cupress

MATLAB
FUNDAMENTALS

Pramote Dechaumphai
Niphon Wansophark

MATLAB
Fundamentals

MATLAB Fundamentals

Pramote Dechaumphai

Niphon Wansophark

Chulalongkorn University press

2023

240.-

Dechaumphai, Pramote
MATLAB Fundamentals / Pramote Dechaumphai, Niphon Wansophark
1. MATLAB. 2. Numerical analysis -- Data processing.
3. Engineering mathematics -- Data processing. I. Wansophark, Niphon.

518.0285536
ISBN (e-book) 978-974-03-4274-8
CUP. 2659

Knowledge to All
www.cupress.chula.ac.th

Published by Chulalongkorn University Press
First edition 2023
www.cupress.chula.ac.th [CUB6611-001K]
Tel. 0-2218-3562-3

Managing editor : Prof. Dr.Aran Hansuebsai Mrs.Orathai Nanthanadisai

Academic Editorial Department : Emeritus Professor Dr.Piyanart Bunnag
Assoc. Prof. Dr.Pimpan Dachakupt
Assoc. Prof. Chitsanu Pancharoen
Assoc. Prof. Dr.Vimolvan Pimpan

Coordinator : Wasana Sumsen

Proof reader : Tassanee Phewkam.

Cover : Nitinun Varongchayakul

Artwork : Kaiumporn Phongkhachorn

Contact : Chulalongkorn University Book Center
Phyathai Road, Pathumwan District, Bangkok 10330, Thailand
http://www.chulabook.com
Tel: 08-6323-3703-4
customer@cubook.chula.ac.th, info@cubook.chula.ac.th
Apps: CU-eBook Store

Preface

MATLAB is a widely used software in universities, known for its user-friendly interface. It provides efficient packages for solving mathematical and computational problems. Among these packages, there are mathematical symbol packages that facilitate the learning of calculus and differential equations. The numerical computing packages offer a variety of commands, making it easier to grasp numerical methods in science and engineering. Moreover, the plotting package allows for easy visualization of results. With concise commands, users can plot graphs in different formats, enhancing their understanding of the problem's physical implications. Overall, MATLAB is an excellent tool for those seeking an efficient and user-friendly software to solve a broad range of scientific and engineering problems.

Due to its high efficiency and versatile capabilities, MATLAB programs tend to be large and contain numerous commands. This book is written to provide learners with the maximum benefit of its fundamental features while minimizing the learning time. Its contents include a wide variety of extensive examples. By studying these examples, users can easily and quickly utilize MATLAB commands. The author would like to thank Chulalongkorn University Press for supporting the publication of this book for the benefit of students and those who realize the importance of this MATLAB software.

