

MATLAB
The Language of Technical Computing

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Second Class

Chapter -1-

- **MATLAB**

MATLAB (an abbreviation of "matrix laboratory") is a proprietary multi-model programming language and numerical computing environment developed by MathWorks . MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms.

- **Why Matlab is useful?**

- 1- Conducting mathematical and engineering operations.
- 2- Development of algorithms.
- 3- Modeling and simulations.
- 4- Data analysis and presentation.
- 5- Conducting engineering graphs.
- 6- Application development.

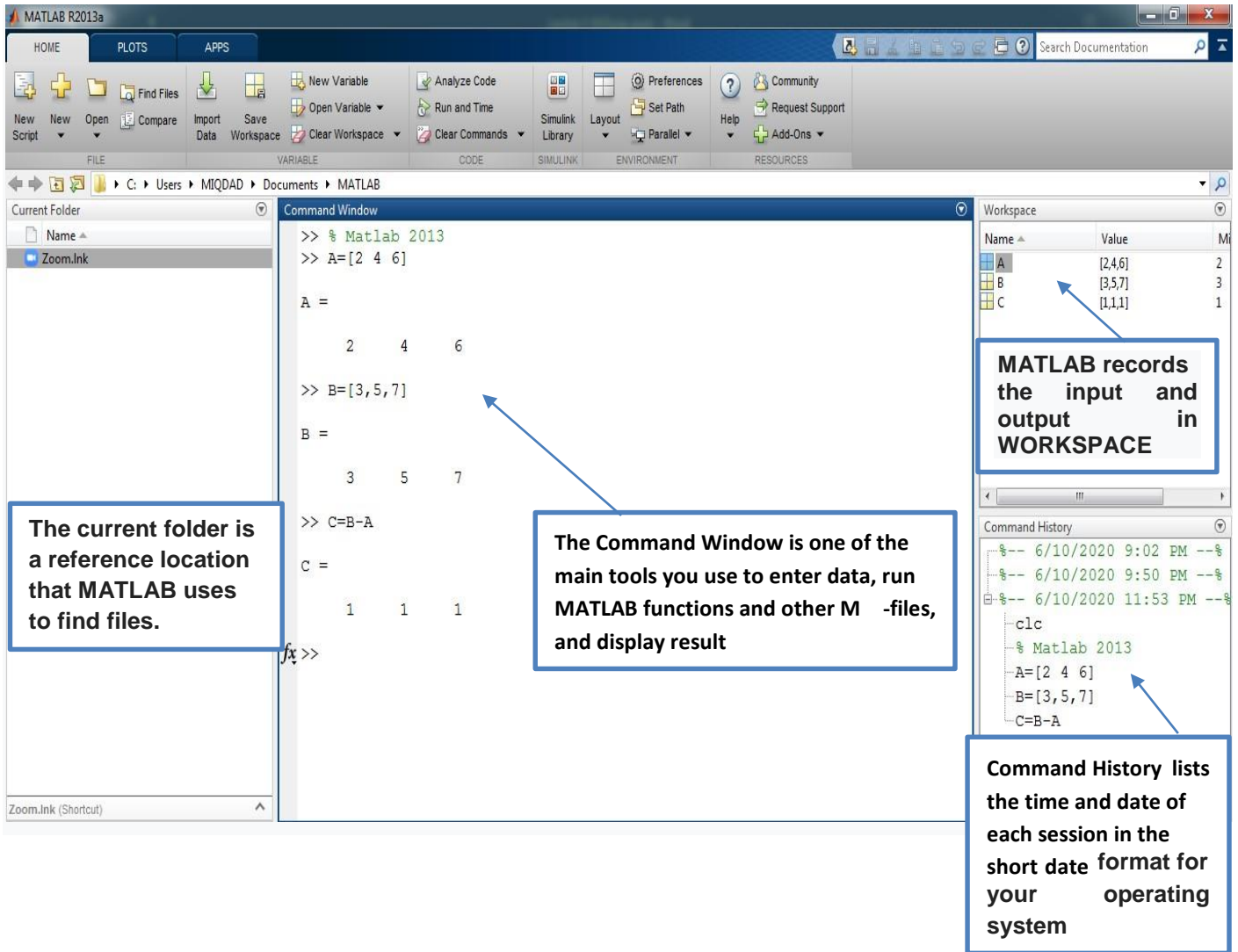
- **Matlab Windows**

Work area divided into three Main area, which are the following:

1- Command Window: This is the main window commands can also be type on this screen and the results were shown in it .

2-Workspace : MATLAB records the inputs and outputs in this screen.

3-Command History: This is the space in which MATLAB stores the previous commands.



• General Commands in Matlab

1 -Stopping MATLAB in different ways:

- a- By means of the command: quit
- b- Clicking on the cross in the upper right of your window.

2-Changing Font Size:


On the Home tab, in the Environment section, click Preferences ► Fonts and select a font size.

3- Some delete commands in matlab

a- Type `clc` : To clear your command window without erasing the variables and functions that you have recorded in the Workspace window or the command history window

b- To remove a variable or data in workspace type clear: You can also clear a specific variable: just follow the clear command with the variable name.

C- To clear all windows such as Command window, command history and workspace:

- On tab HOME Go to 
 - Clear command window
 - Clear command History
 - Clear workspace

d- Clear : Use to Remove variables from the memory.

4- help: search for help

5-Exist: check if the variable exists or not and gives either 0 or 1

6 - load: Load variables from the workspace.

7 - % : To Put titles during programming.

