PHYSLAB

ENGG 100
Measurement and Design Lab
Fall 2025, Section: Waves and Matter

Lecture 1

Introduction to MATLAB

Syed Babar Ali
School of Science and
Engineering

Department of Physics

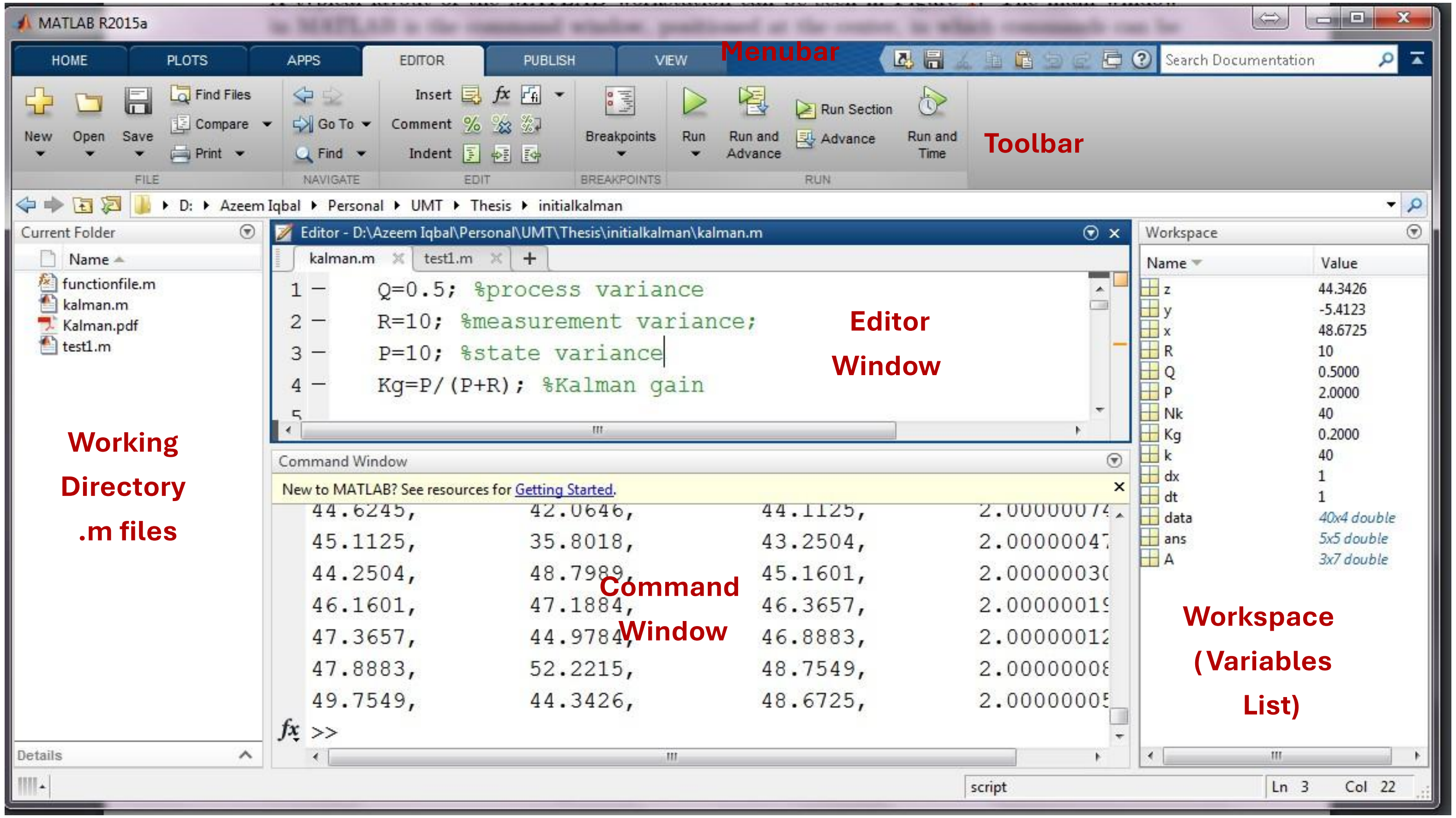
What is MATLAB?