Pramote Dechaumphai
Niphon Wansophark

Contents

Chapter 1

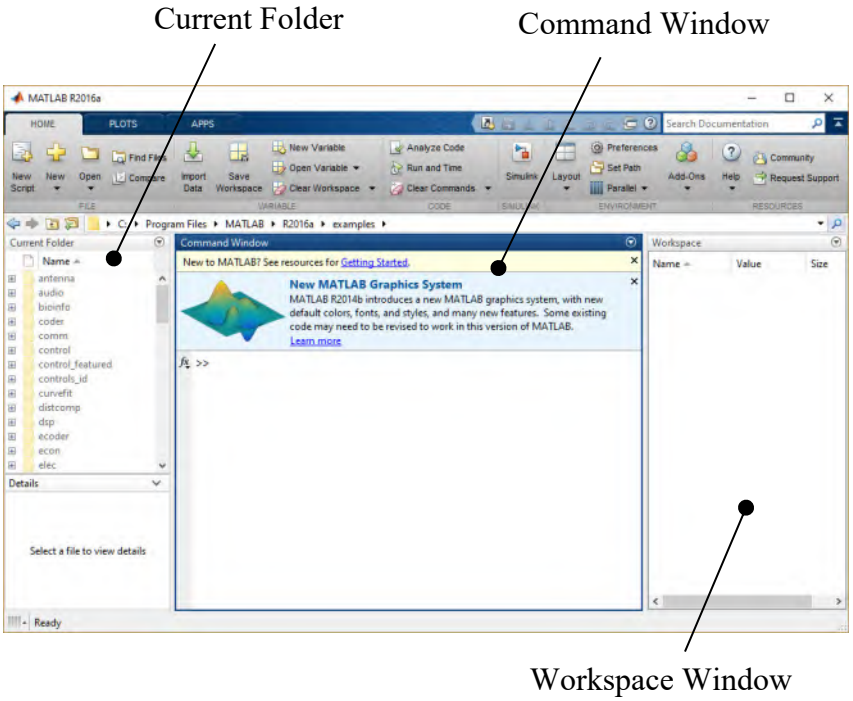
Meet MATLAB

1.1 Introduction

MATLAB is a mathematical computing software widely used in science and engineering institutes. The software is very popular containing a large number of built-in functions to reduce programming effort. The word "MATLAB" stands for "MATrix LABoratory" since the software has been designed to handle the matrix computation conclusively. The software was first developed by Professor Cleve Moler in 1970. His objective at that time was to help his students to employ the LINPACK and EISPACK packages, for solving the algebraic and eigenvalue problems, without understanding the Fortran language. Later, in 1984, he and his team have founded the MathWorks company to enhance the software capability for solving more complicated mathematical problems. Nowadays, MATLAB has become a powerful computing system for analyzing academic problems and industrial applications worldwide.

1.2 MATLAB Window

After installing the MATLAB software, the MATLAB icon will appear on the computer desk-top. By double-clicking the MATLAB icon, the MATLAB window will be open on the computer screen as shown in the figure. The window contains the sub-windows as follows:



1.2.1 Command Window

In the command window, mathematical operations can be performed by entering the commands after the >> (guillemotright) sign. As an example, if we want to multiply 1.35 by 7.59, we type `1.35*7.59` and hit the ENTER key,

```
>> 1.35*7.59
ans =

  10.2465
```

The result of 10.2465 is stored in the `ans` variable automatically. We can use this value of 10.2465 to perform further computations as shown in the following example. The new result will replace and store in the same `ans` variable.

```
>> ans*3.57
ans =
  36.5800
```

We can also assign a new variable such as `volume` to represent the volume of a sphere with its radius of 3.5 as,

```
>> volume = 4/3*pi*3.5^3
volume =
  179.5944
```

pi

In the statement above, `pi` is the built-in constant representing the value of π.

1.2.2 Workspace Window

The variables created in MATLAB such as `ans` and `volume` in the examples above are stored in the computer memory. They are also shown in the workspace window. These variables can be deleted from the computer memory by highlighting them, right-clicking the mouse and selecting `Delete`.

1.2.3 Command History Window

All commands that have been used are collected and stored in the command history window. We can recall and use these commands by simply double-clicking at them. These commands can be deleted in the same way as explained above.

1.2.4 Current Folder Window

This window contains the current folders being used. Files or programs are stored in the folders under this window. New folders can be created and stored in the current folder window.

1.3 Arithmetic Commands

MATLAB can be used as a calculator to perform addition and subtraction through the + and − symbols, respectively. As examples,

```
>> 5.364 + 86.2
ans =
   91.5640

>> 87.3 - 65.4
ans =
   21.9000
```

The * and / symbols are used for multiplication and division, respectively,

```
>> 73.1 * 84.3
ans =
  6.1623e+003

>> 86.5 / 23.3
ans =
    3.7124
```

The ^ symbol is used for raising the power of a number, such as,

```
>> 31^2
ans =
   961
```

We can assign a value to a variable and use it to calculate further. As an example,

```
>> a = 4
a =
     4

>> a + 3
ans =
     7
```

We can also declare several variables within a single line by using, (comma) to separate them,

```
>> a = 4, b = 3, c = 5
a =
     4
b =
     3
c =
     5
>> a + b + c
ans =
    12
```

It is noted that the lowercase and capital letters in MATLAB are different, such as,

```
>> d = 7, D = 3
d =
     7
D =
     3

>> d + D
ans =
    10
```

