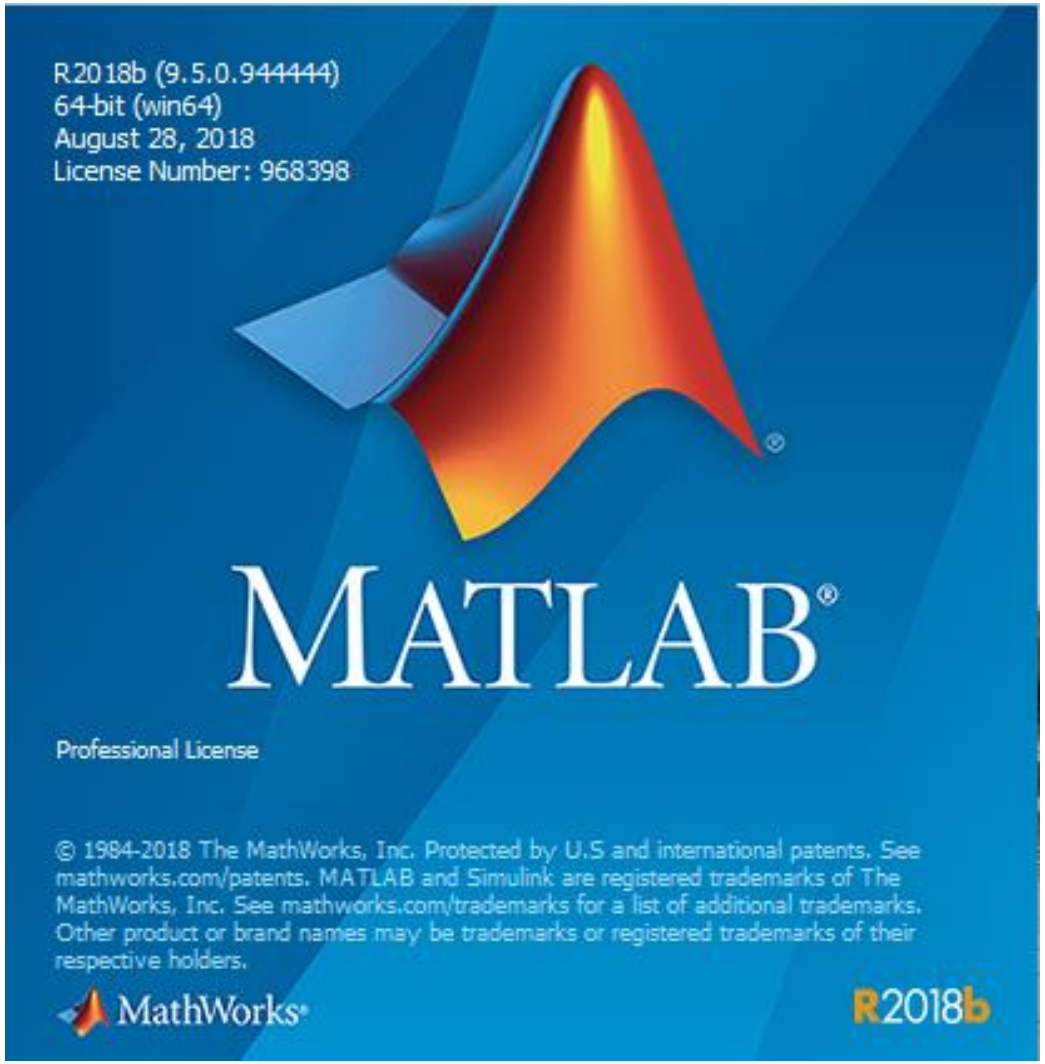
Linear Algebra with MATLAB

Daw Marlar Win Khin
Associate Professor
Faculty of Computing
UCSY

What is MATLAB?