Think of it as a "super calculator" that can handle complex mathematical operations

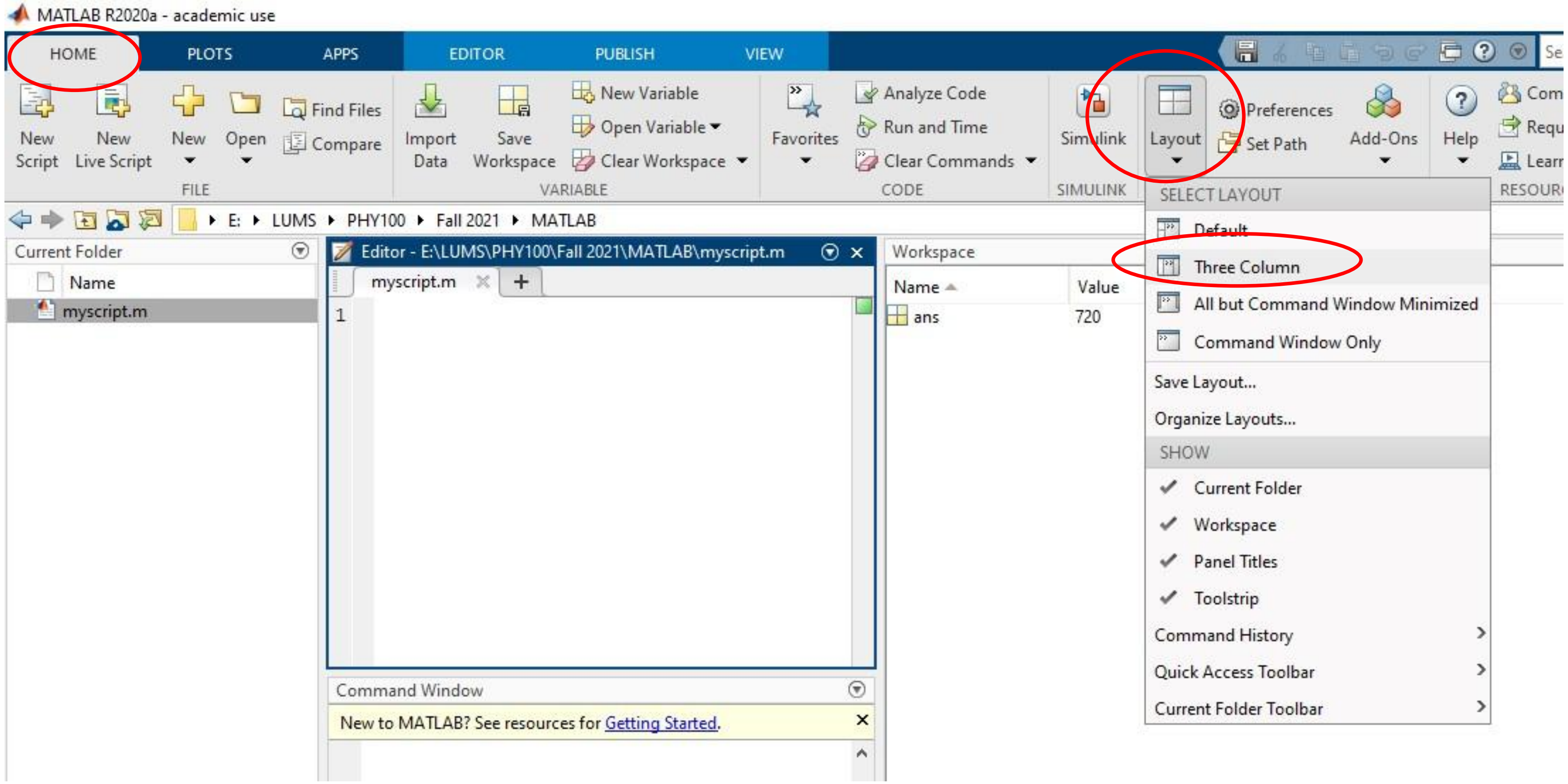
- MATLAB stands for **Matrix Laboratory**.
- It is a power computing environment and programming language focused on numerical computing, visualization, and algorithm development.
- MATLAB is widely used in engineering, physics, and data science.

