MONASH University

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ENGINEERING
ENG1060

MATRIX CALCULATIONS

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GROUP OF EIGHT AUSTRALIA

SCALAR VS. MATRIX CALCULATIONS

- Basic scalar operators include: `+ - * / ^`
  - E.g. 5*6 = 30

- However, these are not necessary the same for matrix calculations
  - E.g. Matrix multiplication is conducted in the following manner
  - Note: Inner dimensions must match (blue) for multiplication to work

$$\underbrace{\begin{bmatrix}1 & 2 & 3\end{bmatrix}}_{1\times 3} \cdot \underbrace{\begin{bmatrix}2 & 1 & 3\\ 3 & 3 & 2\\ 4 & 1 & 2\end{bmatrix}}_{3\times 3} = \begin{bmatrix}1\cdot 2+2\cdot 3+3\cdot 4\\ 1\cdot 1+2\cdot 3+3\cdot 1\\ 1\cdot 3+2\cdot 2+3\cdot 2\end{bmatrix} = \underbrace{\begin{bmatrix}20\\ 10\\ 13\end{bmatrix}}_{1\times 3}$$

ELEMENT-BY-ELEMENT OPERATIONS

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- What if I wanted to multiply corresponding elements between matrices instead?
  - I.e. Multiplying the first element of matrix A by the first element of matrix B, etc.

$$\begin{bmatrix} 99 & 88 & 77 \\ 66 & 55 & 44 \\ 33 & 22 & 11 \end{bmatrix} .* \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- Performing calculations between corresponding elements of multiple matrices in MATLAB are referred to as element-by-element operations
  - Achieved by placing a dot (.) prior to the operation

ELEMENT-BY-ELEMENT OPERATIONS

- In element-by-element operations, matrices must be the same size
  - Addition, subtraction → **+ -**
  - Element-by-element multiplication → **.***
  - Element-by-element division → **./**
  - Element-by-element exponentiation → **.^**

- Different to the *** / ^** operations

SCALARS IN MATRIX CALCULATIONS

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- Remember that for element-by-element operations the matrices must be of the same size
  - So what happens if both a scalar and matrix is involved?
  - MATLAB automatically expands scalars to the right size

- Consider multiplying a vector x by 2 (scalar) and adding 1 (scalar)

```
y = x.^2 – 2*x + 1
y = x.^2 – 2*ones(size(x)).*x + 1*ones(size(x))
```

- These expansions are performed behind the scenes

BUILT-IN FUNCTIONS

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- Many MATLAB built-in functions also operate on matrices
  - sin, cos, tan, sqrt, round, log, etc.
  - These functions operate on each element individually

- Examples

$$A = \begin{bmatrix} 4 & 9 \\ 36 & 81 \end{bmatrix} \qquad B = \begin{bmatrix} 2.4 & 5.7 \\ 8.8 & 9.1 \end{bmatrix}$$

- This makes MATLAB an invaluable tool for solving engineering problems

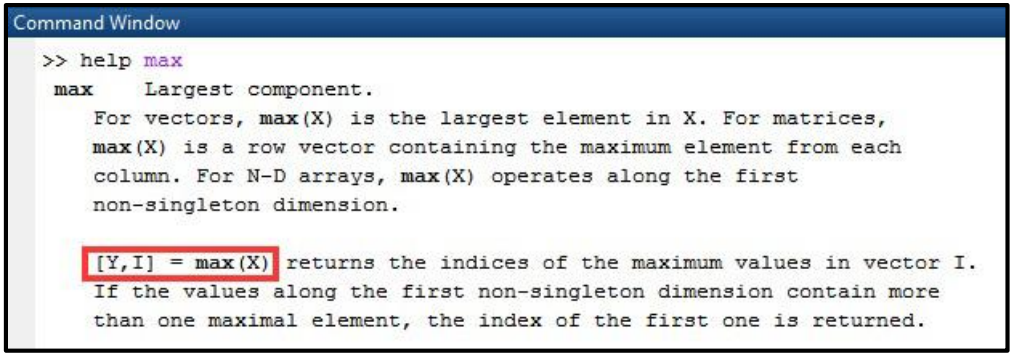
MORE BUILT-IN FUNCTIONS

- There are many built-in functions designed especially for matrices
  - sum
  - mean
  - median
  - min
  - max
  - sort
  - unique

- Some of these functions have two outputs!

THE MAX FUNCTION

- The max function can find the maximum value in a matrix
  - It can also find the address of the max value



- E = [10 40 80 60 90 20 30]

  maximum_in_E = max(E) (1 output)

  [maximum_in_E, index_of_max] = max(E) (2 outputs)

SUMMARY

- Scalar calculations are different to regular matrix calculations
- Element-by-element operations
- In-built functions for matrices
- The max function can have multiple outputs!!

- Does the “sum( )” function add up all of the elements in a two-dimensional matrix and return a scalar as a result?