- **MATLAB** stands for **Mat**rix **Lab**oratory.
- It is forth generation **technical computing** and **programming language.**
- All the computations performed and programs implemented in MATLAB environment are **based on matrix.**

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \dots & a_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{bmatrix}$$



What can We Do with MATLAB

Arithmetic

+, -, ×, ÷, x2

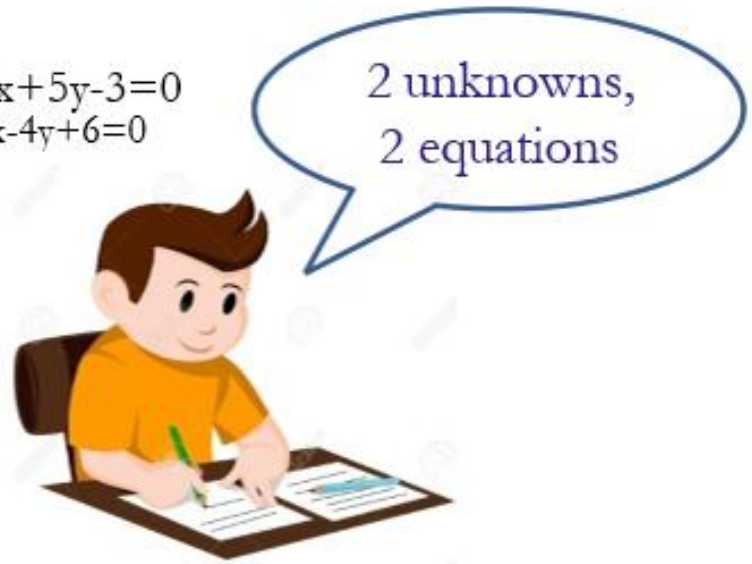
Calculus

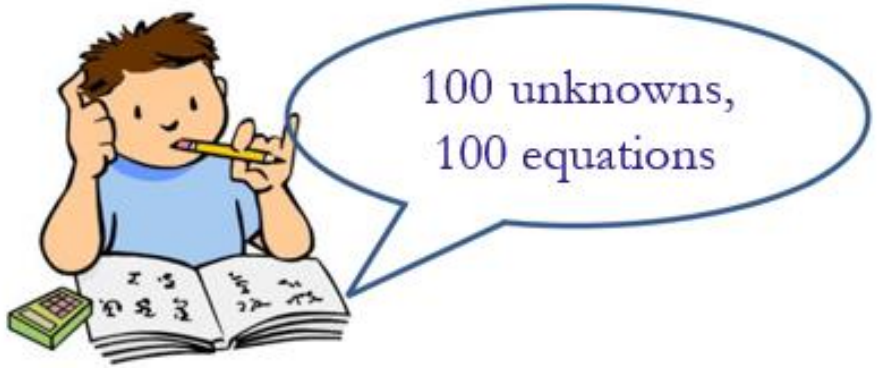
∫, d/dx

Trigonometric

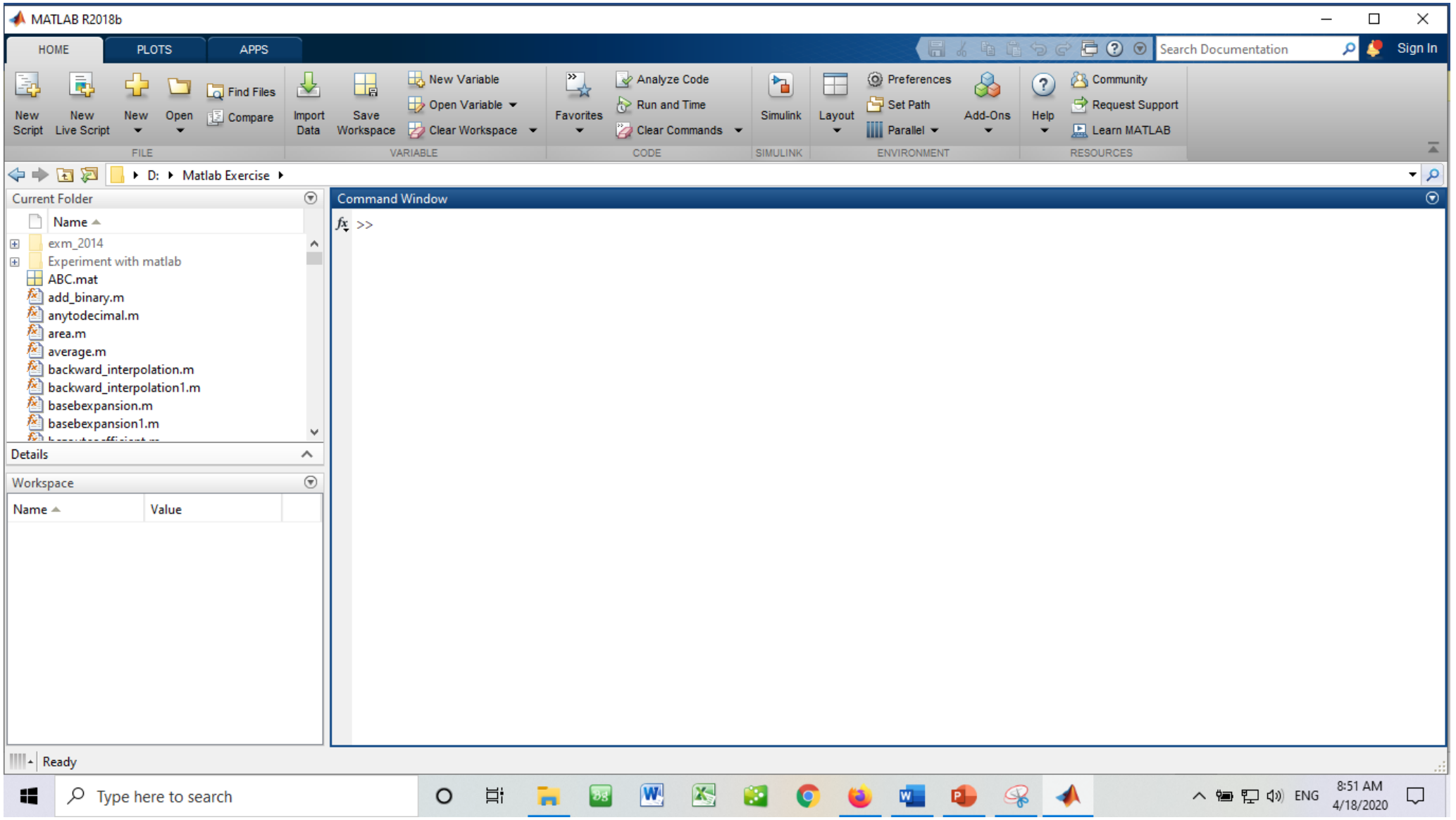
sin(x), cos (x), tan (x)