- **Lecture Goals:**
  - Understand basic MATLAB operations
  - Learn about variables, vectors, and matrices
  - Use logical statements and loops
  - Create plots and fit curves to data
  - Write simple functions

Basic Layout



Basic Layout



Basic Arithmetic and Variables

- MATLAB can be used as a calculator with standard arithmetic operators
- MATLAB follows **PEMDAS** for operator precedence:
  - **P**arentheses: ()
  - **E**xponents: ^
  - **M**ultiplication/Division: * /
  - **A**ddition/Subtraction: + -

OPERATOR	MATLAB SYMBOL
Addition	+
Subtraction	-
Multiplication	*
Division	/
Power	^

Practice Examples

- 2 + 2 % Basic addition
- 4 * 12.2 % Multiplication with decimals
- sqrt(-3) % Square root (note: complex result)
- 1 / (1 + 3i)^(-4) % Complex number operations

- The Semicolon Rule:
  - 2 + 2; % Semicolon suppresses output
  - 2 + 2 % No semicolon shows result

Variables

- Variables are like labeled boxes that store values for later use.

```
% Good variable naming practices
height = 1.75                    % Use descriptive names
weight = 68.5
bmi = weight / height^2 % Calculate using stored variables


% Avoid these naming mistakes:
% 123name = 5 % Can't start with number
% my-var = 10 % Can't use hyphens
% if = 20 % Can't use MATLAB keywords
```

Hands-on Exercise 1: Quadratic Formula

- Problem: Solve $ax^2 + bx + c = 0$, where a=28.0, b=-9.4, c=405.6

Solution

> $a = 28.0$

> $b = -9.4$

> $c = 405.6$

> (-b + sqrt(b^2 - 4*a*c))/2/a

> (-b - sqrt(b^2 - 4*a*c))/2/a

ans: $0.1679 \pm 3.8023i$

Vectors

- A *vector (array)* is a list of numbers (row or column): 1-dimensional

- % Method 1: Manual entry

```
x = [1 2 3 4 5 6 7 8 9 10]; % Row vector (spaces/commas)
y = [1; 2; 3; 4; 5]; % Column vector (semicolons)
```

- % Method 2: Using ranges

```
x = 1:10; % 1 to 10, step = 1
x = 1:2:10; % 1 to 10, step = 2 (odd numbers)
x = 10:-1:1; % Counting backwards
```

- % Method 3: Linear spacing

```
y = linspace(1, 10, 10); % 10 equally spaced points from 1 to 10
z = linspace(0, 2*pi, 100); % Useful for smooth curves
```

Matrices

- A *matrix* is a 2D array of numbers: 2-dimensional

- % Manual definition

```
M = [1 2; 3 4; 7 6]; % 3×2 matrix
```

- % Built-in functions

```
I = eye(3);         % 3×3 identity matrix
Z = zeros(3, 4);    % 3×4 matrix of zeros
O = ones(2, 5);     % 2×5 matrix of ones
R = rand(3, 3);     % 3×3 random numbers [0,1]
MG = magic(3);      % 3×3 magic square
```

Matrix Operations vs Element-wise Operations

```
A = [1 2; 3 4];
B = [5 6; 7 8];
```

- % Matrix operations
  ```
  C = A * B; % Matrix multiplication
  D = A^2; % Matrix power
  ```

- % Element-wise operations (use the dot!)
  ```
  C_elem = A .* B; % Element-wise multiplication
  D_elem = A.^2; % Element-wise power
  E = A ./ B; % Element-wise division
  ```

Accessing elements using indexing

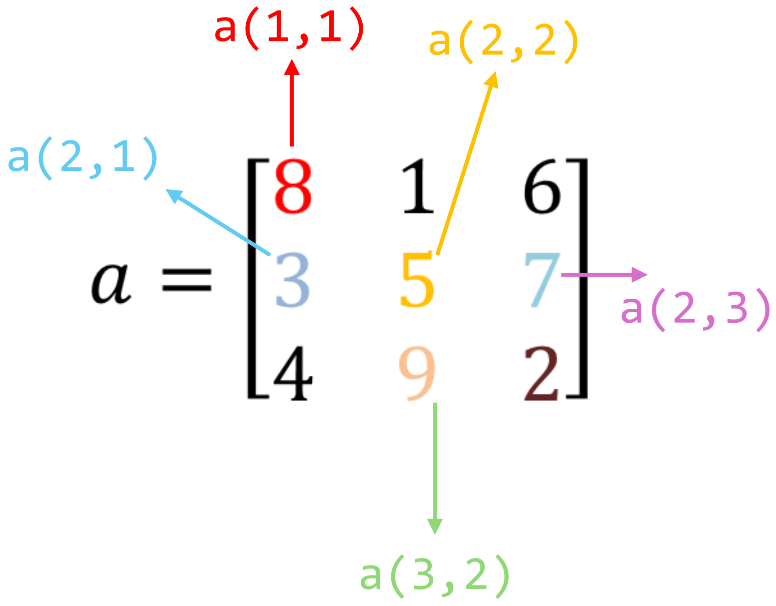
A = magic(3);

