Introduction to MATLAB

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Overview

- **Introduction** 👋:
  - Interface
  - Documentation
  - Getting help
  - Common commands
  - MATLAB symbols
- **Syntax** 🛠:
  - Matrix manipulation
  - `:` operator
  - *for* loop
  - *while* loop
  - *if* statements
  - *switch* statements
  - Vectorization
- **Graphics** 📈:
  - Common commands
  - Examples - 2D plot
  - Example - 3D plot
- **Scripts & Functions** ⚡
- **Demonstration** 💻
- **Final word** 📢
- **Quiz** 📝
- **Pizza** 🍕

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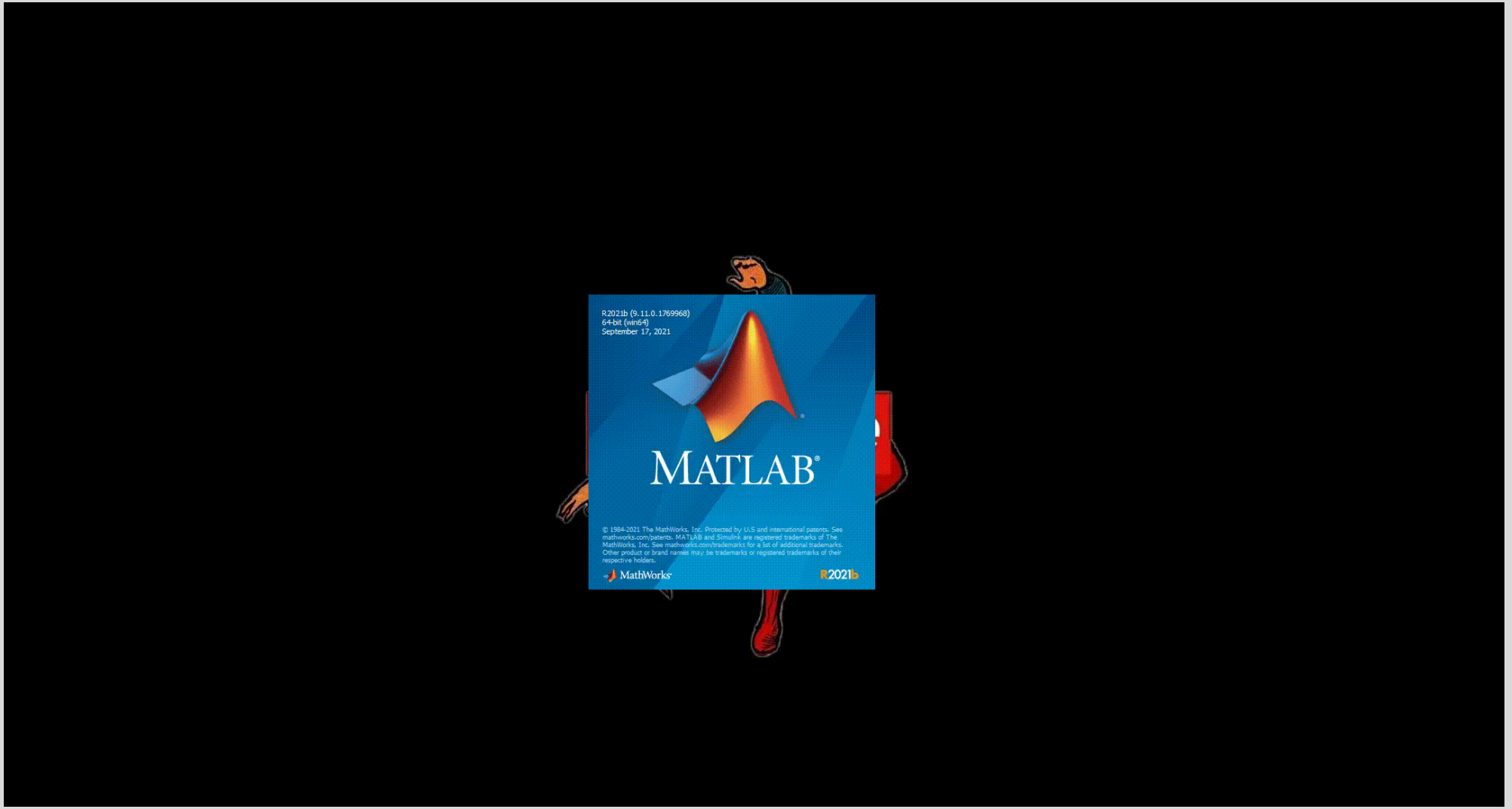
Introduction

- Stands for **MAT**rix **LAB**oratory.
- Designed for the manipulation of matrices:
  - **Engineering / Physics**: Model physical systems and perform precise calculations.
  - **Robotics / Kinematics:** Rotation matrices; translations through planes to be easily calculated.
  - **Betting:** Complex betting combinations without separate formulae such as multiple complex simultaneous equations.
  - **Data Mining**: Fundamental to the handling of data.
  - **Graphics/Gaming**: From particle collision to ray tracing.
- Great visualisation capabilities.
- Multiple libraries of built-in functions.

Interface


R2021b (9.11.0.1769968)
64-bit (win64)
September 17, 2021
MATLAB
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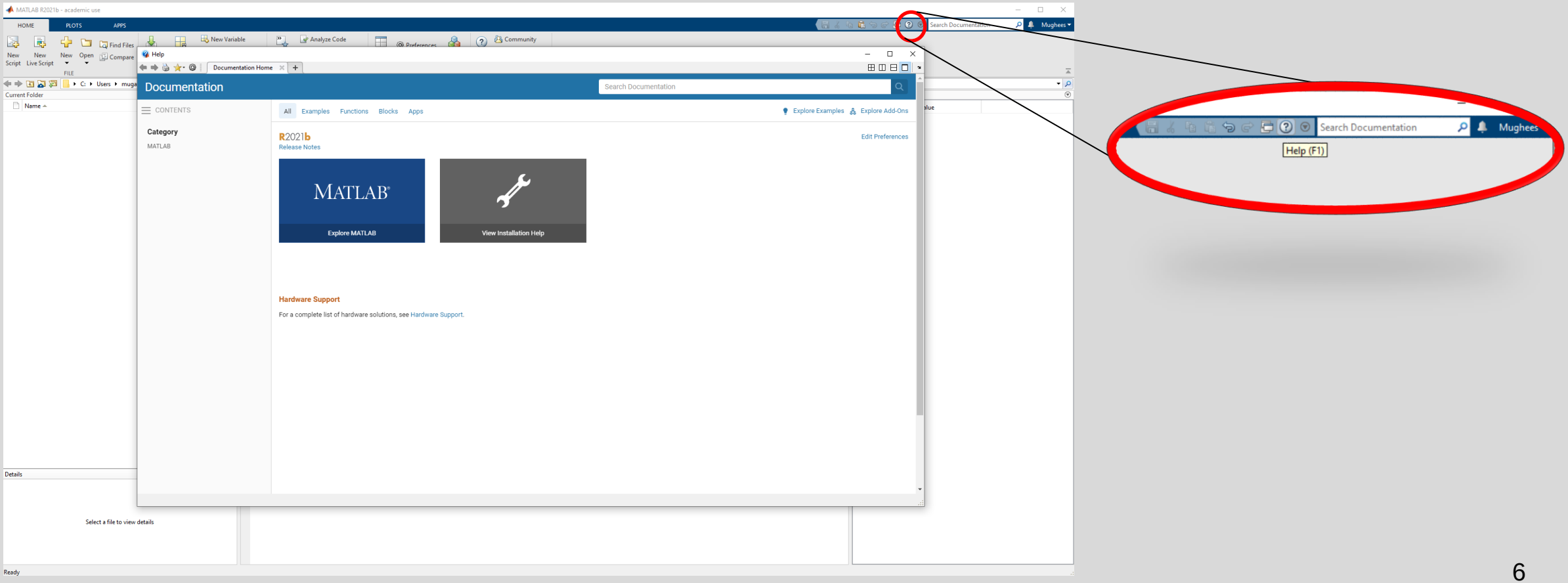
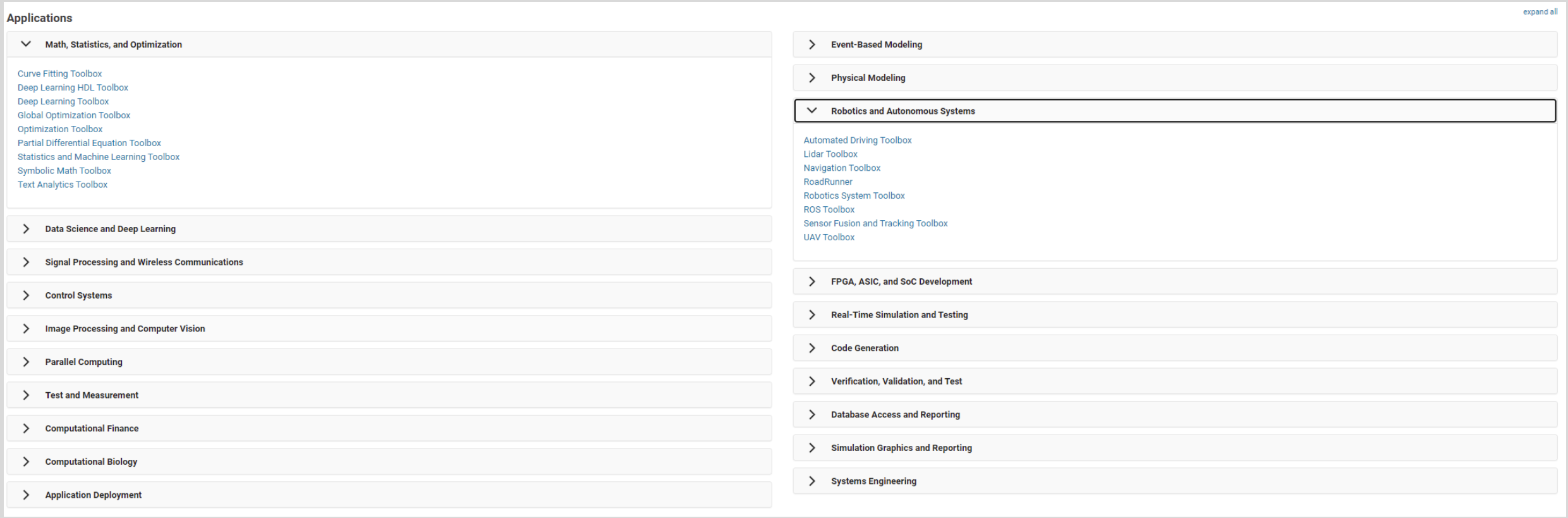
Documentation