$2x+5y-3=0$
$3x-4y+6=0$

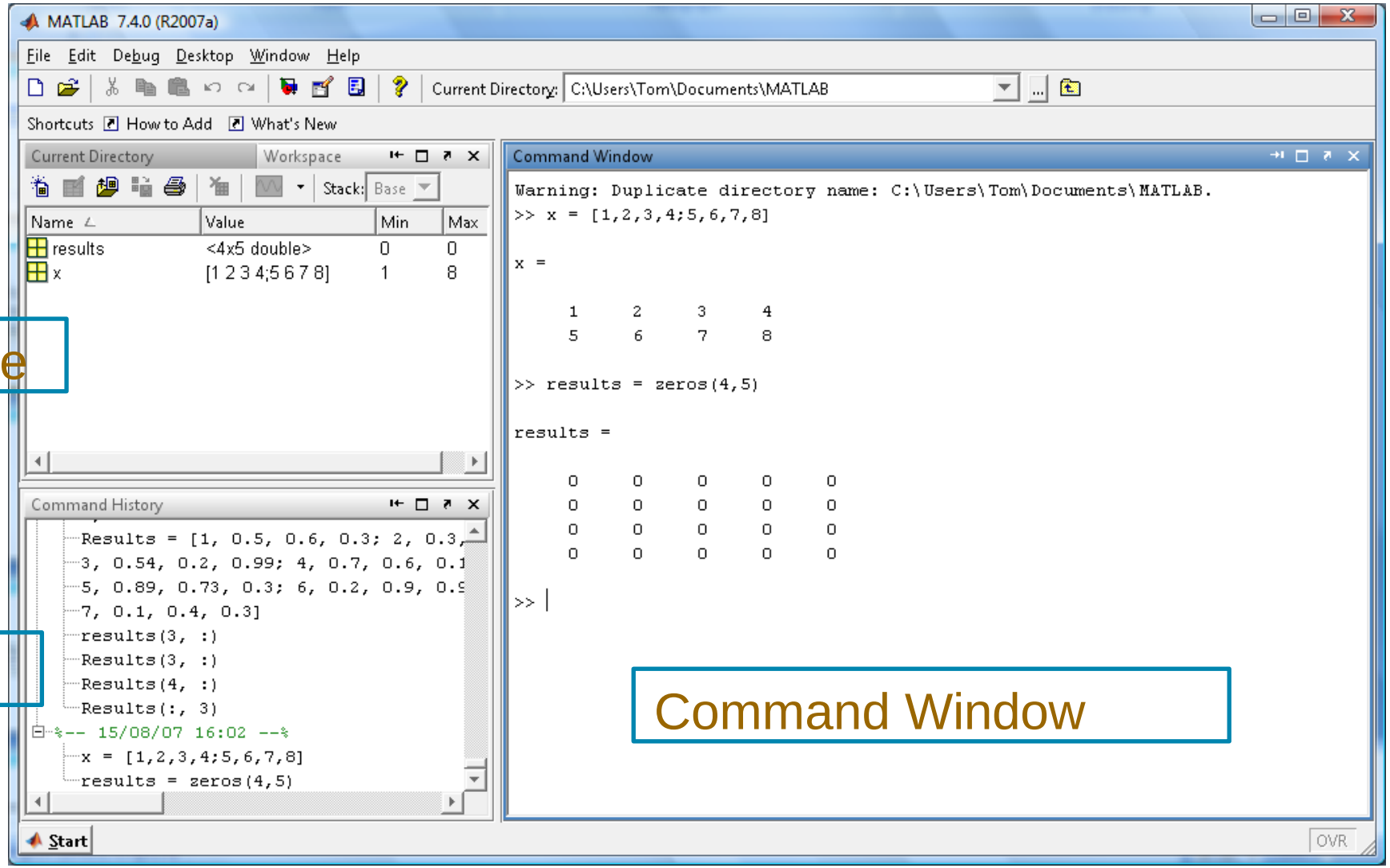




The MATLAB Desktop (Window)