- % Single elements
  first_element = A(1,1); % Row 1, Column 1
  last_element = A(end,end); % Last row, last column
-

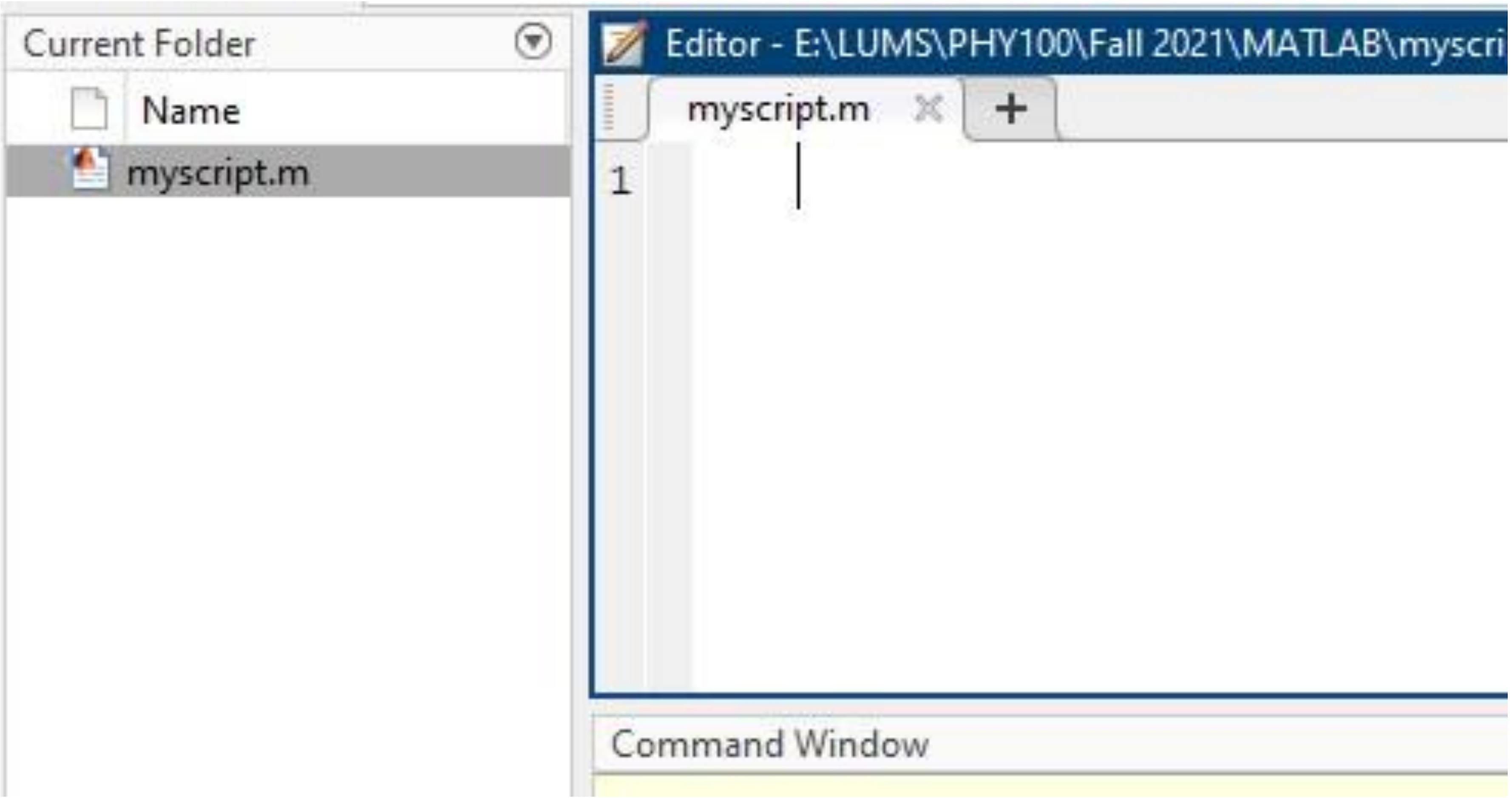
  % Entire rows or columns
  first_row = A(1, :); % All columns of row 1
  second_col = A(:, 2); % All rows of column 2