Arithmetic operations

Symbol	Operation	Matlab form
^	power	A^B
*	multiplication	A*B
/	right division (slash)	A/B
\	left division (backslash)	A\B=B/A
+	addition or plus	A+B
-	subtraction or negation	A-B

Example :

1) Write using matlab the following :

1) $A = 6 \frac{10}{13} + 18 \frac{5}{7} + 5(9)^2$

SOL :

$$A=6*(10/13) + 18 *(5/7)+5*(9^2)$$

A =
422.4725

$$A=(6*(10/13)) +(18*(5/7))+(5*(9^2))$$

A =
422.4725

2) *Find the value of z if you know that x = 2 , y =17*

$$Z = X^3 + Y^2 + \frac{3\pi}{X^2 + Y^2}$$

$$x = 2$$

$$y = 3$$

$$z= x^3+y^2+(3*\pi/(x^2+y^2))$$

$$z=17.2$$

$$3)f(X) = X^3 + \sin(9X)$$

$$f(X) = X^3+\sin(9 * X)$$

4) *Solve the following equation :*

$$y = e^{-a}\sin(x) + 10\sqrt{y}$$

$$a = 5; x = 2; y = 8;$$

$$f = \exp(-a)*\sin(x)+10*\sqrt{y}$$

f =
28.2904

To calculate $\sin(\pi/4)$ and e^{10} , we enter the following commands in MATLAB,

`sin(pi/4)`

`ans = 0.7071`

`>> exp(10)`

`ans = 2.2026e+004`

4) **Find derivative for the function f**

a) $f = x^2 e^x$

$$f = 2*x*exp(x) + x^2*exp(x)$$

By matlab

```
syms x
```

```
diff (f)
```

b) $g = xy + x^2$

```
syms x y
```

```
diff (g)
```

5) **Find integral for the this function:**

a) $\int_2^3 (8x^3 + 3x^2 + 6x) dx$

$$= 8 \frac{x^4}{4} + 3 \frac{x^3}{3} + 6 \frac{x^2}{2} \Big|_2^3$$

By matlab

```
int((8*x^3+ 3*x^2+6*x),2,3)
```

H.W 1 //

- $Y = \frac{2e^{2t} + 2e^{-t}}{\log 2}$
- $a = \frac{2x}{4y}$
- $b = \pi r^2$
- $c = \frac{x}{2x-y^2}$
- $x(t) = e^{-0.1t}$
- $d = \sqrt{x^2 + y^2}$
- $e = \frac{\sin 2t + \cos 5t}{2}$

H.W 2// Find the derivative for the following function:

- 1) $f = \sin(\pi t)$
- 2) $f = \cos(x^2) + \sin(x)$
- 3) $f = \frac{2x}{x^2-1}$
- 4) $f = \frac{1}{1 + e^{-x}}$

H.W // Find integral for the following function:

- 1) $f = \int_0^\pi \sin(x) dx$
- 2) $f = \int_1^4 xe^x(x) dx$
- 3) $f = \int_0^1 \sqrt{1+x^3} dx$

Hint: The code(subs) is used to replace a variable to another variable :

EX1: $f = x^2 e^x$

$f = 2*x*\exp(x) + x^2*\exp(x)$

subs(f,x,2)

8*\exp(2)

pretty(f)

2

x exp(x) + 2 x exp(x) (لإعادة المعادلة كما كانت)

Chapter -2-

M Files

MATLAB allows writing Several kinds of program files we mention some of them:

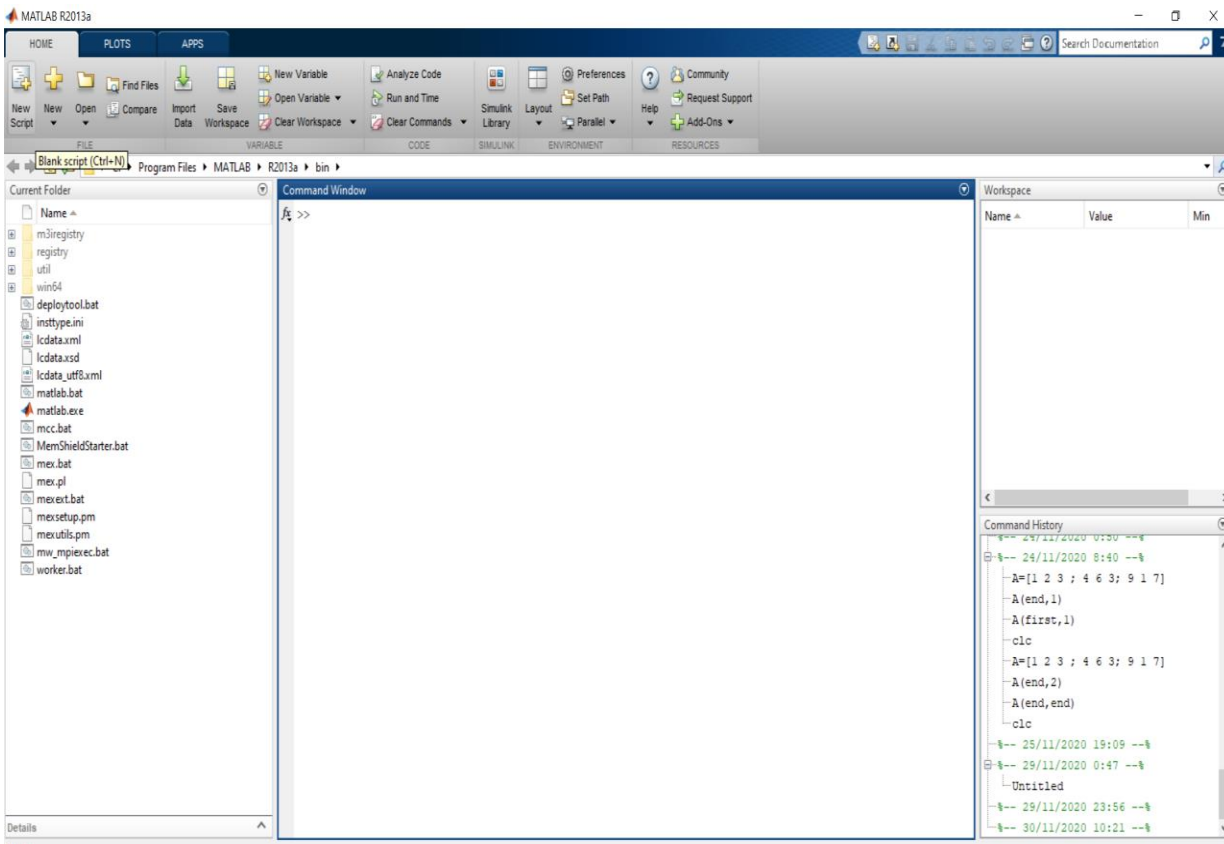
Scripts: Are the kind of files script that a program works on MATLAB as a means of entering commands and code, where program commands are edited in a File Script .