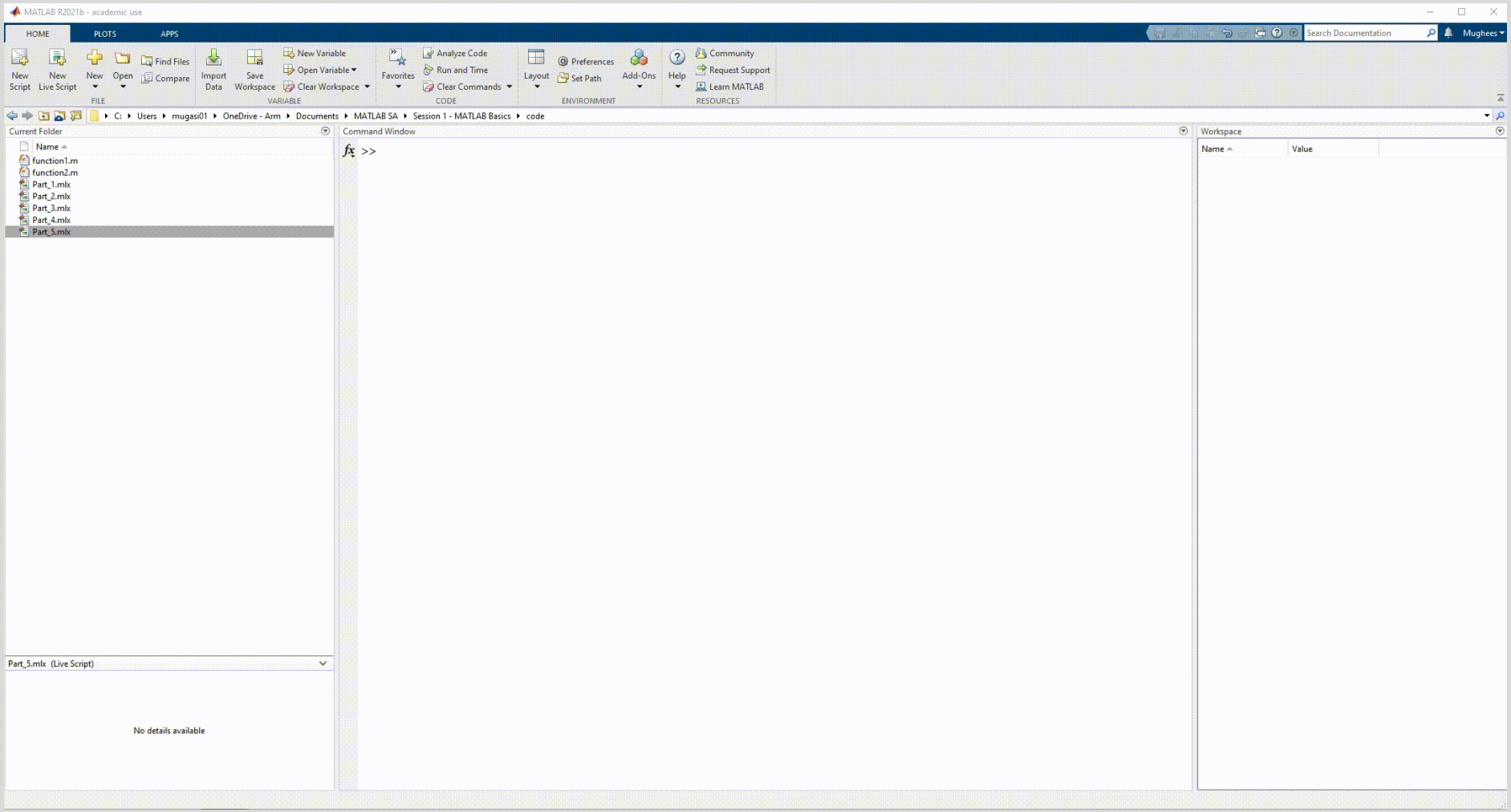
- Most useful.
- Most unused.



https://uk.mathworks.com/help/



Getting help on specific functions



Common commands

- **who**, **whos** – current workspace vars
- **save** – save workspace vars to *.mat file
- **load** – load vars from *.mat file
- **clear all** – clear workspace vars
- **close all** – close all figures
- **clc** – clear screen
- **clf** – clear figure

MATLAB symbols

>>	prompt
. . .	continue statement on next line
,	separate statements and data
%	start comment which ends at end of line
;	(1) suppress output
	(2) used as a row separator in a matrix

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Matrix manipulation

- Do not need to initialise type, or dimensions.

```
>> A = [3 2 1; 5 1 0; 2 1 7]

A =

     3     2     1
     5     1     0
     2     1     7
```

square brackets to define matrices

; specifies the next row in the matrix

Matrix manipulation

- Access elements of a matrix
- Syntax: *matrixname(row, column)*

indices of matrix element(s)

```
>> A = [3 2 1; 5 1 0; 2 1 7]

A =

     3     2     1
     5     1     0
     2     1     7

>> A(1, 2)

ans =

     2

>> A(3, 3)

ans =

     7
```

Matrix manipulation

```
>> A.'          % transpose
>> B * A        % matrix multiplication
>> B.* A        % element by element
                % multiplication
>> B / A        % matrix division
>> B./ A        % element by element
                % division
>> [B A]        % join matrices (horizontally)
>> [B; A]       % join matrices (vertically)
```

```
>> A

A =

     3     2     1
     5     1     0
     2     1     7

>> B

B =

     1     3     1
     4     9     5
     2     7     2

>> C = B * A

C =

    20     6     8
    67    22    39
    45    13    16

>> D = B.* A

D =

     3     6     1
    20     9     0
     4     7    14
```

`:` operator

- Vector creation, array subscripting, and *for* loop iteration.

```
>> a = 5;
b = 15;
c = a:b

c =

     5     6     7     8     9    10    11    12    13    14    15
```

```
>> 1:10

ans =

     1     2     3     4     5     6     7     8     9    10

>> 1:2:10

ans =

     1     3     5     7     9
```

```
>> A

A =

     3     2     1
     5     1     0
     2     1     7

>> % n-th column of matrix A
>> A(:,2)

ans =

     2
     1
     1

>> % m-th row of matrix A
>> A(2,:)

ans =

     5     1     0
```

for loops

Syntax

```
for index = values
   statements
end
```

```
>> for i = 1:10        % Start at 1 and
       disp(i)         % finish at 6
   end
     1

     2

     3

     4

     5

     6

     7

     8

     9

    10
```

for loops

```
>> for v = 1:-0.2:0        % Start at 1, decrement by -0.2,
       disp(v)             % and stop when 0
   end
     1

    0.8000

    0.6000

    0.4000

    0.2000

     0
```

for loops

```
>> x = 0;
   for i = 1:2:15
         x = x + i;
         sprintf('i: %d, x: %d', i, x)
   end
```

for loops

```
>> x = 0;
   for i = 1:2:15              % start at 1, increment i by 2,
       x = x + i;              % keep adding x & i, stop when i = 15.
       sprintf('i: %d, x: %d\n', i, x)
   end
```

```
'i: 1, x: 1'
'i: 3, x: 4'
'i: 5, x: 9'
'i: 7, x: 16'
'i: 9, x: 25'
'i: 11, x: 36'
'i: 13, x: 49'
'i: 15, x: 64'
```

while loops

Syntax

```
while expression
    statements
end
```

```
>> k = 1;
   while k <= 10     % Keep looping until k is less than or
     disp(k)         % equal to 10.
     k = k + 1;
   end
     1

     2

     3

     4

     5

     6

     7

     8

     9

    10
```

while loops

```
>> n = 10;
   while n > 1     % Keep looping until n is more
      disp(n)      % than 1.
      n = n-1;
   end
    10

     9

     8

     7

     6

     5

     4

     3

     2
```