- % Multiple elements
  subset = A(1:2, 2:3); % Rows 1-2, Columns 2-3

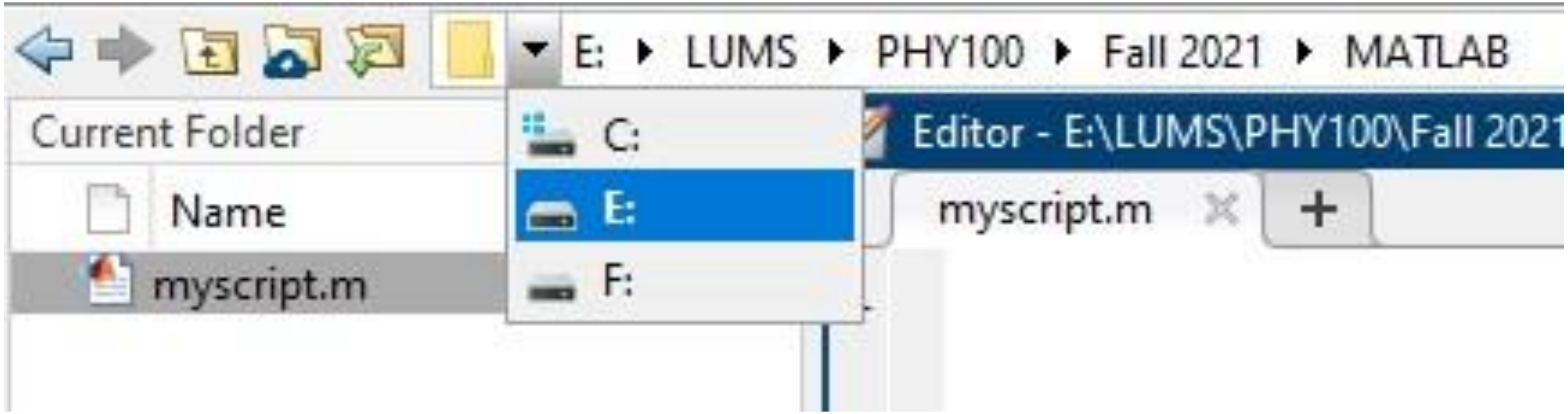
- % Modifying elements
  A(1,1) = 100; % Change single element
  A(end, :) = [4 9 2]; % Replace last row



Script


Current Folder
Name
myscript.m
Editor - E:\LUMS\PHY100\Fall 2021\MATLAB\myscri
myscript.m
+
1
Command Window

Script



E: LUMS PHY100 Fall 2021 MATLAB
Current Folder
Name
myscript.m
C:
E:
F:
Editor - E:\LUMS\PHY100\Fall 2021
myscript.m
+

Plotting

Q. We are given a relationship between the variables x and y defined by the equation:

$$y = -(x-2)^2 + 5.$$

We need to analyze the relationship in the range $0 < x < 5$.

(a) Plot the function.

(b) What is the maximum value of the equation in the mentioned range?

(c) What is the minimum value of the function?

(d) At what x-value does the maximum y-value occur?

Multiple figures on same plot

Q. Plot following equations on the same figure:

$$y = -(x-2)^2 + 5\,,$$
$$y = -(x-2)^2 + 10,$$
$$y = -(x-2)^2,$$

for range $0 < x < 5$.

Logical (Boolean) Operations

```
% Comparison operators
4 > 2       % true (logical 1)
28 == 28 % true (note: double equals!)
65 ~= 68 % not equal (true)


% Logical operators
(5 > 3) && (2 < 4) % AND operator
(5 > 8) || (2 < 4) % OR operator
~(5 > 8) % NOT operator
```

The conditional statements: if-else

- Syntax
  ```
  if condition
  % code if true
  else
  % code if none true
  end
  ```

```
> a = sqrt(1/2); % define a number
> b = sqrt(1/3); % define another number
> if a > b % whether 4 is greater than 2
> disp(' a is bigger ');
> else
> disp(‘b is bigger’);
> end
```

Problem

- Generate 5 random integers between 1 to 10.
- Count the number of 2’s generated.
- Display ‘wow’ if the 2’s generated is more than 2 times.