Output can be suppressed by ending the statement with ; (semi colon). As an example,

```
>> e = 6; g = 8;
>> e * g
ans =
    48
```

MATLAB follows the standard arithmetic operation priority starting from raising the power, multiplication and division, then addition and subtraction, respectively. As an example,

```
>> 10 - 3 ^ 2 * 2 / 3 + 7
ans =
    11
```

In practice, however, we should use brackets for clarity. As an example, if we want to calculate,

$$5^3\left(\frac{3}{5}+\frac{9}{2^3}\right)$$

we may enter a statement as follow,

```
>> (5^3)*((3/5) + (9/(2^3)))
ans =
  215.6250
```

1.4 Trigonometric and Other Commands

The trigonometric and some other commands that are useful in science and engineering calculation are presented in this section.

1.4.1 Trigonometric Functions

The `sine` value of a 30 degree angle can be determined by simply entering the command,

sin

```
>> sin(pi/6)
ans =
    0.5000
```

In the above example, the argument must be input in form of radian, not in degree. Similarly,

cos

```
>> cos(pi/6)
ans =
    0.8660
```

tan

```
>> tan(pi/4)
ans =
    1.0000
```

If we prefer to input the argument in degree, the command is slightly different,

```
>> sind(30)
ans =
    0.5000
```

sind

```
>> cosd(90)
ans =
     0
```

cosd

```
>> tand(45)
ans =
    1.0000
```

tand

The inverse trigonometric functions can also be determined easily, such as,

```
>> asin(0.5)
ans =
    0.5236
```

asin

```
>> acos(-0.3)
ans =
    1.8755
```

acos

```
>> atan(1.5)
ans =
    0.9828
```

atan

The hyperbolic functions, such as hyperbolic sine, hyperbolic cosine and hyperbolic tangent can be determined in the same way,

```
>> sinh(3)
ans =
   10.0179
```

sinh

```
>> cosh(2)
ans =
    3.7622
```

cosh

```
>> tanh(4)
ans =
    0.9993
```

tanh

1.4.2 Exponential and Logarithmic Functions

The exponential function is in the form of e^x. As an example, if we want to determine the value of e^3, we simply enter the command,

```
>> exp(3)
ans =
   20.0855
```

A natural logarithm value can be determined by using the `log` command,

```
>> log(1)
ans =
     0
```

log

The based 10 logarithm value is determined from the `log10` command,

```
>> log10(10)
ans =
     1
```

log10

1.4.3 Roots

As an example, a square root of 7 is determined by using the command,

```
>> sqrt(7)
ans =
    2.6458
```

sqrt

Similarly, the cube root of 8 may be determined from the command,

```
>> 8^(1/3)
ans =
     2
```

1.4.4 Other Useful Commands

Results from the preceding examples are shown with 4 decimal points. We can request MATLAB to display a value with more decimal points by using the `long` command,

```
>> format long
```

Format

Results with a total of 15 decimals will then be displayed. As an example,

```
>> sqrt(6)
ans =
   2.449489742783178
```

We can reverse the display back to the former by using the `short` command,

```
>> format short
```

Note that results in other format can also be displayed as shown in the following examples.

```
>> format short e
>> sqrt(6)
ans =
  2.4495e+000

>> format long e
>> sqrt(6)
ans =
    2.449489742783178e+000
```

In addition, results may be displayed in form of the rational numbers, such as,

```
>> format rat
>> 32.5*28.56
ans =
    4641/5
```

During calculation, we may have several variables. We can keep track by listing them through the `who` command. As an example,

who

```
>> who
Your variables are:
D    a    ans  b    c    d    e    g
```

If we enter the `whos` command, MATLAB will show more details of these variables,

```
>> whos
  Name      Size      Bytes  Class      Attributes
  D         1x1           8   double
  a         1x1           8   double
  ans       1x1           8   double
  b         1x1           8   double
  c         1x1           8   double
  d         1x1           8   double
  e         1x1           8   double
  g         1x1           8   double
```

Variables can be cleared from the command window by entering the command,

```
>> clc
```