if statements

Syntax

```
if expression
    statements
elseif expression
    statements
else
    statements
end
```

```
>> x = 10;
   minVal = 2;
   maxVal = 6;

   if (x >= minVal) && (x <= maxVal)
    disp('Value within specified range.')
   elseif (x > maxVal)
    disp('Value exceeds maximum value.')
   else
    disp('Value is below minimum value.')
   end
Value exceeds maximum value.
```

if statements

```
>> x = 10;
   minVal = 2;
   maxVal = 12;

   if (x >= minVal) && (x <= maxVal)
    disp('Value within specified range.')
   elseif (x > maxVal)
    disp('Value exceeds maximum value.')
   else
    disp('Value is below minimum value.')
   end
Value within specified range.
```

switch statement

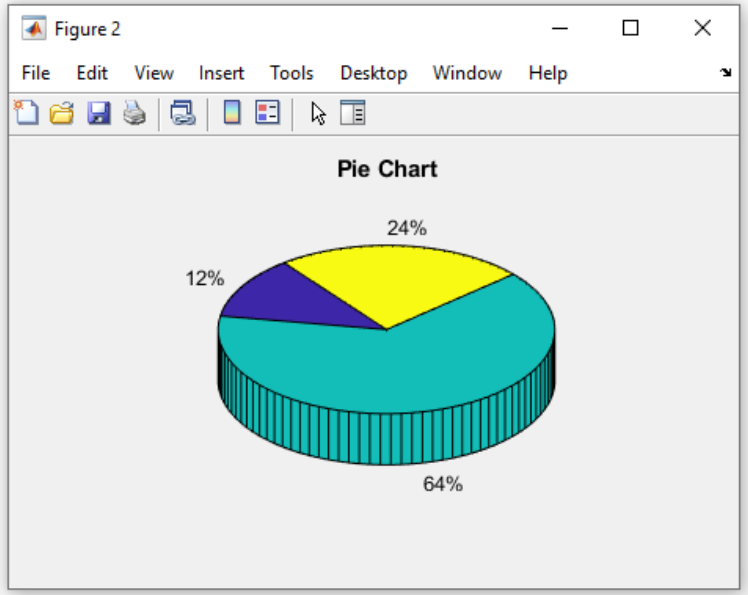
Syntax

```
switch switch_expression
   case case_expression
      statements
   case case_expression
      statements
    ...
   otherwise
      statements
end
```

switch statement

```
>> x = [12 64 24];
   plottype = 'pie3';

   switch plottype
      case 'bar'
          bar(x)
          title('Bar Graph')
      case {'pie','pie3'}
          pie3(x)
          title('Pie Chart')
      otherwise
          warning('Unexpected plot type. No plot created.')
   end
```



Vectorization

- Optimized for operations involving matrices and vectors.
- Interpreted language, i.e., it is not compiled before execution, loops run slowly.
- *Vectorized code* runs faster in MATLAB.

Example

- This code computes the *multiplication table* of 2:

```
>> x = 2;
>> for i = 1:10
       disp(x * i)
   end
```

- This is a vectorized version of the same code:

```
>> timestable = (1:10)'*(2)
```

Example

- This code computes the *sine* of 1,001 values ranging from 0 to 10:

```
>> i = 0;
   for t = 0:.01:10
       i = i + 1;
       y(i) = sin(t);
   end
```

- This is a vectorized version of the same code:

```
>> t = 0:.01:10;
   y = sin(t);
```

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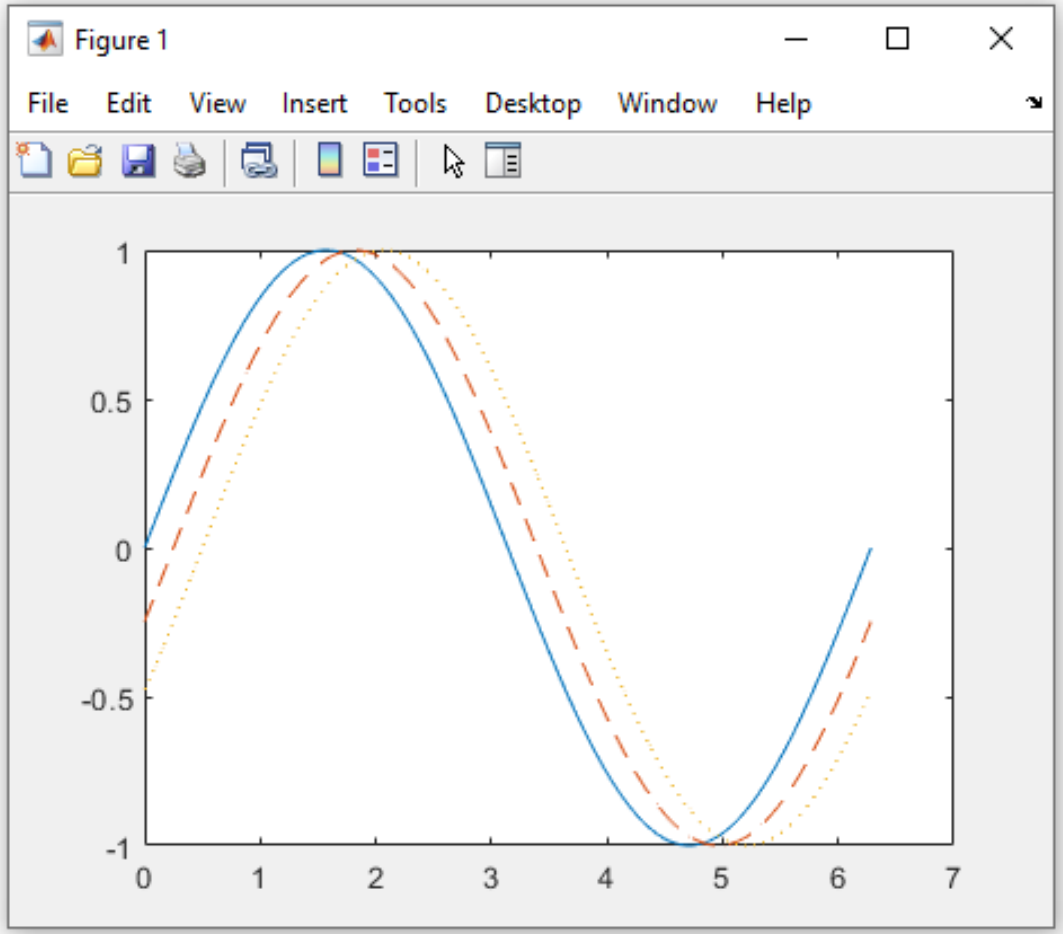
Common commands

- **plot(x, y);** % plots y vs. x.
- **plot(x, y, ‘k-’);** % plots a black line of y vs. x.
- **hold on;** % put several plots in the same % figure window.
- **figure;** % open new figure window.

Common commands

```
>> x = 0:pi/100:2*pi;
   y1 = sin(x);
   y2 = sin(x-0.25);
   y3 = sin(x-0.5);

   figure
   plot(x,y1,x,y2,'--',x,y3,':')
fx >>
```