Loops: for

- Loops allow repeating statements over a range of values.
- Syntax:

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

- Example:

```
for v = 1.0:-0.2:0.0
       disp(v)
end
```

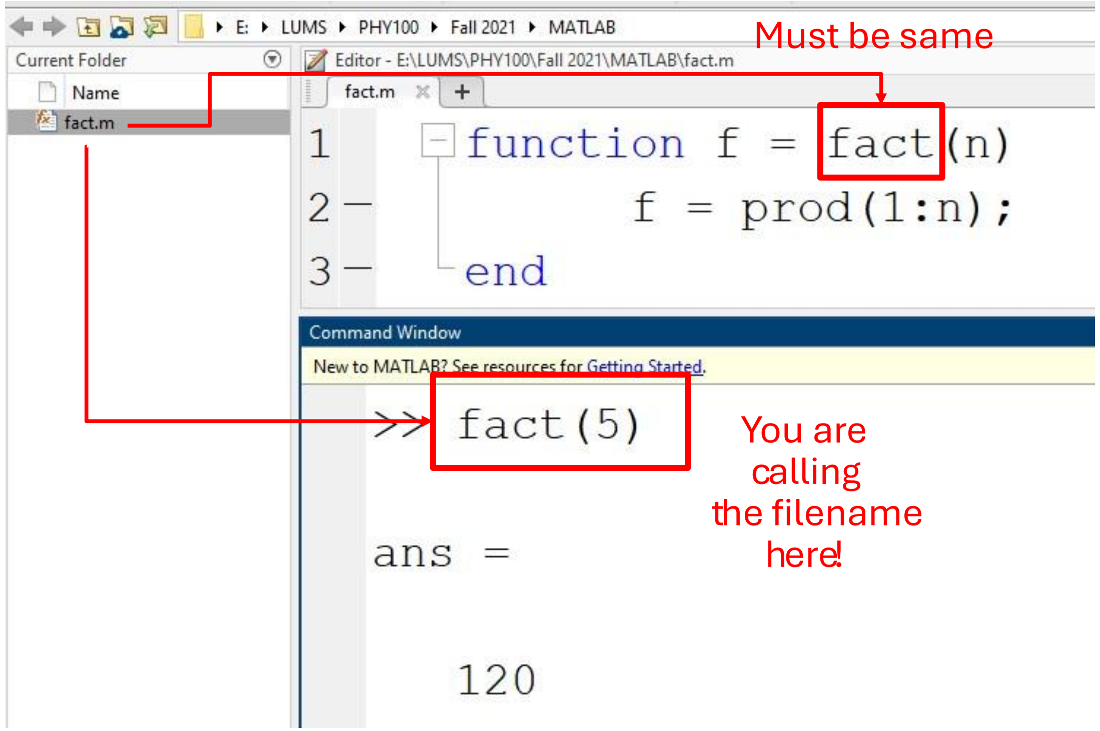
How to create your own function

```matlab
function [outputArg1,outputArg2] = untitled6(inputArg1,inputArg2)
%UNTITLED6 Summary of this function goes here
%   Detailed explanation goes here
outputArg1 = inputArg1;
outputArg2 = inputArg2;
end
```

How to create your own function

```
function [outputArg1,outputArg2] = untitled6(inputArg1,inputArg2)
%UNTITLED6 Summary of this function goes here
%   Detailed explanation goes here
outputArg1 = inputArg1;
outputArg2 = inputArg2;
end
```