Functions: functions files are also program files with .m extension. Functions can accept inputs and return outputs. Internal variables are local to the function.

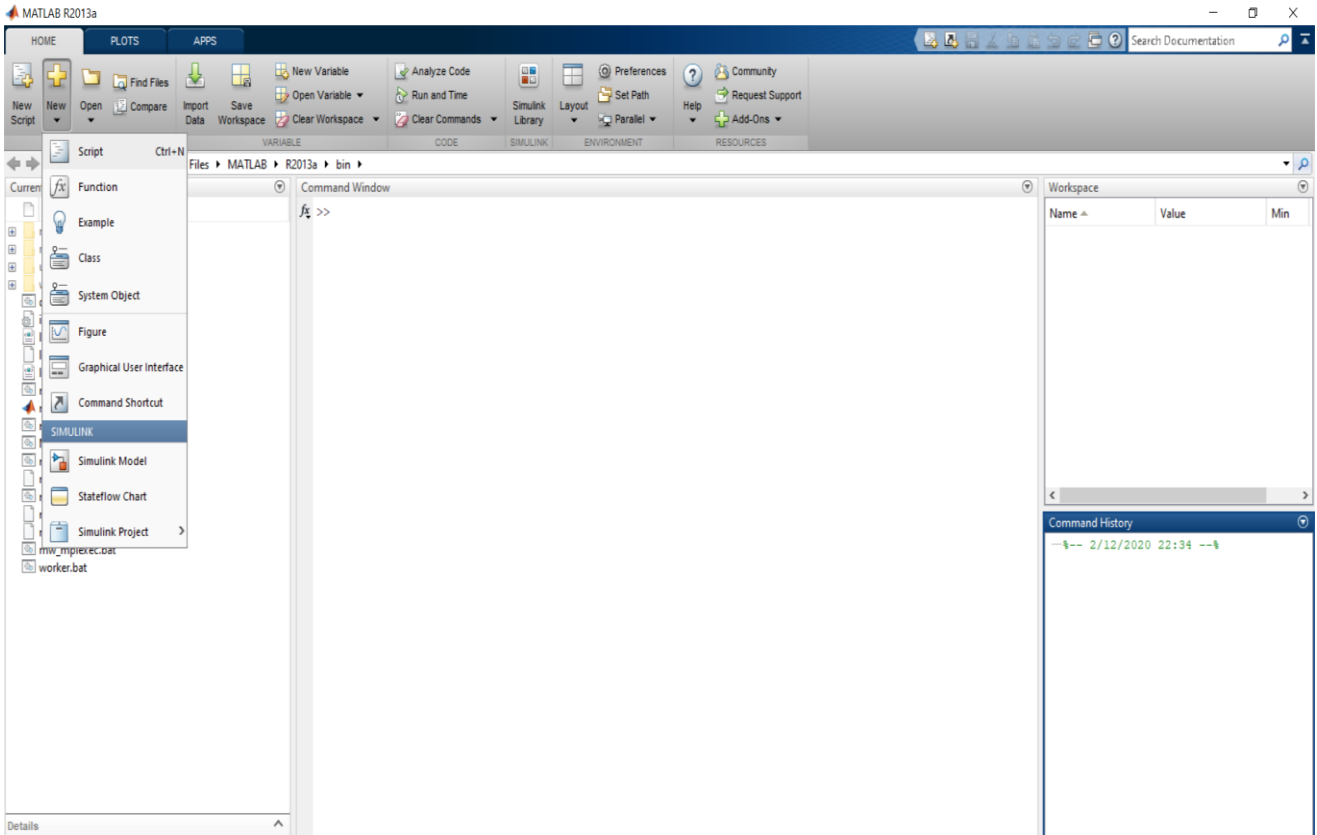
- **Create a new File-M:**

There are two ways to create a new file to write MATLAB:

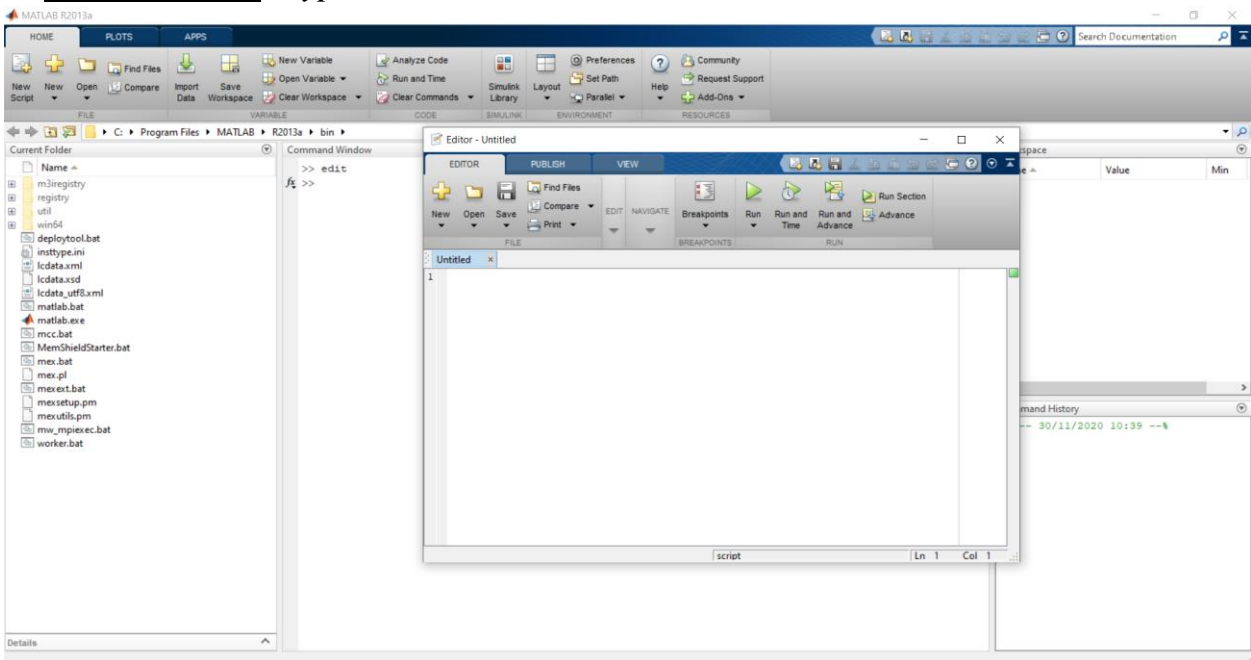
1- **First way:** -from the Home menu choose new script as in the following: -