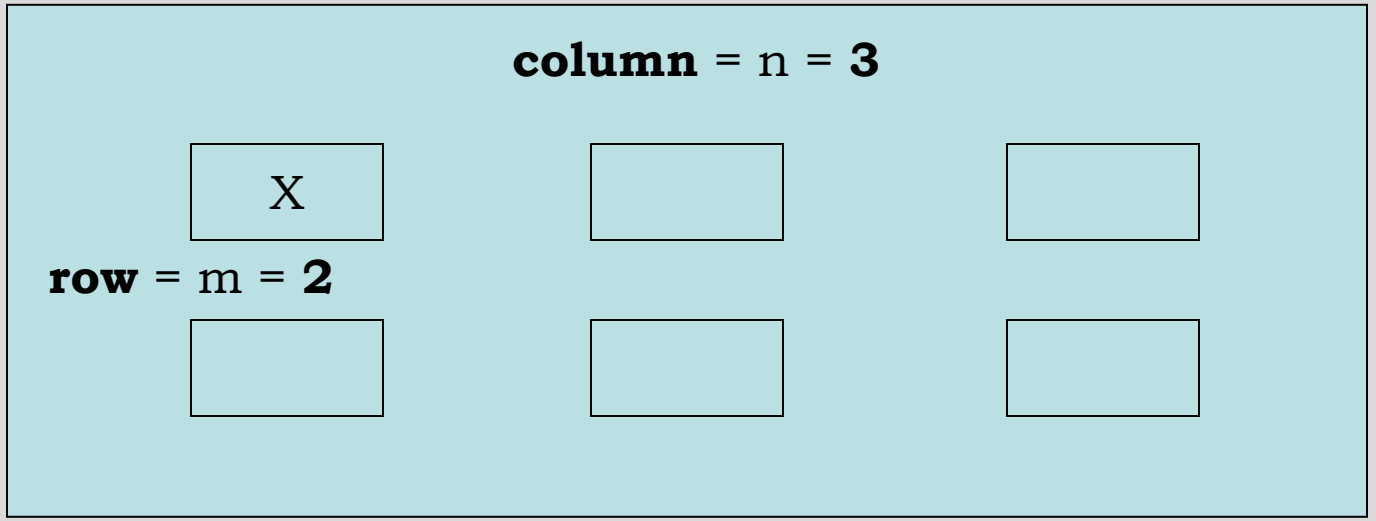


Common commands

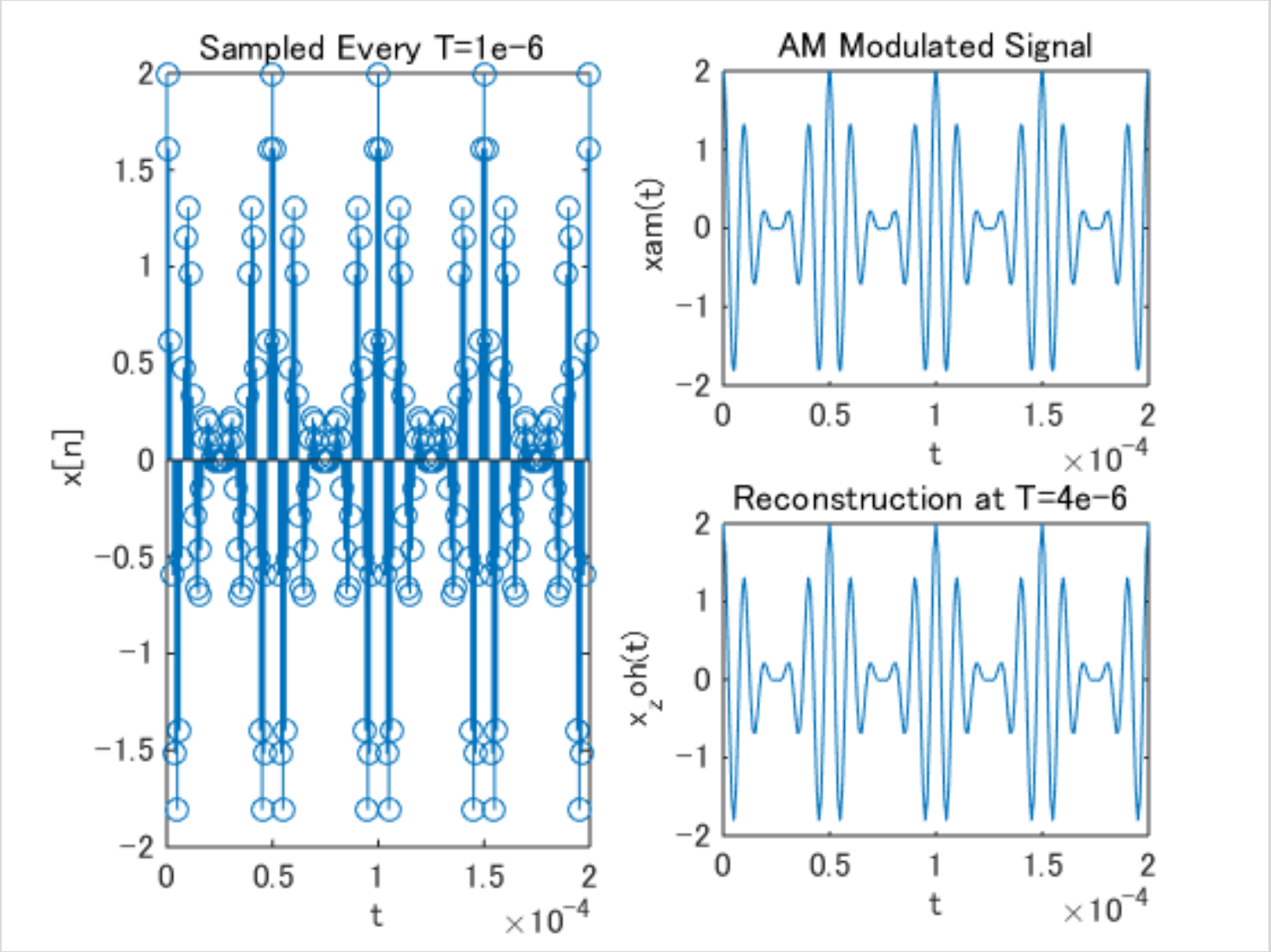
- **plot3(***x, y, z***)** – plot 2D function
- **mesh(***x, y, z***)** – surface plot
- **contour(***z***)** – contour plot of *z*
- **axis([***x_{min} x_{max} y_{min} y_{max}***])** – change axis limits
- **title(‘**My title**’)** – add title to figure
- **xlabel(**‘y label’**), ylabel**(‘y label’) – label axes
- **legend** – add key to figure

Common commands

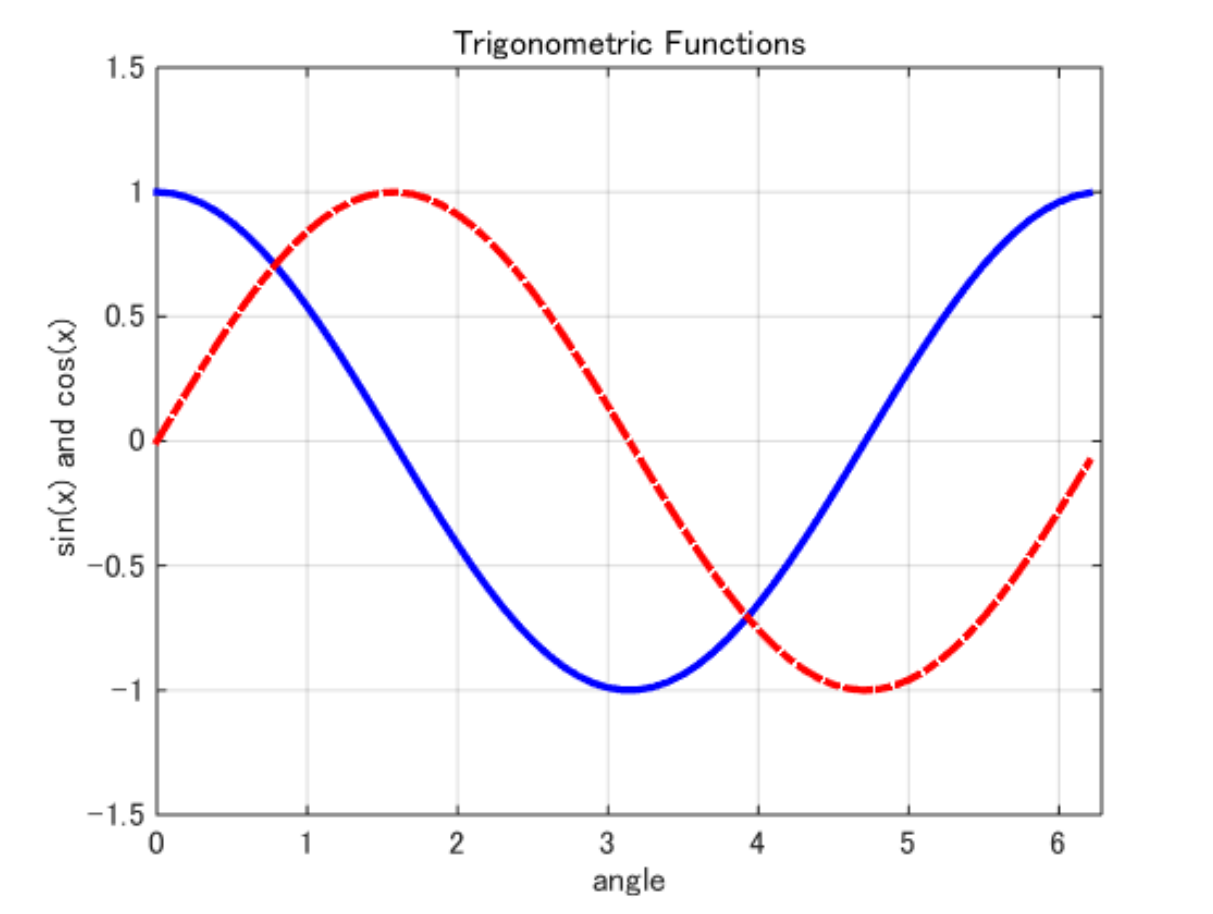
- **subplot(m, n, 1)** % Makes an **m x n** array
  % for plots. Will place plot in 1st
  % position.