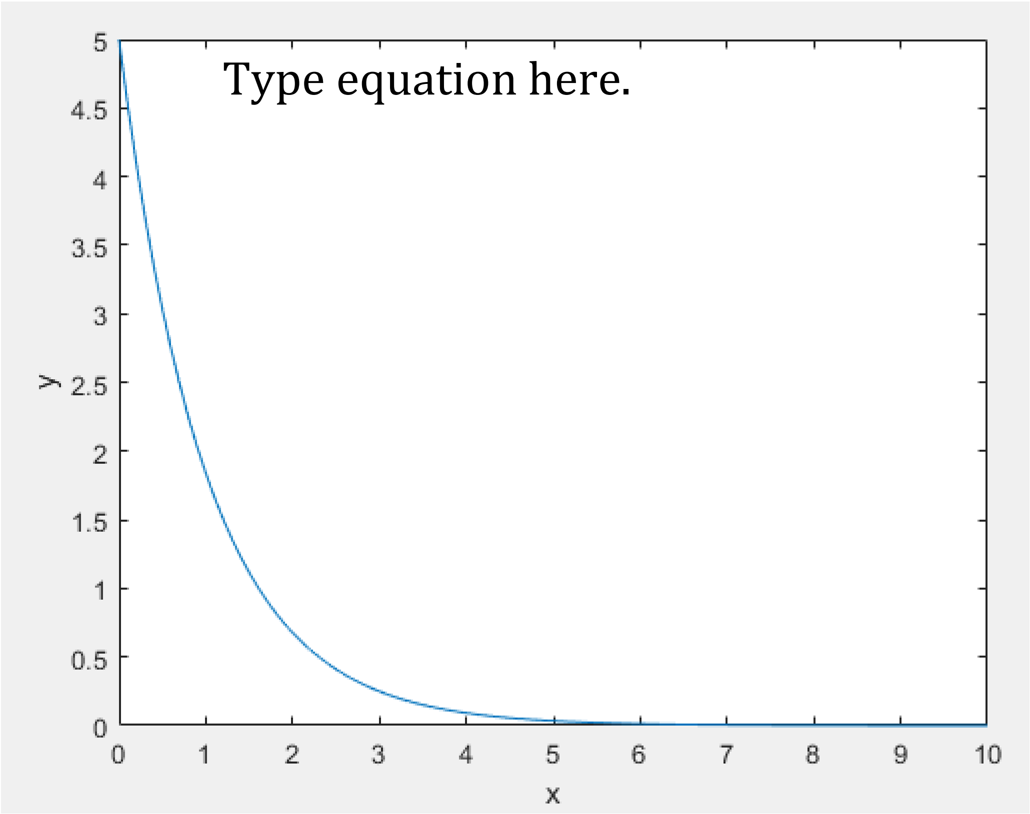
How to create your own function



Linearization (1)

$y = 5\,e^{-x}$

% Write the MATLAB To plot the exponential decay function

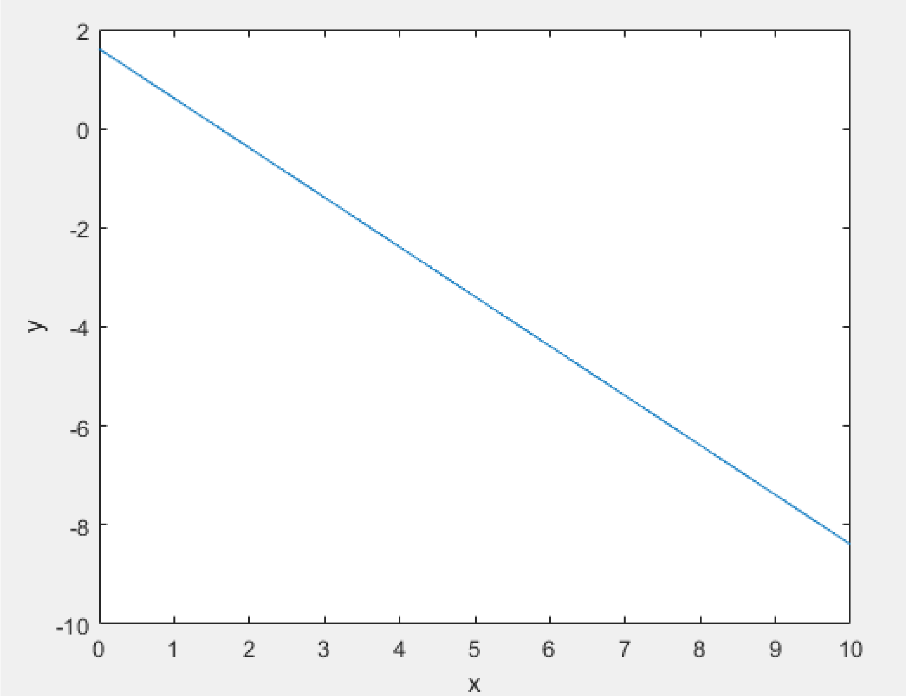


Linearization (2)