The MATLAB interfaces



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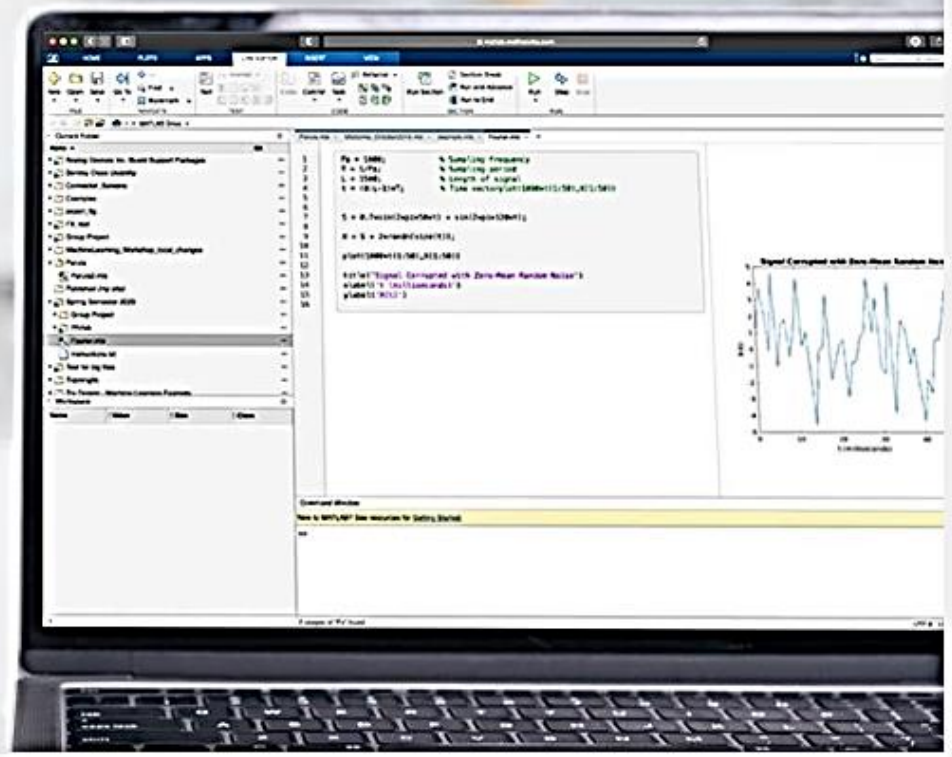
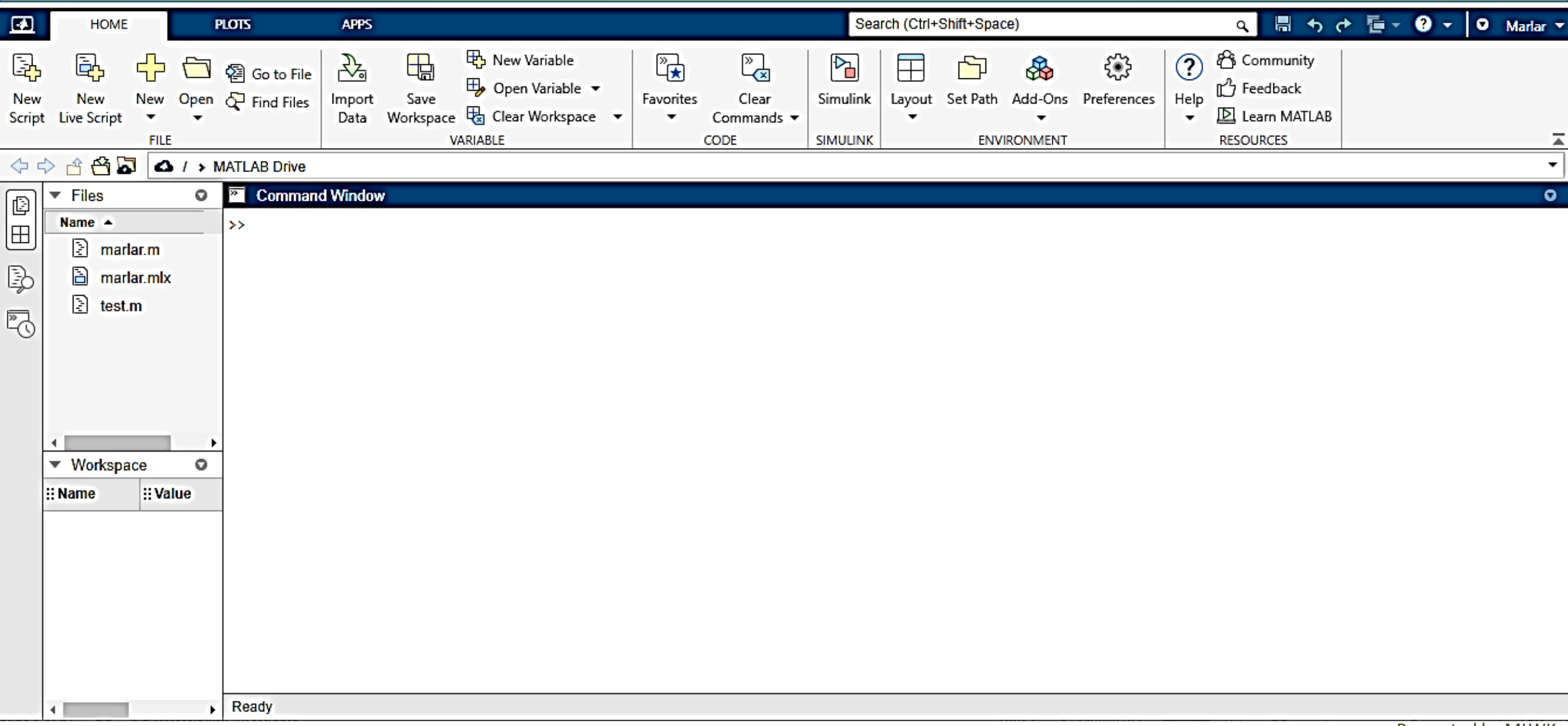
Use MATLAB and Simulink through your web browser