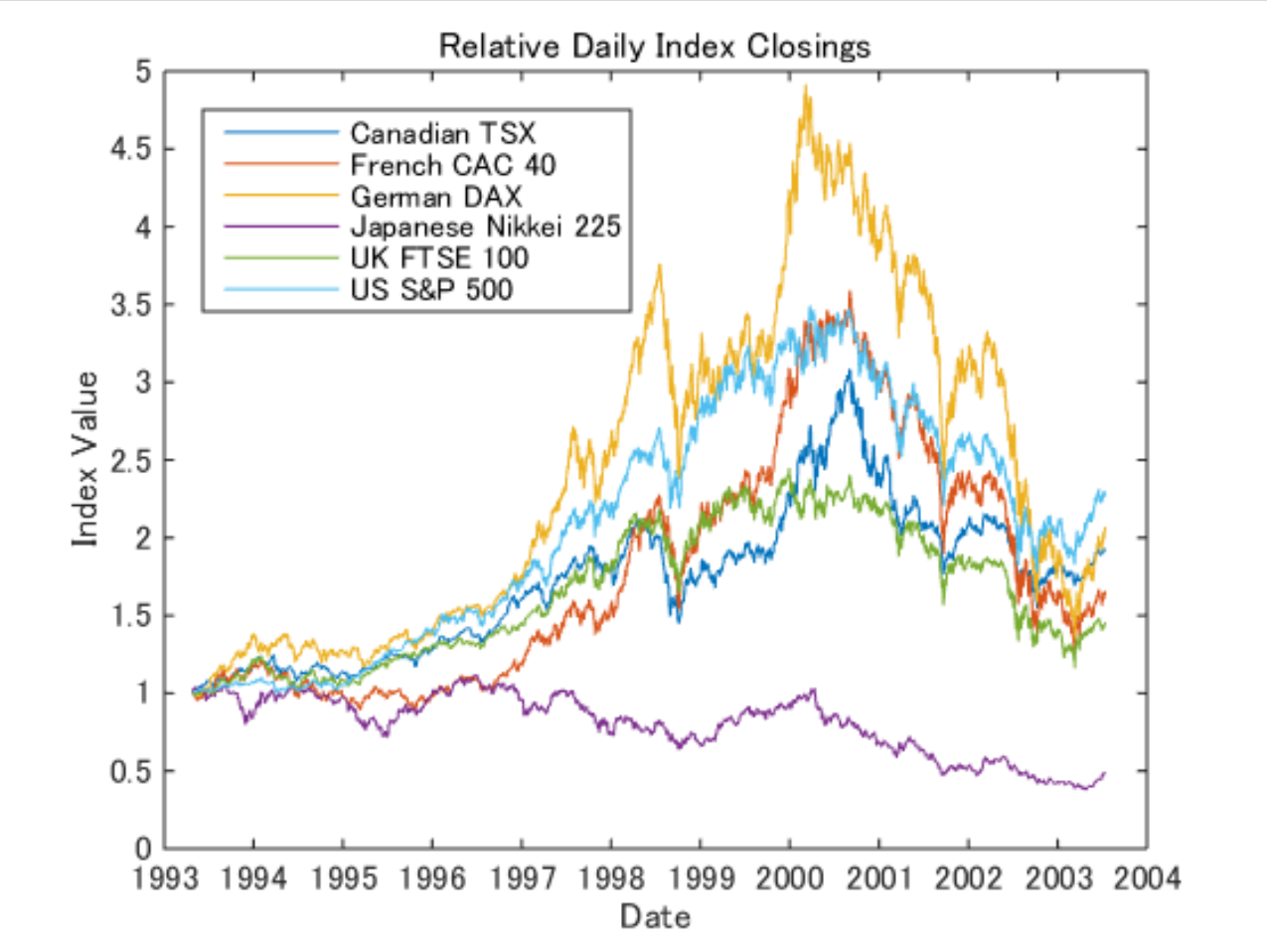
Common commands



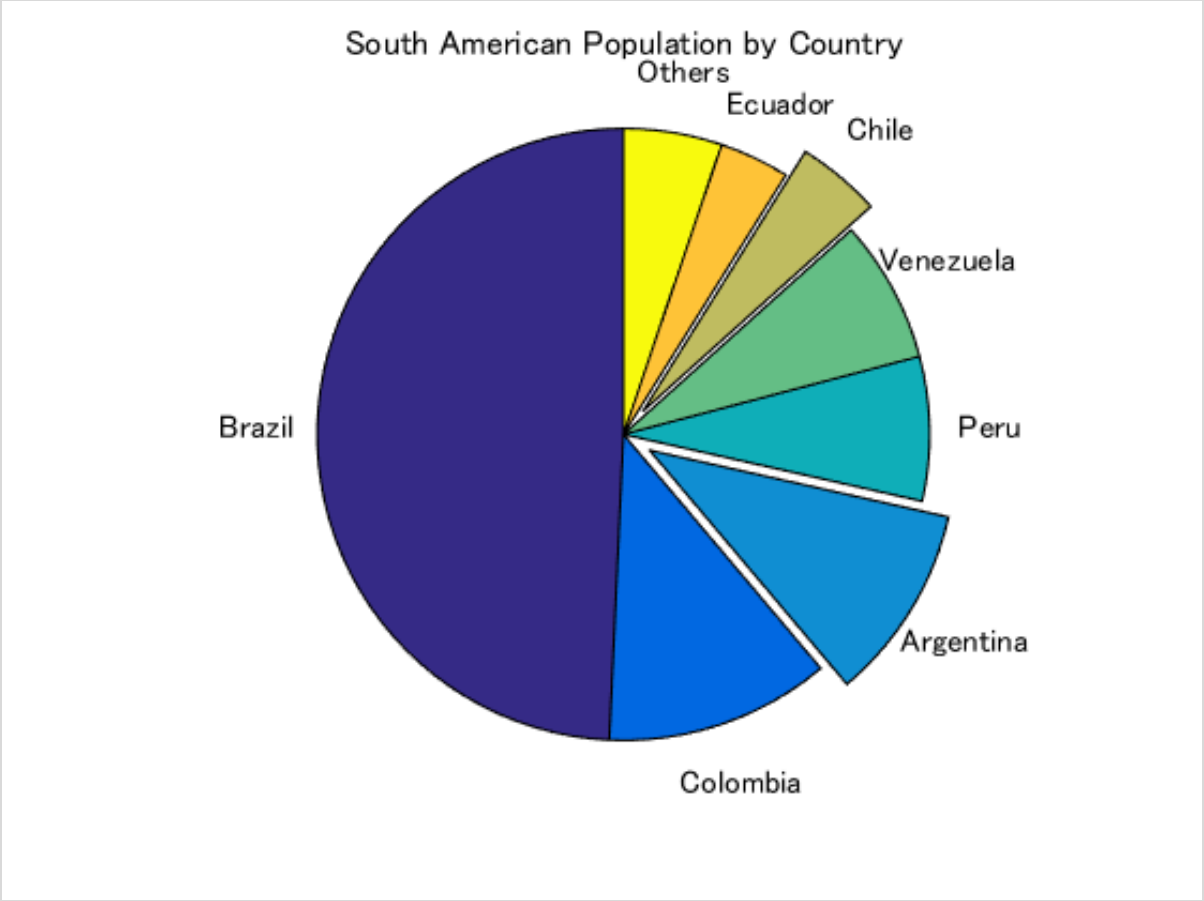
Examples of Plots – *2D*



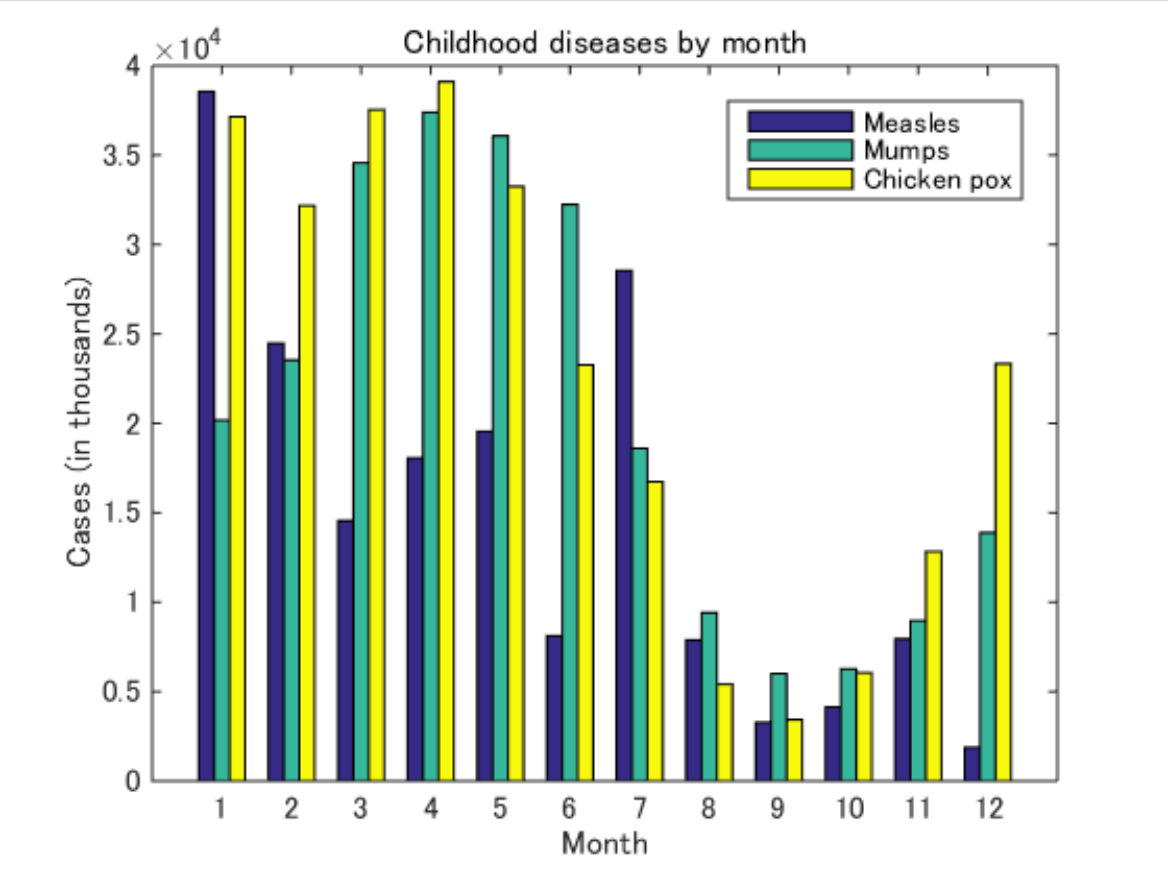
Examples of Plots – *2D*



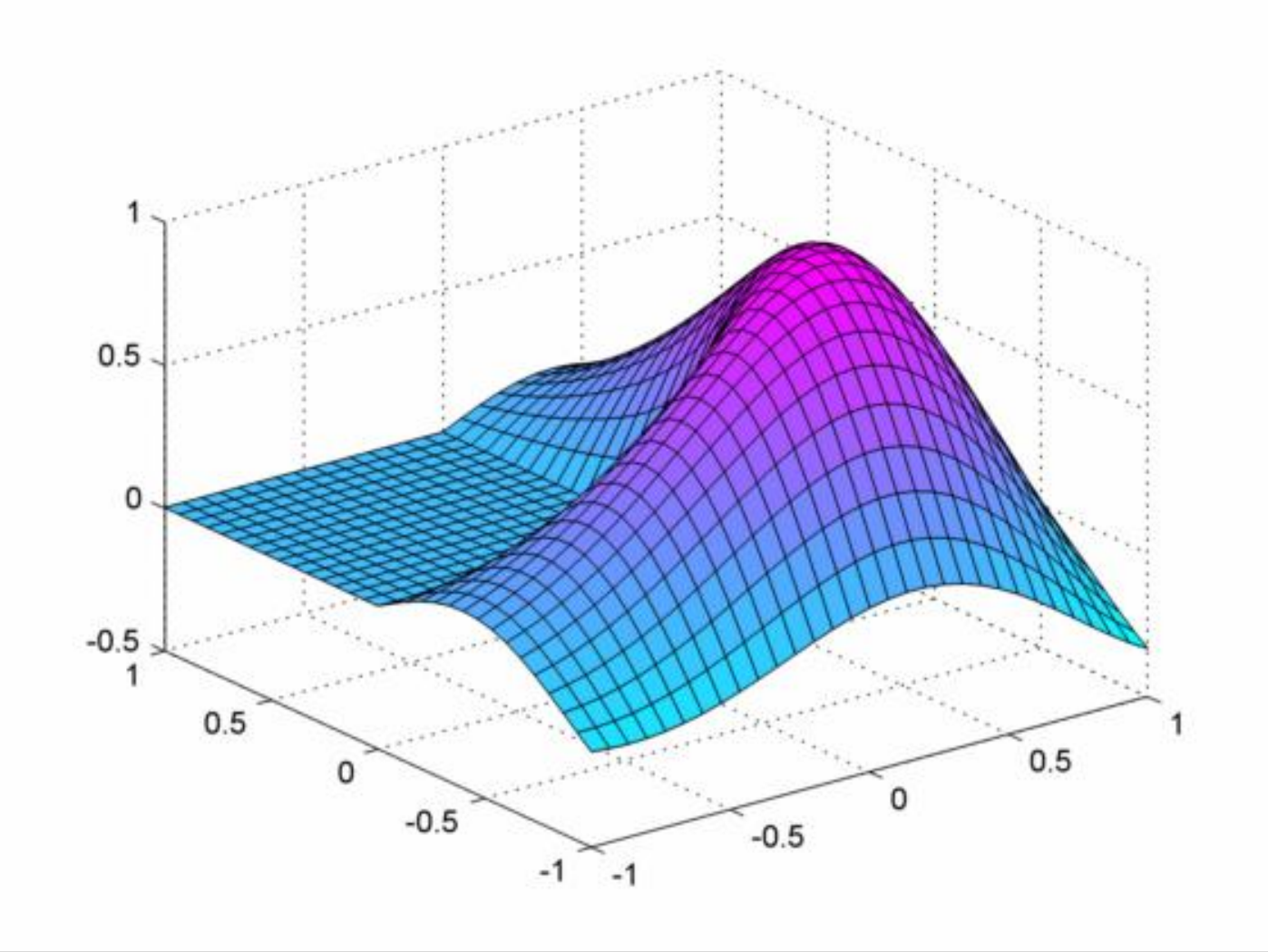
Examples of Plots – *2D*



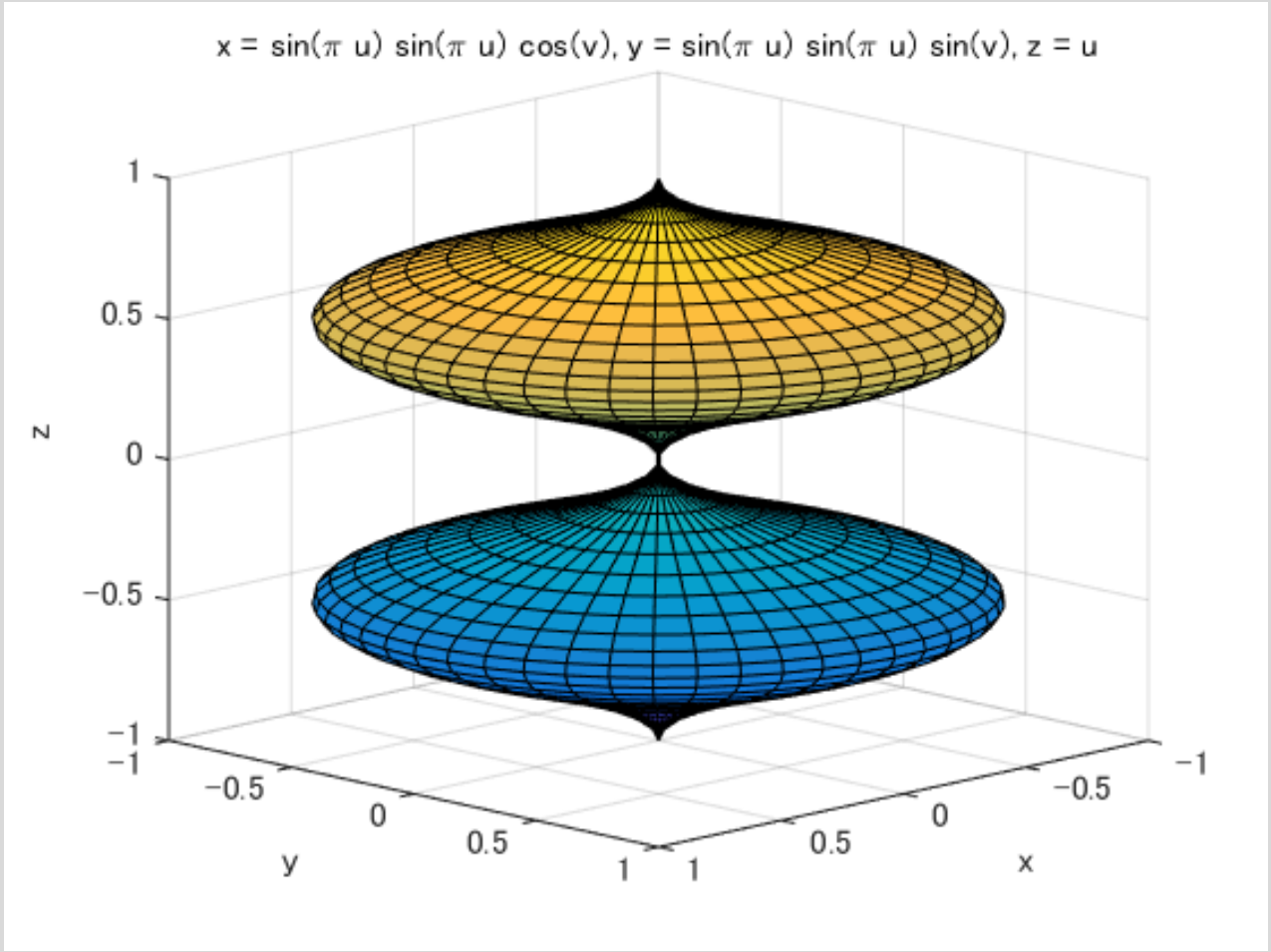
Examples of Plots – $2D$



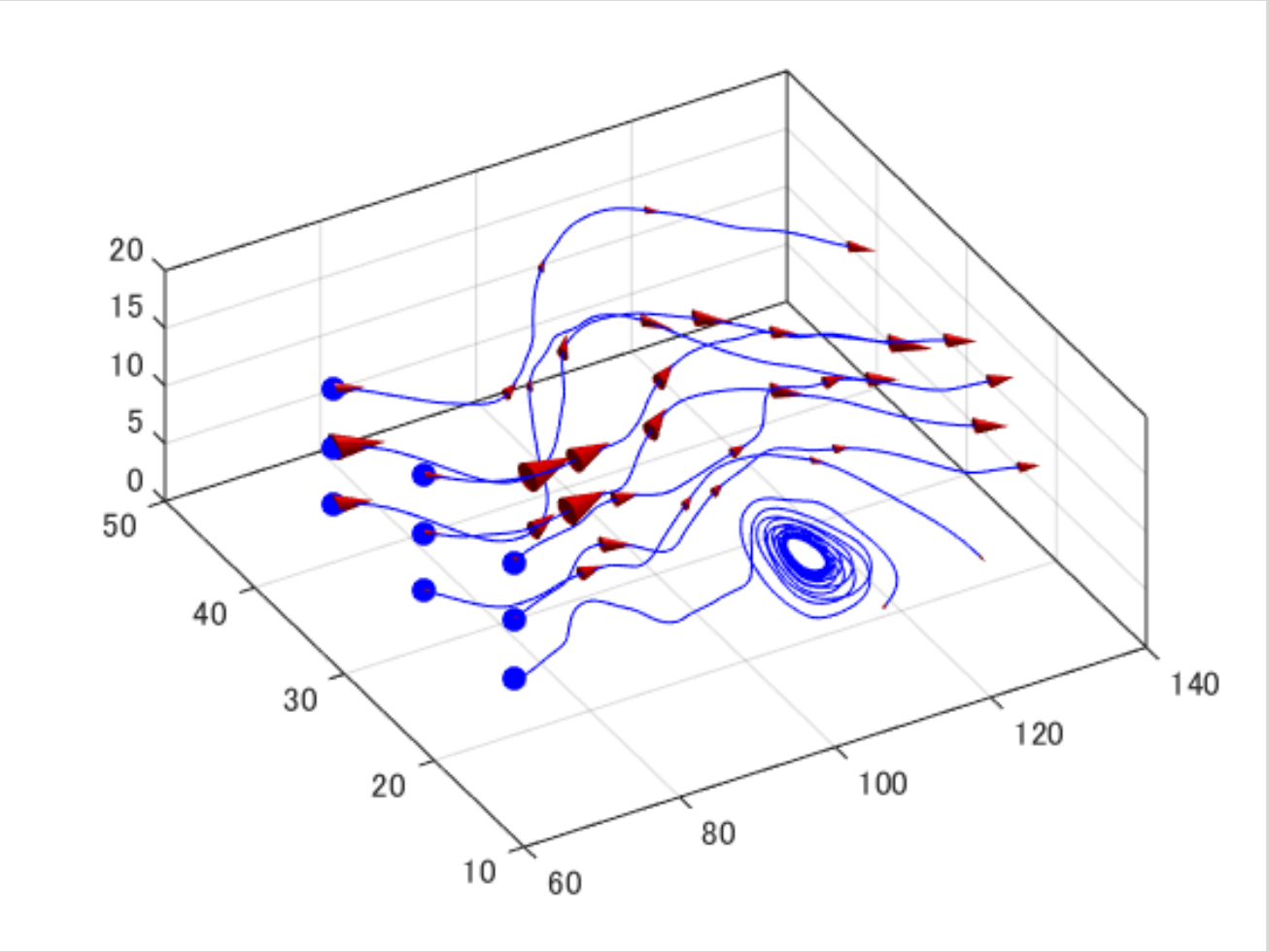
Examples of Plots – $3D$



Examples of Plots – $3D$



Examples of Plots – $3D$



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Scripts and Functions

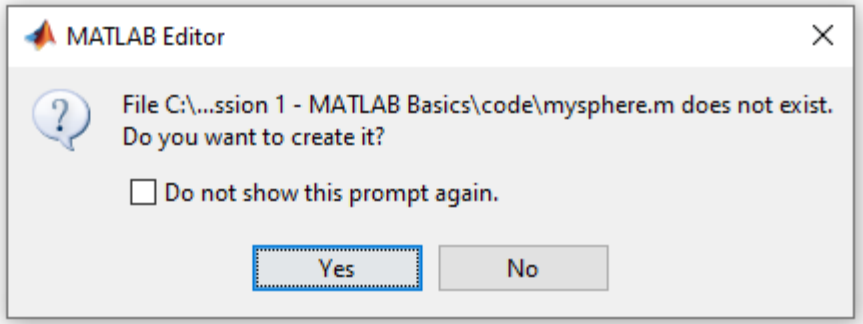
- Two main types of `.m` files:

  - **Scripts:** do not accept input arguments or return output arguments. They operate on data in the workspace. *FIXED*

  - **Functions:** can accept input arguments and return output arguments. Internal variables are local to the function. *VARIABLE*

Scripts - workflow

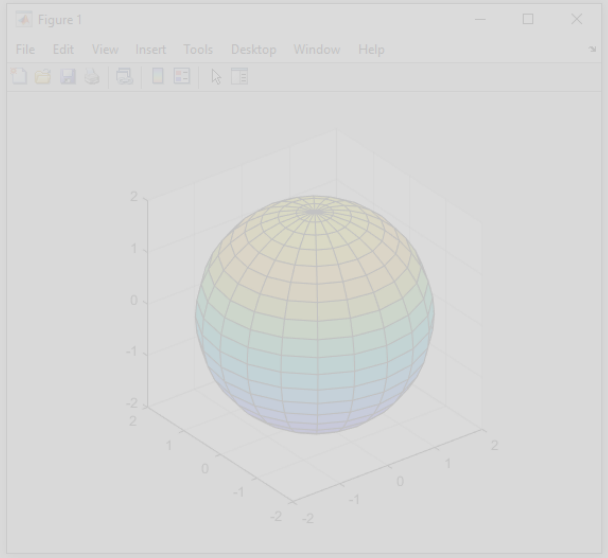
```
>> edit mysphere
```




```
% Create and plot a sphere with radius r.
[x,y,z] = sphere;       % Create a unit sphere.
r = 2;
surf(x*r,y*r,z*r)       % Adjust each dimension and plot.
axis equal              % Use the same scale for each axis.

% Find the surface area and volume.
A = 4*pi*r^2;
V = (4/3)*pi*r^3;
```

```
