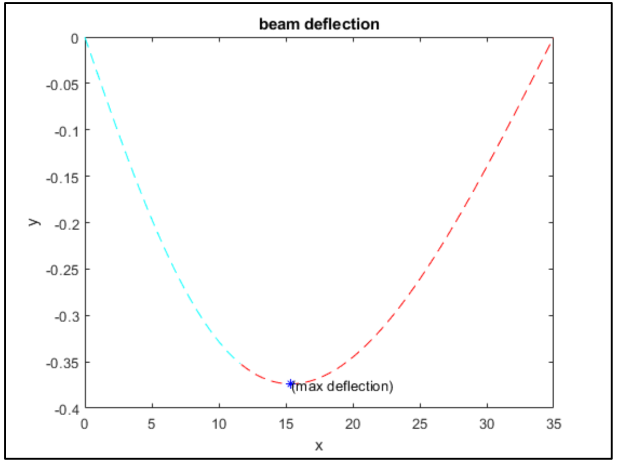
$$y = \frac{-wL}{216EI}\left(2x^3 - 6Lx^2 + \frac{37}{9}L^2x - \frac{1}{9}L^3\right) \qquad \text{for } \frac{1}{3}L \le x \le L$$

1. Plot the deflection of the:
   a. First segment of the beam using a cyan dashed line
   b. Second segment of the beam using a red dashed line

Line Style	Description
-	Solid line (default)
--	Dashed line
:	Dotted line
-.	Dash-dot line

2. Determine the maximum deflection and the corresponding location along the beam. On the figure:
   a. Mark this point as a blue asterisk
   b. Label the maximum deflection point

3. Experiment with markersize and linewidth options



[15 MINS]

ACTIVITY: SUBPLOTS AND LOG PLOTS

SUBPLOT_LOGPLOT_TEMPLATE.M

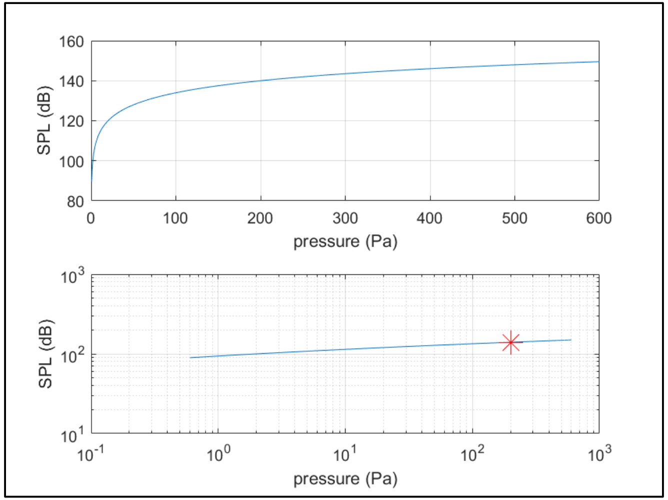
Equations:

$$SPL = 20log_{10}\left(\frac{p}{p_{ref}}\right)\ \text{dB}$$

MATLAB commands:

```
subplot(…)
loglog(…)
grid on
```

Logarithmic phenomena occur in many contexts in nature. Logarithmic functions can be transformed into linear space for easier analysis. E.g. Sound pressure level (SPL) is measured in decibels (dB).
p is the sound pressure and $p_{ref} = 2 \times 10^{-5}$ Pa.



Activity involves:

1. Creating logarithmic plots
2. Comparing different plots on a subplot
3. Adding:
    a. Line and marker formatting
    b. Axis titles
    c. Hold and grid

[15 MINS]

ACTIVITY: SUBPLOTS AND LOG PLOTS

SUBPLOT_LOGPLOT_TEMPLATE.M

Equations:

$$SPL = 20log_{10}\left(\frac{p}{p_{ref}}\right)\ \text{dB}$$

MATLAB commands:

```
subplot(…)
loglog(…)
grid on
```

Sound pressure level (SPL) in measured in decibels (dB).
p is the sound pressure and $p_{ref} = 2 \times 10^{-5}$ Pa.
Normal conversation $SPL = 60$ dB.

1. Generate SPL values for 1000 equally spaced values of pressure from 0 to 600 Pa.

2. Create a 2x1 subplot and plot SPL against p with.
   a. [top subplot] linear axes using plot()
   b. [bottom subplot] logarithmic axes using loglog()

3. Ms ENG1060's Viking metal rock band reached a pressure of 200 Pa, what dB would register on a decibel metre? Mark this on the top right subplot.

IN THIS WORKSHOP

1. Basic plotting and chart formatting
    a. Axes titles and limits
    b. Legend
    c. Line and marker formatting
    d. Chart title
    e. Grid
    f. Hold on/off
    g. New figure
    h. Data point markers
2. Min, max and indices
3. Subplots
4. Logarithmic plots

PART A: MATLAB PROGRAMMING

1. ~~Introduction, variables and matrices~~
2. ~~Matrix calculations and plotting~~
3. Functions, commenting, debugging and strings
4. Input, output and IF statements
5. Loops and debugging
6. Loops, advanced functions and MATLAB limitations

You can now complete lab 2!

SUPPLEMENTARY SLIDES

[15 MINS]

ACTIVITY: WATER TANK

WATER_TANK_TEMPLATE.M

MATLAB commands:

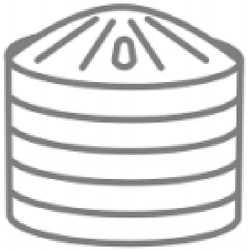
`plot(…)`
`xlabel(…)`
`ylabel(…)`
`title(…)`
`[…,…] = min(…)`

Mr ENG1060 has a budget of $100k to construct a 800m^3 water tank, which consists of:

- cylindrical part of radius r and height h, and
- a hemispherical top of radius r (base is supplied).

Activity involves:

1. Deriving a physical model
2. Using the model to optimise metrics (e.g. cost)
3. Determining the optimised set of variables
4. Marking the optimised variables on a figure



[15 MINS]

ACTIVITY: WATER TANK

WATER_TANK_TEMPLATE.M

Mr ENG1060 has a budget of $100k to construct a 800m^3 water tank

	Surface area	volume	Cost
Cylindrical part	$2\pi rh$	$\pi r^2 h$	\$300/m^2
Hemispherical part	$2\pi r^2$	$2\pi r^3/3$	\$400/m^2

1. Derive a model for the total cost as a function of radius

2. Plot the total cost against radius (0.025 increments). Label the figure appropriately.

3. Determine the minimum cost and corresponding radius and height. Mark the minimum cost on the plot. Can he afford to construct it?