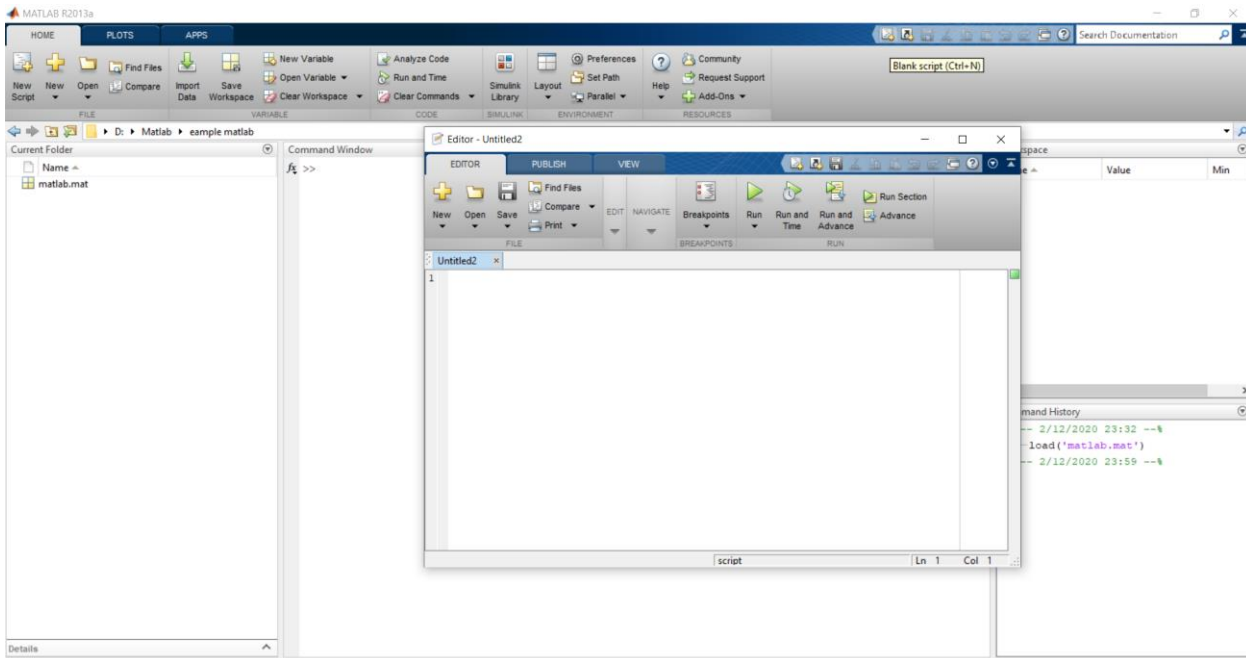
2- **Second way:** -from the Home menu choose new \longrightarrow script as in the following:



3- **Third Method:** Type the edit command inside the Window Command window as follows:

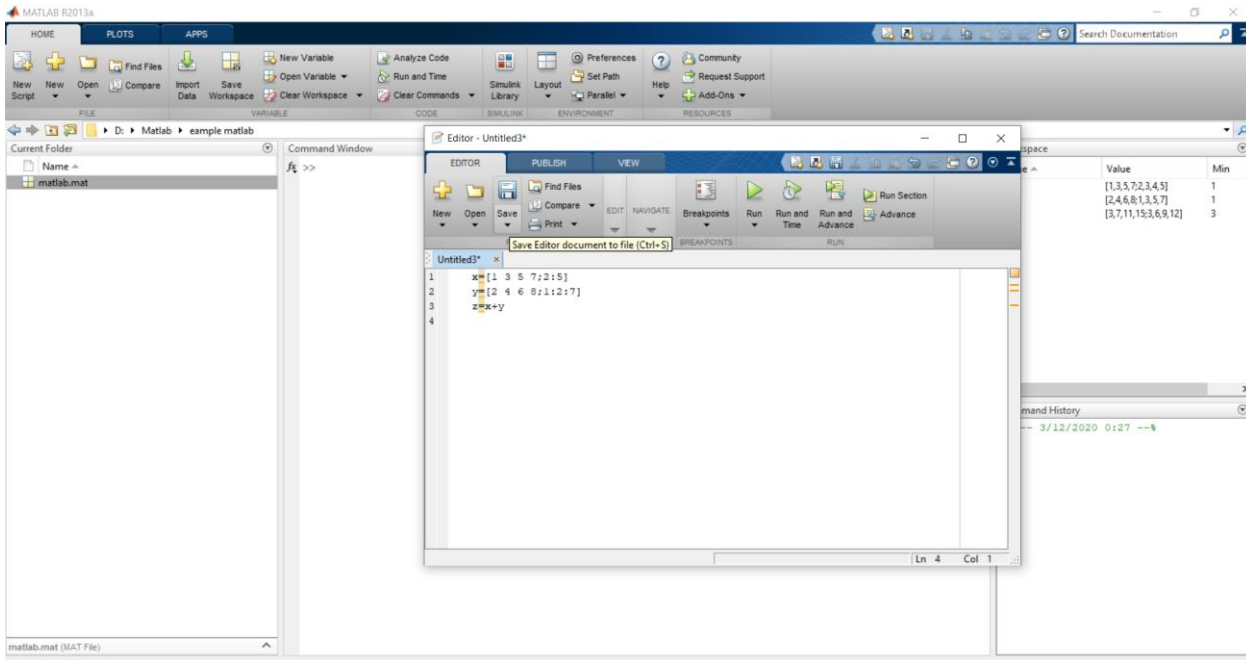


4- Fourth Method: In the right upper part of the matlab program we choose Blank script as follows:

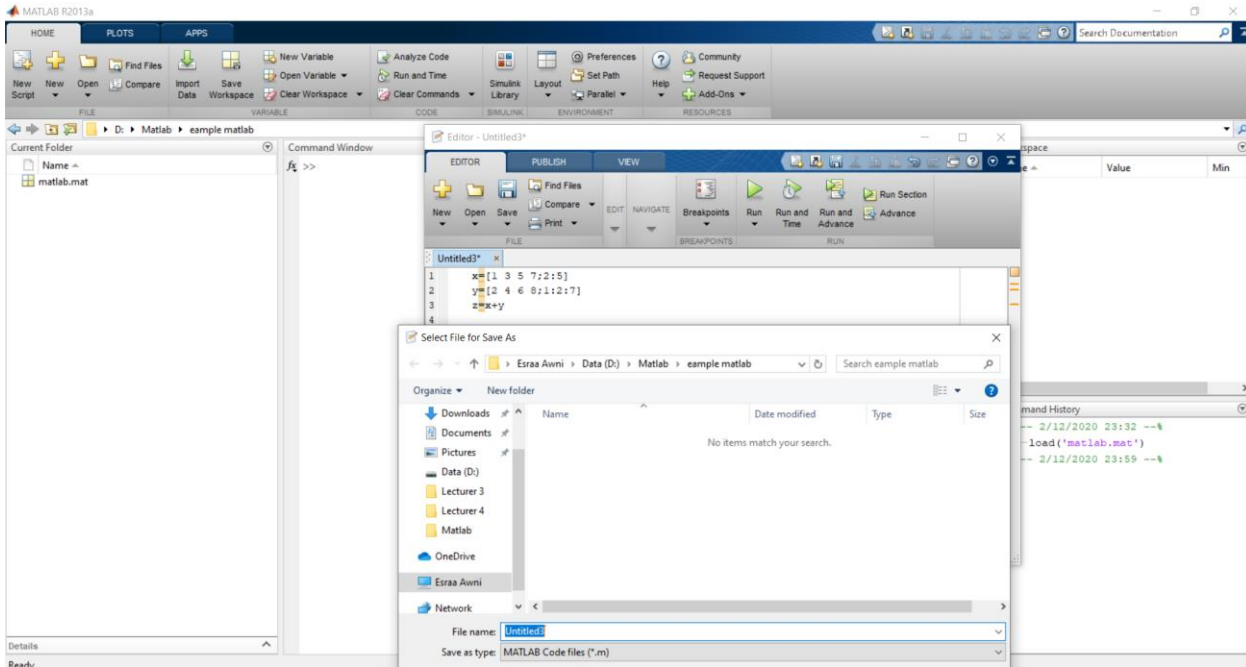


Fifth method: In the keyboard click (ctrl+N)
Methods for storing programs in an m-file

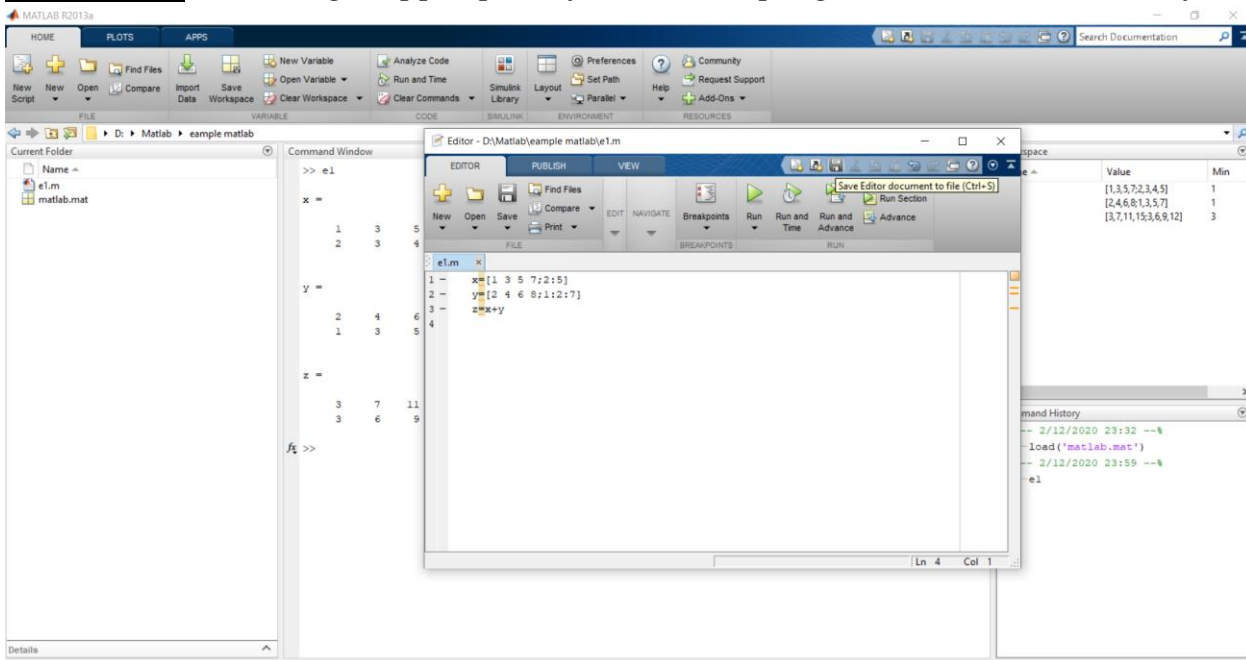
First way: In the EDITOR list in m-file choose icon save as the follows:



Second way: In the EDITOR list in m-file choose icon Run as the follows:



Third way :In the right upper part of the matlab program we choose save as follows



Fourth method: Use F5 or (ctrl+S) from the keyboard.

General Note:

1-We can implementation of specific step in command program by select those steps and use the right click and choose Evaluate Selection.

2- we can get all the windows through :

Menu Home ----- Layout ----- Default

3- We can enter several step in the command window without running by using (Shift +Enter) after each step.

Chapter -3-

Matrices & Operations Matrix

It is a set of data that is putted in the form of rows and columns.

Example 1: How do you enter the following matrix ?

$$A = \begin{pmatrix} 3 & 7 \\ 9 & 1 \\ 2 & 6 \end{pmatrix}$$

SOL:

$$A = [3 \ 7 ; 9 \ 1 ; 2 \ 6]$$

A =

$$\begin{matrix} 3 & 7 \\ 9 & 1 \\ 2 & 6 \end{matrix}$$

Note :

- 1- separated between number of rows by creating a space between the numbers or put comma (,) between two number.
- 2- Put semicolon(;) or by pressing the Enter key between columns.

Example 2: For the following matrix :

$$A = [1 \ 2 \ 3 ; 4 \ 6 \ 3 ; 9 \ 1 \ 7]$$

$$B = [2 \ ,5 \ ,9 ; 0 \ ,8 \ ,1 ; 6 \ ,3 \ ,7]$$

Find:

1) $C = A + B$

2) $D = B - A$

3) $E = A * B$

4) $F = A. / B$

5) A^2

6) $A.^2$

SOL :

1) $C=A+B$

```
ans =  
    3    7   12  
    4   14    4  
   15    4   14
```

2) $D = A - B$

```
ans =  
   -1   -3   -6  
    4   -2    2  
    3   -2    0
```

3) $E=A*B$

```
ans=  
   20   30   32  
   26   77   63  
   60   74  131
```

4) $F = A. / B$

F =

```
5)    0.5    0.4    0.33333  
      Inf    0.75     3  
      1.5    0.33333    1
```

6) $A.^2$

```
ans =  
   36   17   30  
   55   47   51  
   76   31   79
```

7) $A.^2$

```
ans =  
    1    4    9  
   16   36    9  
   81    1   49
```

Note:

1-The number of (rows or column) in matrix(A)should be equal to the number of (rows or column) in matrix B when you collect and subtract Matrices.

2- The condition of multiplying any two matrices is that the number of columns of the first matrix of n1 is equal to the number of rows in the second matrix m2.

Operations on vectors

Example 1:

$$A=[1,2,3,4,5,6,7,8,9]$$

1- **Length** : Number of column in vector or matrices .

length (A)

ans=

9

2- Add number to any vector

A(10) = 22

A =

1 2 3 4 5 6 7 8 9 22

A(14)= 44

A =

1 2 3 4 5 6 7 8 9 22 0 0 0 44

3- Replacement element

A(2)= 50

A =

1 50 3 4 5 6 7 8 9 22 0 0 0 44

4- Delete element

A(11:14)=[]

A =

1 50 3 4 5 6 7 8 9 22

5- Maximum element

Max(A)=

50

6- Minimum element

Min(A)=

1

7- Size of the matrix

```
A=
  1  50  3  4  5  6  7  8  9  22
size(A)=
     1    10
  (Number of row)    (number of column )
```

* If we just want to know how many rows we're going to write the following

```
size(A,1)=
     1
```

* If we just want to know how many columns we're going to write the following

```
size(A,2)=
    10
```

8- A(3:end)

```
ans =
     3     4     5     6     7     8     9
```

9- Sort in ascending or descending order.

a)For matrices:

1) sort(x) or sort(x,1): sorts each column of x in ascending order.

2) sort(x,2): sorts each row of x in ascending order.

Example 1: x=[7 3 6 15 1 25];

```
N=sort(x) or sort(x, 'ascend')
```

```
N
     =
     1     3     6     7    15    25
```

```
M=sort(x,'descend')
```

```
ans =
    25    15     7     6     3     1
```

Example 2:

```
[r q] = sort(x)
```

```
r =
     1     3     6     7    15    25
```

```
q =
     5     2     3     1     4     6
```

```
S=sort(x, 'descend')
```


Example 2: `z=[2 4;8 1];`

`sort(z)` or `sort(z,1)`

ans =

```
2  1
8  4
```

`sort(z,2)`

ans =

```
2  4
3  8
```

b) For vectors, `sort(x)` or `sort(x,'ascend')` sorts the elements of x in ascending order.

EX: `x=[2 0 8 4 9];`

ans =

```
0  2  4  8  9
```

`sort(x,'descend')`

ans =

```
9  8  4  2  0
```

Example 2:

`M = [1:3 ; 5 12 0 ; 6 : -1 :4]`

`M =`

```
1  2  3
5 12  0
6  5  4
```

1) `M(:,2)`

ans =

```
2
12
5
```

This says all rows within the second column, or in other words, the entire second column.