>> mysphere
>>
```



Scripts - workflow

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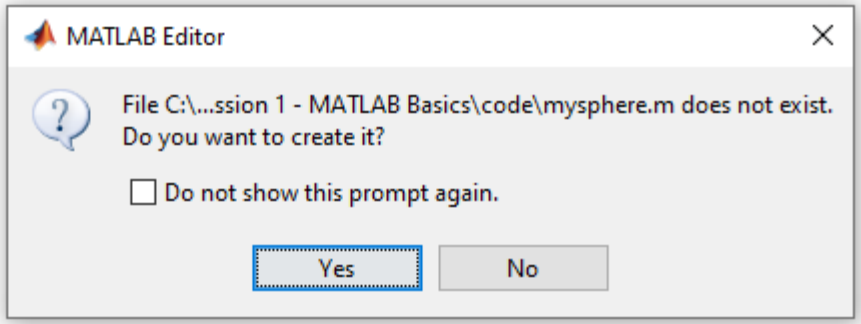

Editor - C:\Users\mugasi01\OneDrive - Arm\Documents\MATLAB SA\Session 1 - MATLAB Basics\code\mysphere.m

mysphere.m

```
% Create and plot a sphere with radius r.
[x,y,z] = sphere;       % Create a unit sphere.
r = 2;
surf(x*r,y*r,z*r)       % Adjust each dimension and plot.
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```

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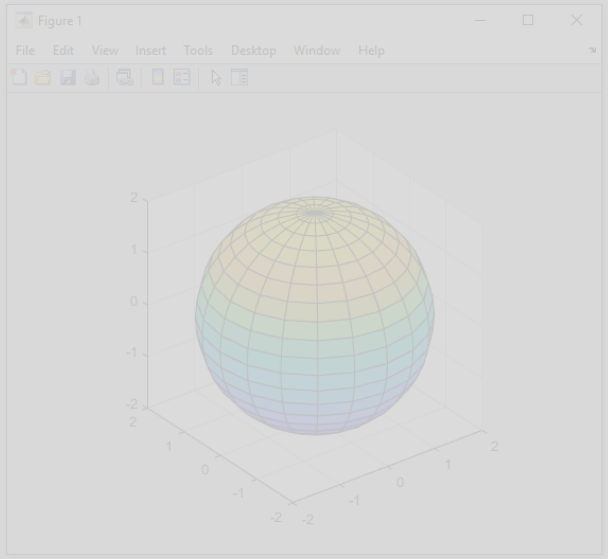
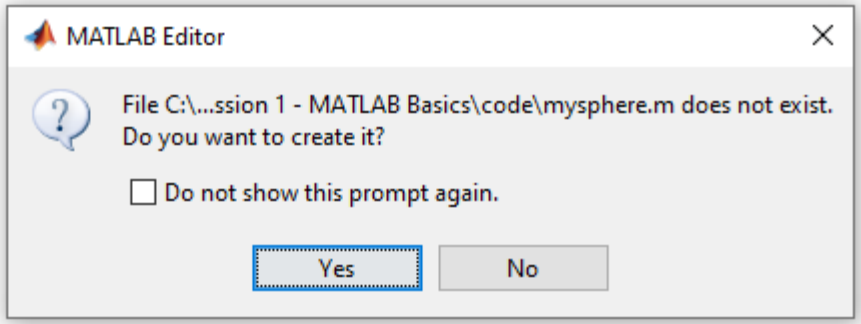


Scripts - workflow