Start using MATLAB Online



Linear Algebra with MATLAB

MATLAB Online



Functions and Commands

Eg, >>clc
>>clear
>>exit

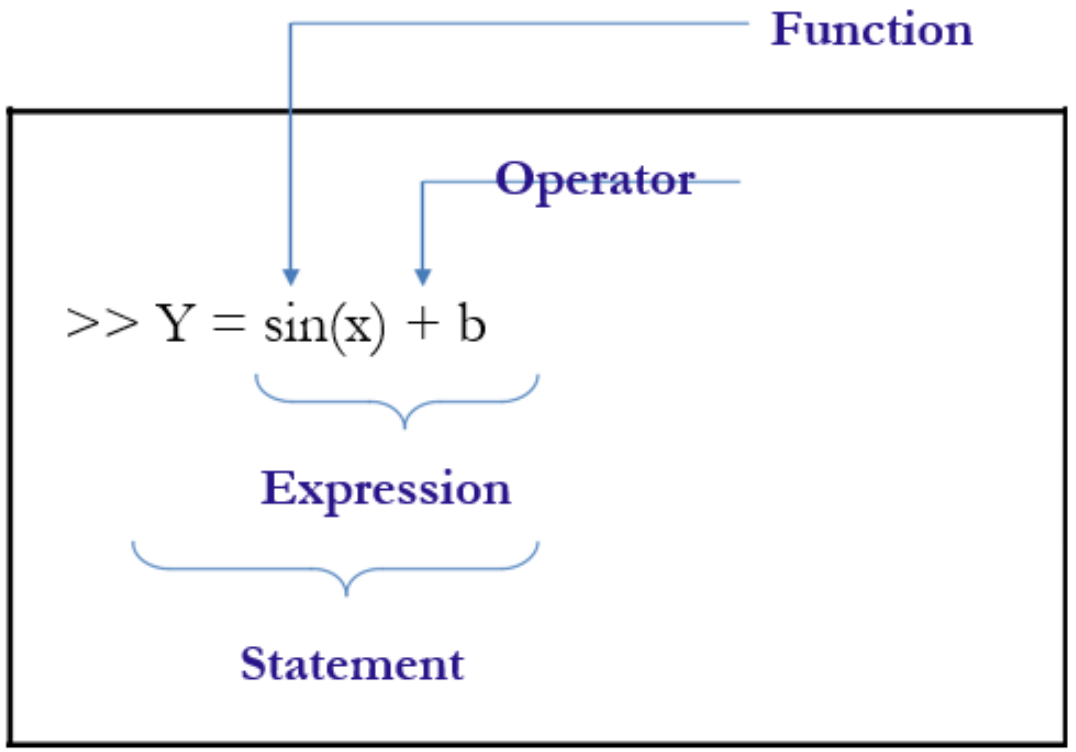
} Commands

Eg, >>date
>>sqrt(144)
>>calendar

} Functions

```
>> date

ans =

    '05-Jun-2023'

>> sqrt(169)

ans =

    13

>> calendar
                    Jun 2023
     S     M     Tu     W     Th     F     S
     0     0     0     0     1     2     3
     4     5     6     7     8     9    10
    11    12    13    14    15    16    17
    18    19    20    21    22    23    24
    25    26    27    28    29    30     0
     0     0     0     0     0     0     0
```