2) `M(1,end)`

ans =

```
3                    ( The last element in the first row)
```

3) `M(:,2)=[]`

M =

```
1  3
5  0
6  4
```

(delete the second column)

4) **To replace** one or more than one row or column, the replacement must conform to the target:

M(:,2) = [10 11 12]

ans =

```
1  10  3
5  11  0
6  12  4
```

5) M(2,:)= [10 11 12]

ans =

```
1  2  3
10 11 12
6  5  4
```

6) M(3,2)

ans =

```
5
```

7) length(M)

ans

```
3
```

8) size(M)

ans

```
3  3
```

9) prod(M)

ans =

```
30 120  0
```

10) max(M)

ans =

```
6  12  4
```

11) **M(end:-1:1,end)**

ans =

4

0

3

12) **M(2:3,2:3)**

ans =

12 0

5 4

13) **M(end,2:end)**

ans =

5 4

H.W// IF we have the following matrix :

$$B = \begin{pmatrix} 1 & 2 & 5 & 8 \\ 5 & 4 & 8 & 7 \\ 4 & 8 & 5 & 0 \\ 11 & 14 & 9 & 10 \end{pmatrix}$$

1) B(2,3)

2) B(4,4)

3) B(:, 2)

4) B(3 , :)

5) B(2,2:4)

6) B(2:4,3)

7) B(:,4)=[1 4 5 8]

8) B(4,:)=[]

9) length(B)

10) B(:,end)

11) size(B)

12) max(B)

13)min(B)

14) prod(B)

Logical Subscripts

These expressions can be used to extract elements which meet a particular condition. If the condition is true the answer returns 1 otherwise return 0 .

Operation in Matlab	Meaning
<	Less than
>	Greater than
<=	Less than or equal
>=	Greater than or equal
==	equal
~ =	Not equal

Logical Operators

Operation	Meaning	Description
~	Not	The new array has ones where A is zero The new array has zeros where A is non zero
&	AND	The new array has ones where both A&B non zero element The new array has zeros where either A &B have zero element
	OR	The new array has ones where at least one element in A or B is non zero, The new array has zeros where either A or B are both zero

Logical Operators (Scalar logical)

Operation	Meaning	Description
&&	AND	A && B Returns To True if both of them(A and B) is true and Returns To false if one of them is false
	OR	A B Returns To True if either (A and B) is true and false if both of them is false

Example 1:

M=[1 10 3;10 11 12; 6 12 4]

M =

```
1 10 3
10 11 12
6 12 4
```

1) (M>3)

ans =

```
0 1 0
1 1 1
1 1 1
```

1- disp(M > 6)

ans=

```
0 1 0
1 1 1
0 1 0
```

2- M>=10

ans =

```
0 1 0
1 1 1
0 1 0
```

3- M<5

ans =

```
1 0 1
0 0 0
0 0 1
```

4- disp(M < 10 & M < 6)

ans=

```
1 0 1
0 0 0
0 0 1
```

Example 2:

a=[5 0 -2 8 9 0]

b=[3 0 7 0 6 5]

1) ~a

ans =

0 1 0 0 0 1

2) ~b

ans =

0 1 0 1 0 0

3) ~(a & b)

ans =

0 1 0 1 0 1

4) a|b

5) a<5

ans =

0 1 1 0 0 1

Example 3:

x=10 ; y=4 ; z=7;

1) x==10 && y~= 9

ans =

1

2) z>6 && x<9

ans =

0

3) $z > 4 \parallel z == 7$

ans =

1

4) $x >= 10 \parallel y \sim 4$

ans =

1

5) $x > 11 \ \&\& \ y < 0$

ans =

0

6) $y > 6 \ \&\& \ x < 9$

0

H.W//

Create the matrices first row include (1 to 3) and the second row include(0 to 0.8 by step 0.4) and the third row include (7 to 5 by step -1) named this matrix A?

$$A = \begin{pmatrix} 0 & 1 & 2 \\ -2 & 7 & 8 \\ 4 & 5 & 0 \end{pmatrix} \quad B = \begin{pmatrix} 0 & 1 & 2 \\ 0 & -3 & 8 \\ 0 & 5 & 0 \end{pmatrix}$$

Find:

1) $\sim A$

2) $\sim B$

3) $\sim(A \ \& \ B)$

4) $A|B$

5) $A < 5$

6) $\text{disp}(A < 10 \ \& \ B < 6)$

Chapter - 4 -

Special Function for matrix or vector

There are many built-in functions in MATLAB that create special matrices. Some of them are listed here:

1) **zeros(m,n)** creates an m x n matrix of all zeros zeros(n) creates an (n x n) matrix of zeros

```
a)zeros(3)
ans =
0 0 0
0 0 0
0 0 0
```

```
b)zeros(2,3)
ans =
0 0 0
0 0 0
```

2) **ones(m,n)** creates an m x n matrix of all ones ones(n) creates an n x n matrix of ones.

```
a) ones(4)
ans =
1 1 1 1
1 1 1 1
1 1 1 1
1 1 1 1
```

```
b) ones(3,2)
ans =
1 1
1 1
1 1
```

```
c) ones(1,3)
ans =
```


1 1 1

3) eye(n) creates an n x n identity matrix (all zeros but ones on the diagonal)

a) eye(5)

ans =

```
1  0  0  0  0
0  1  0  0  0
0  0  1  0  0
0  0  0  1  0
0  0  0  0  1
```

4) magic(n) creates an n x n magic matrix (sum of all rows, columns, and diagonal are the same)

a) M = magic(3)

M =

```
8  1  6
3  5  7
4  9  2
```

b) M = magic(4)

M =

```
16  2  3  13
5  11 10  8
9  7  6  12
4  14 15  1
```

5-pascal(n) creates Pascal matrix of order n that made up from Pascal's triangle

$p = \text{pascal}(n)$ $p = p'$

pascal(4)

ans =

```
1 1 1 1
1 2 3 4
1 3 6 10
1 4 10 20
```

6 - We also can put several matrices together in a single matrix

```
B = [ones(3) , zeros(3,2) ; zeros(2,3) , 4*eye(2)]
```

```
ans =
```

```
1 1 1 0 0
1 1 1 0 0
1 1 1 0 0
0 0 0 4 0
0 0 0 0 4
```