$y = 5\, e^{-x}$

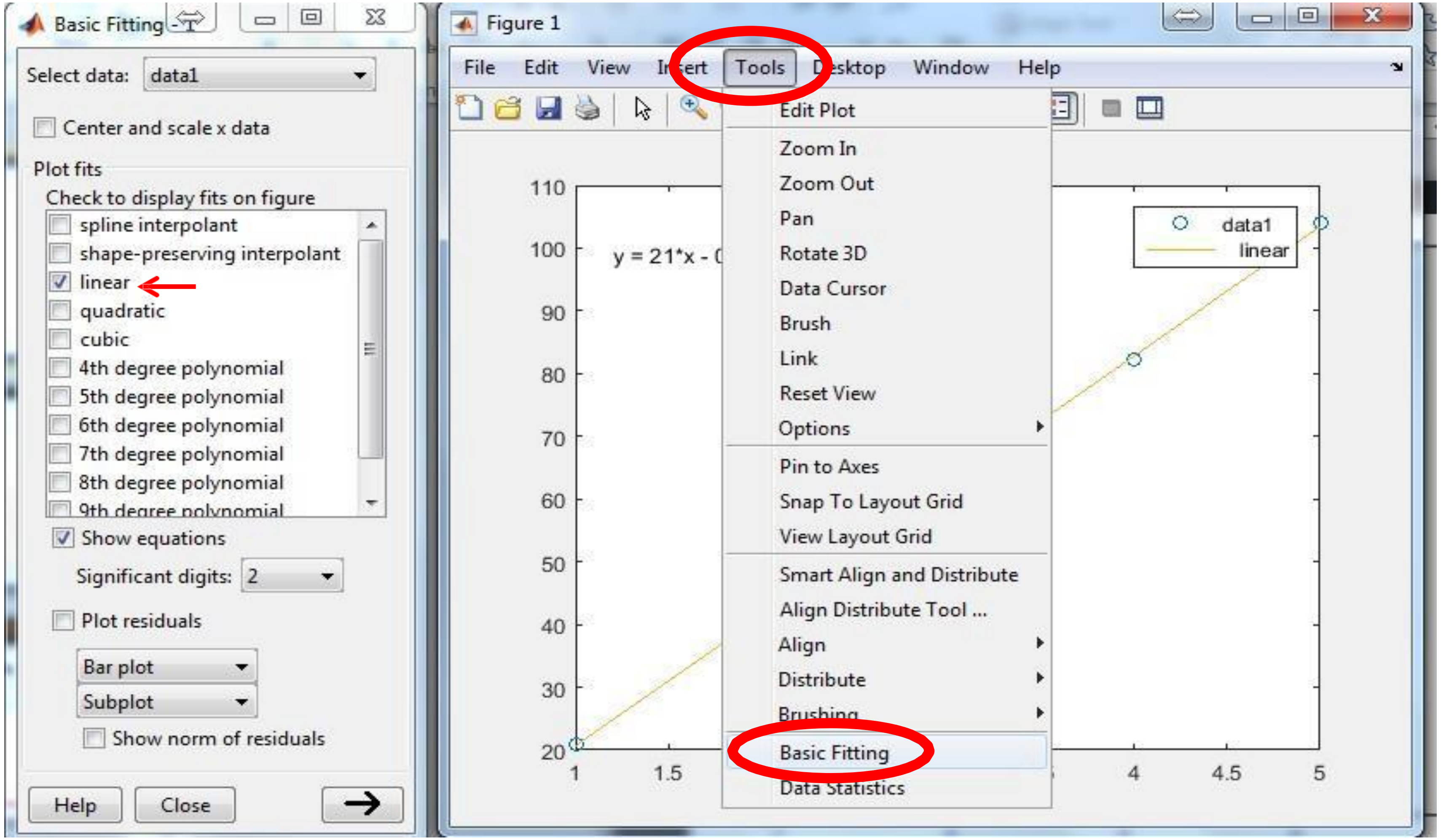
$\ln(y) = \ln(5) - x$

% write MATLAB code to linearize the non linear equation



Curve Fitting Using Figure Tools

Basic Fitting



Estimating "Resistance" from Ohm's Law

- A student wants to check the resistance of a resistor by measuring voltage (V) across it and the resulting current (I) through it and then calculating the resistance through Ohm's Law.
- *Using slope of the relation:*

$$V = R\,I$$

$$y = m\,x + c$$

Estimating "Resistance" from Ohm's Law

Voltage (V)	**11.2**	**13.4**	**15.1**	**17.7**	**19.3**
Current (A)	4.67	5.46	6.28	7.22	8.30