Operators, Expressions ,Statements



x, b, Y

Variables

>> 2*sin(x) (**Expression**)

>> Y= sin(2*x) (**Statement**)

Initialization Matrices and Vectors

Matrices are stored as two-dimensional arrays in **MATLAB**. A matrix is a collection of numbers and/or scalars arranged in rows and columns.

```
>> v=[4;2]
v =
     4
     2
```

```
>> 2*v
ans =
     8
     4
```

```
>> v+w
ans =
     3
     4
```

```
>> w=[-1;2]
w =
    -1
     2
```

```
>> -1*w
ans =
     1
    -2
```

```
>> v-w
ans =
     5
     0
```

Matrices are entered into MATLAB row by row with rows separated either by semicolons or by line returns. To enter the 2×3 matrix ,

$$A = \begin{bmatrix} 2 & 3 & 1 \\ 1 & 4 & 7 \end{bmatrix}$$

just type

```
>> A=[2 3 1;1 4 7]

A =

     2     3     1
     1     4     7
```

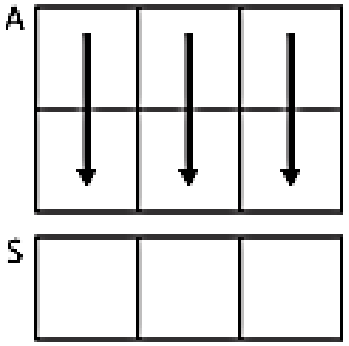
Initialization Matrices and Vectors

MATLAB has very sophisticated methods for addressing the entries of a matrix. You can directly address individual entries, individual rows, and individual columns. To display the entry in the 1st row, 3rd column of A, type A(1,3). To display the 2nd column of A, type A(:,2); and to display the 1st row of A, type A(1,:). For example, to add the two rows of A and store them in the vector x, just type

```
>> x = A(1,:) + A(2,:)

x =

     3     7     8
```

Operations of Matrices

- `sum(A,1)` operates on successive elements in the columns of `A` and returns a row vector of the sums of each column.

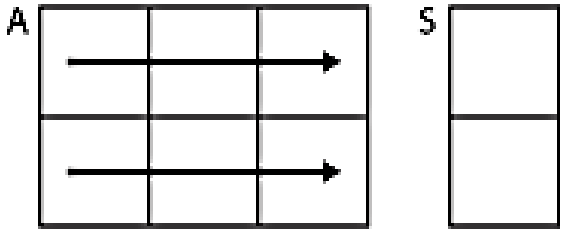


sum(A,1)

```
>> A=[2 3 1;1 4 7]

A =

     2     3     1
     1     4     7
```

```
>> sum(A,1)

ans =

     3     7     8
```

- `sum(A,2)` operates on successive elements in the rows of `A` and returns a column vector of the sums of each row.



sum(A,2)

```
>> sum(A,2)

ans =

     6
    12
```

1. Enter the 3×4 matrix

$$A = \begin{pmatrix} 1 & 2 & 5 & 7 \\ -1 & 2 & 1 & -2 \\ 4 & 6 & 8 & 0 \end{pmatrix}.$$

As usual, let a_{ij} denote the entry of A in the i^{th} row and j^{th} column. Use MATLAB to compute the following:

(a) $a_{13} + a_{32}$.

(b) Three times the 3^{rd} column of A.

(c) Twice the 2^{nd} row of A minus the 3^{rd} row.