7- Transpose of Matrix

```
A=[-3 4 11;0 -2 1]
```

```
A =
```

```
-3 4 11
0 -2 1
```

```
>> A'
```

```
ans =
```

```
-3 0
4 -2
11 1
```

```
>> transpose (A)
```

```
ans =
```

```
-3 0
4 -2
11 1
```

8- Inverse Matrix

The Inverse of A is A^{-1} When:

$$A * A^{-1} = A^{-1} * A = I$$

➤ **The matrix must be square**

Ex 1:

x=magic(2)

ans =

1 3
4 2

>>**inv(x)**

ans =

-0.2 0.3
0.4 -0.1

* Sometimes there is no Inverse at all for example:

Ex2: M=[6 2;3 1]

Ans =

6 2
3 1

>> inv(M)

ans =

Inf Inf
Inf Inf

Ex3: math=[2 4 -1;3 1 4;-6 2 4]

math =

2 4 -1
3 1 4
-6 2 4

inv(math)

ans =

0.02439 0.10976 -0.10366
0.21951 -0.012195 0.067073
-0.07317 0.17073 0.060976

9) Determinant of matrix

It is useful for finding inverse of matrix,the symbole of determinant is |A|.

Ex1: x=magic(2)

```
x =  
    1    3  
    4    2
```

```
>> det(x)
```

```
ans =  
   -10
```

Ex2: x=magic(3)

```
x =  
    8    1    6  
    3    5    7  
    4    9    2
```

```
>> det(x)
```

```
ans =  
  -360
```

10) Rank of Matrix

The rank of a matrix is defined as (a) the maximum number of linearly independent column vectors in the matrix .

- If r is less than c , then the maximum rank of the matrix is r .
- If r is greater than c , then the maximum rank of the matrix is c .

```
A=[2 4;7 1]
```

```
A =  
    2    4  
    7    1
```

```
>> rank(A)
```

```
ans =  
    2
```

Ex 2: A=[1 2 3;4 5 6; 7 8 9]

```
A =
```

```
1 2 3
4 5 6
7 8 9
```

```
>> det(A)
ans =
6.6613e-16
Then det(A)=0
```

We take part of matrix(2*2) for example:

```
A=[1 2;4 5]
```

```
A =
1 2
4 5
```

```
det(A)
```

```
ans =
-3
```

```
>> rank(A)
```

```
ans =
2
```

11) Trace of matrix

It is the sum of the diagonal element of matrix.

➤ **The Trace matrix must be square**

```
Ex 1 : T = [ 1 2 1;-2 3 5;-1 4 -2]
```

```
T =
1 2 1
-2 3 5
-1 4 -2
```

```
>> trace(T)
```

```
ans =
2
```

12) Orthogonal Matrix

$$A' * A = I \ \& \ A^{-1} = A'$$

```
A=[1/3 -2/3 2/3;2/3 -1/3 -2/3;2/3 2/3 1/3]
```

```
A =  
    0.33333    -0.66667    0.66667  
    0.66667    -0.33333   -0.66667  
    0.66667    0.66667    0.33333
```

```
>> A'*A  
ans =  
    1    0    0  
    0    1    0  
    0    0    1
```

```
>> inv(A)  
ans =  
    0.33333    0.66667    0.66667  
   -0.66667   -0.33333    0.66667  
    0.66667   -0.66667    0.33333
```

```
>> A'  
ans =  
    0.33333    0.66667    0.66667  
   -0.66667   -0.33333    0.66667  
    0.66667   -0.66667    0.33333
```

```
>> orth(A)  
ans =  
    0.66667    0.66667   -0.33333  
   -0.66667    0.33333   -0.66667  
    0.33333   -0.66667   -0.66667
```

Example : In analyzing of matrix if you know that :

$$\begin{pmatrix} 7 & 8 & 3 \\ 2 & 4 & 7 \\ 5 & 1 & 3 \end{pmatrix}$$

Find the following:

1-Rank matrix.

2-Determination matrix.

3- Trace matrix.

4-Orthogonal matrix.

5- Inverse of the matrix.

Solution:

$$B = [7 \ 8 \ 3 ; 2 \ 4 \ 7 ; 5 \ 1 \ 3]$$

1- Rank matrix

$$R = \text{rank}(B)$$

$$R =$$

3

2-Determination matrix

$$D = \det(B)$$

$$D =$$

213.0000

3-Trace matrix.

$$T = \text{trace}(B)$$

$$T = 14$$

4- Orthogonal matrix.

$$O = \text{orth}(B)$$

$$O =$$

$$\begin{matrix} -0.7687 & 0.5554 & -0.3171 \\ -0.5219 & -0.8313 & -0.1911 \\ -0.3698 & 0.0185 & 0.9289 \end{matrix}$$

5- Inverse of the matrix.

I = inv(B)

ans =

```
0.0235 -0.0986 0.2066    0.1362 0.0282
-0.2019
    -0.0845 0.1549 0.0563
```

H.W // In analyzing of matrix if you know that :

$$\begin{pmatrix} 1 & 0 & -3 \\ 4 & -2 & 1 \\ -2 & 0 & 3 \end{pmatrix}$$

Find the following:

- 1-Rank matrix.
- 2-Determination matrix.
- 3- Trace matrix.
- 4-Orthogonal matrix.
- 5- Inverse of the matrix.

13) Matrix Square root

The square root of each element in matrix is

N=[5 1;6 2]

Sqrtm (N)

N =

```
5 1
6 2
```

>> sqrtm(N)

ans =

```
2.1106    0.30151
1.8091    1.206
```

14) Matrix Exponential