```
>> edit mysphere
```



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mysphere.m

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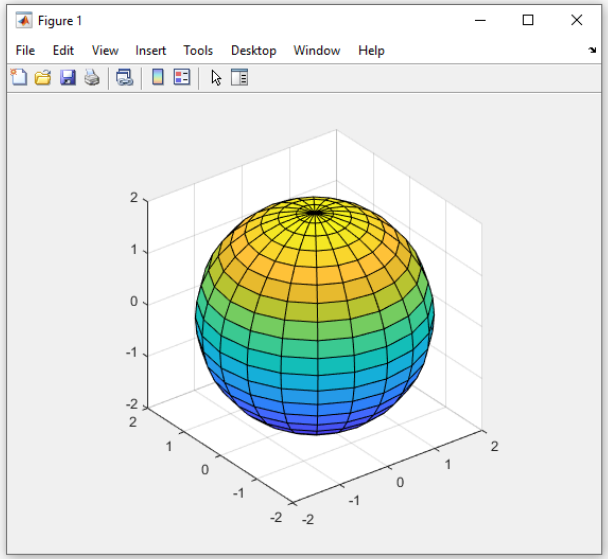
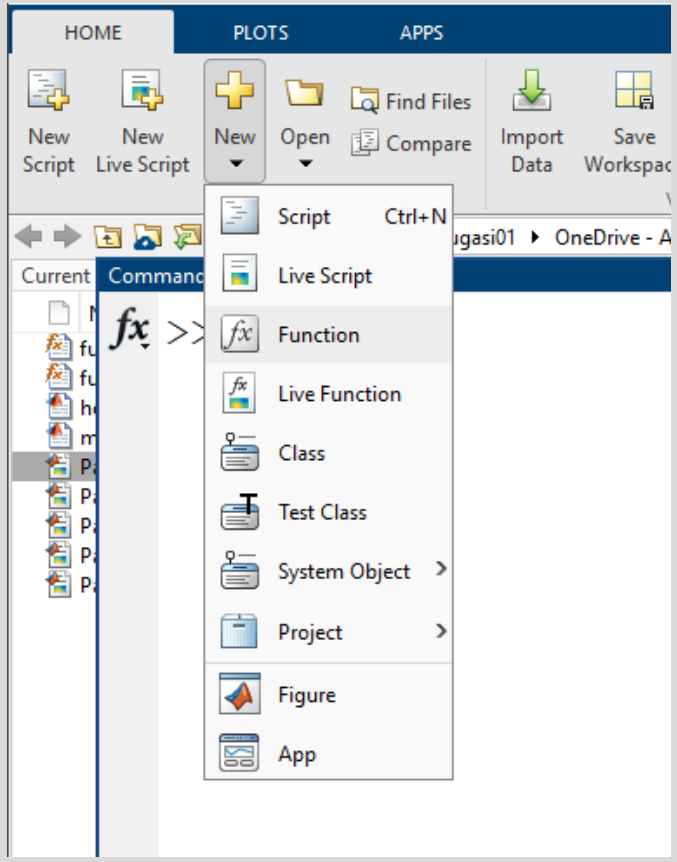
```

```
>> mysphere
>>
```



Functions - workflow



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average.m

```
% Define a function in a file named average.m that
% accepts an input vector,
% calculates the average of the values,
% and returns a single result.

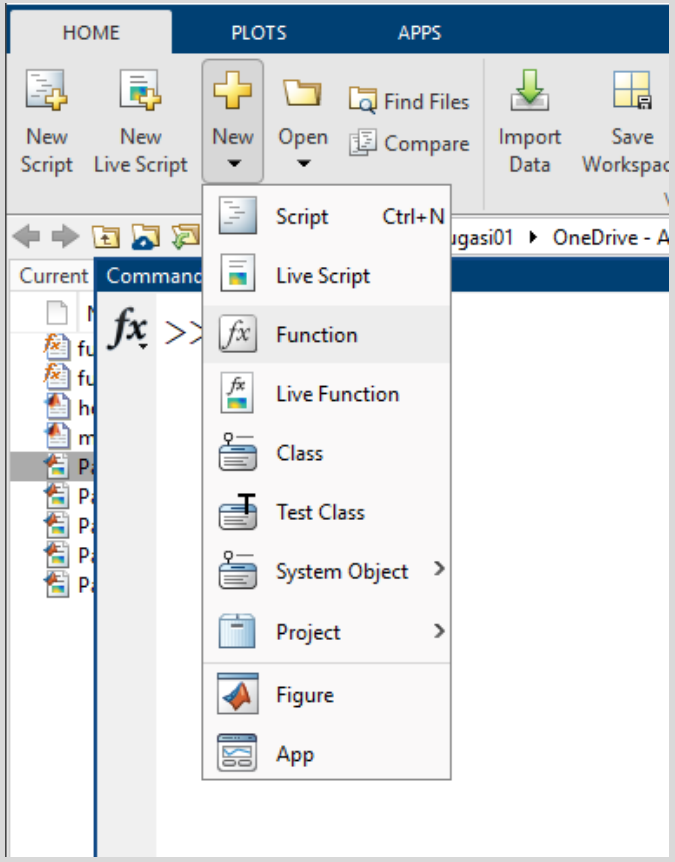
function ave = average(x)
    ave = sum(x(:))/numel(x);
end
```

```
>> z = 1:20;
   ave = average(z)

ave =

   10.5000
```

Functions - workflow



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    ave = sum(x(:))/numel(x);
end
```
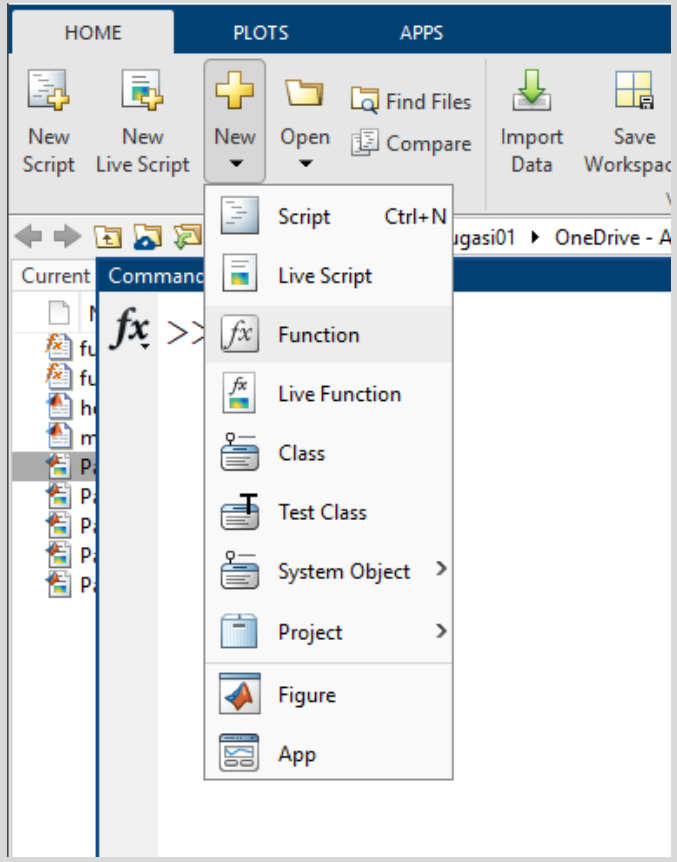

```
>> z = 1:20;
   ave = average(z)

ave =

   10.5000
```

Functions - workflow



Editor - C:\Users\mugasi01\OneDrive - Arm\Documents\MATLAB SA\Session 1 - MATLAB Basics\code\average.m

average.m

```
% Define a function in a file named average.m that
% accepts an input vector,
% calculates the average of the values,
% and returns a single result.

function ave = average(x)
    ave = sum(x(:))/numel(x);
end
```

```
>> z = 1:20;
   ave = average(z)

ave =

   10.5000
```

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  - Interface
  - Documentation
  - Getting help
  - Common commands
  - MATLAB symbols
- **Syntax** 🛠:
  - Matrix manipulation
  - `:` operator
  - *for* loop
  - *while* loop
  - *if* statements
  - *switch* statements
  - Vectorization
- **Graphics** 📈:
  - Common commands
  - Examples - 2D plot
  - Example - 3D plot
- **Scripts & Functions** ⚡
- **Demonstration** 💻
- **Final word** 🔊
- **Quiz** 📝
- **Pizza** 🍕

```
function [y,dist] = euclidean(x,cb) %#eml
% Initialize minimum distance as first element of cb
idx=1;
dist=norm(x-cb(:,1));
% Find the vector in cb with minimum distance to x
for i=2:size(cb,2)
    d=norm(x-cb(:,i));
    if d < dist
        dist=d;
        idx=i;
    end
    plot_distances(x,cb,i);
end
% Output the minimum distance vector
y=cb(:,idx);
end
```

Let's look at some **code** now!

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Thank you!

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Join the FB group to stay up to date with future events:

https://www.facebook.com/groups/196042678284982

The code and presentation can be downloaded from:

https://github.com/mughees-asif/matlab-qmul