(d) The sum of all of the columns of A.

```
>> A=[1 2 5 7;-1 2 1 -2;4 6 8 0]

A =

     1     2     5     7
    -1     2     1    -2
     4     6     8     0
```

(a) $a_{13} + a_{32}$.

```
>> A(1,3)+A(3,2)

ans =

    11
```

(b) Three times the 3^{rd} column of A.

```
>> 3*A(:,3)

ans =

    15
     3
    24
```

(c) Twice the 2^{nd} row of A minus the 3^{rd} row.

```
>> 2*A(2,:)-A(3,:)

ans =

    -6    -2    -6    -4
```

(d) The sum of all of the columns of A.

```
>> sum(A,2)

ans =

    15
     0
    18
```

Special Kinds of Matrices

- **A square matrix** is a matrix with the same number of rows and columns; that is, a square matrix is an $n \times n$ matrix.

- **A diagonal matrix** is a square matrix whose only nonzero entries are along the main diagonal; that is, $a_{ij} = 0 \; if \; i \neq j$. The following is a 3×3 diagonal matrix.

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$

```
>> diag([1 2 3])

ans =

     1     0     0
     0     2     0
     0     0     3
```

Special Kinds of Matrices

- **The identity matrix** is the diagonal matrix all of whose diagonal entries equal 1.

  The $n \times n$ identity matrix is denoted by I_n.

```
>> eye(3)

ans =

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

Special Kinds of Matrices

- **A zero matrix** is a matrix all of whose entries are 0. A zero matrix is denoted by 0.

```
>> A=zeros(3,4)

A =

     0     0     0     0
     0     0     0     0
     0     0     0     0
```

- The transpose of an $m \times n$ matrix A is the $n \times m$ matrix obtained from A by interchanging rows and columns.

```
>> A=[2 1;-1 2;3 4;5 7]

A =

     2     1
    -1     2
     3     4
     5     7
```

```
>> A'

ans =

     2    -1     3     5
     1     2     4     7
```

Lengths and Dot Products

$$\cos\theta = \frac{\boldsymbol{x}.\boldsymbol{y}}{\|\boldsymbol{x}\|\|\boldsymbol{y}\|}$$

```
>> x = [1 ;4 ;2]; y = [2 ;3 ;-1]; dot(x,y)

ans =

    12
```

```
>> norm(x)

ans =

    4.5826
```

```
>> norm(y)

ans =

    3.7417
```

```
>> theta=acos(dot(x,y)/(norm(x)*norm(y)))

theta =

    0.7956
```

```
>> rad2deg(theta)

ans =

   45.5847
```

Find the angle in degrees between the given pair of vectors.

1. $u = \begin{bmatrix} 2 \\ 1 \\ -3 \\ 4 \end{bmatrix}, v = \begin{bmatrix} 1 \\ 1 \\ -5 \\ 7 \end{bmatrix}$

2. $x = \begin{bmatrix} 2.43 \\ 10.2 \\ -5.27 \\ \pi \end{bmatrix}, y = \begin{bmatrix} -2.2 \\ 0.33 \\ 4 \\ -1.7 \end{bmatrix}$

```
>> u=[2;1;-3;4]

u =

     2
     1
    -3
     4

>> v=[1;1;-5;7]

v =

     1
     1
    -5
     7

>> dot(u,v)

ans =

    46
```

```
>> cosinetheta=dot(u,v)/(norm(u)*norm(v))

cosinetheta =

    0.9634

>> theta=acos(cosinetheta)

theta =

    0.2715

>> rad2deg(theta)

ans =

   15.5570
```

```
>> x=[2.43;10.2;-5.27;pi]

x =

    2.4300
   10.2000
   -5.2700
    3.1416

>> y=[-2.2;0.33;4;-1.7]

y =

   -2.2000
    0.3300
    4.0000
>> dot(x,y)

ans =

  -28.4007
```

```
>> cosinetheta=dot(x,y)/(norm(x)*norm(y))

cosinetheta =

   -0.4788

>> theta=acos(cosinetheta)

theta =

    2.0701

>> rad2deg(theta)

ans =

  118.6076
```

Thanks for your attention.