These variables can also be cleared from the computer memory by using the command,

```
>> clear
```

clear

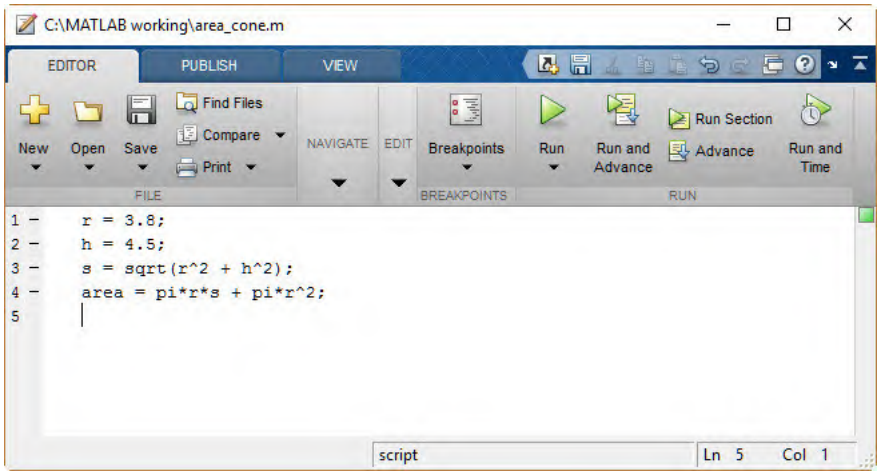
Note that, if we want to only remove some particular variables such as `a`, `b`, and `c` from the computer memory, we enter the command,

```
>> clear a b c
```

1.5 Saving Commands into File

The variables used and determined in the command window can be saved into a file. This is done by selecting the Save Workspace icon under the Home menu, a MAT file will be created. This file containing all variables can then be downloaded and used later in the command window.

If we have a set of commands, we can store them in an *m-file*. An m-file can be created by selecting the New Script icon under the Home menu. Series of commands can then be entered. As an example, the figure herein shows a list of commands for determining the surface area of a cone. The cone has the base radius of $r = 3.8$ with the height of $h = 4.5$. We may save the file containing these commands as area_cone.m. Then, we can execute the file by typing the file name on the command window and pressing the Enter key as follows,




```
>> area_cone
area =
  115.6776
```

By doing these, the program will execute one line statement at a time before printing out the result. It is noted that, such program is sometimes referred as the *script file*, for which we will learn how to create and use it in details in chapter 4.

1.6 Closing MATLAB Program

MATLAB program can be closed by either: (1) clicking the cross symbol on the upper right of the screen, (2) right-clicking the MATLAB logo on the upper left of the screen and selecting close, or (3) typing quit or exit at the command prompt in the command window.

1.7 Conclusion

This first chapter introduces the essential use of MATLAB program. The main MATLAB window that appears on the screen consisting of several sub-windows is first explained. The command sub-window allows users to calculate arithmetic expressions conveniently. The current folder sub-window shows files so that they can be brought into calculation directly. The workspace sub-window highlights all variables with their sizes in the program memory. The use of some basic arithmetic commands that are frequently encountered in science and engineering calculations are explained. These commands include addition, subtraction, multiplication, division and raising power of numbers. Trigonometric functions, such as sine, cosine, logarithmic and exponential are presented. Some other useful commands often needed during calculation are also explained. All of the working commands can then be saved for future use. MATLAB program thus works like a large calculator allowing users to perform calculation on a notebook or laptop computer effectively.

Exercises

1. Use MATLAB to calculate the followings,

   (a) $4\frac{3}{5} + 5\frac{9}{8}$

   (b) $\frac{3}{5} + \frac{26}{7}$ (show result as a rational number)

   (c) $43\left(\frac{\sqrt{513}}{6}+8^2\right) + \left(\frac{54}{7}+5.23^3\right)^{0.75}$

   (d) $\frac{\ln 150}{3.2} + 7.5^{\frac{2}{3}} - \left(\frac{\sqrt{135}+\sqrt[3]{250}}{e^{-0.3}}\right)^{\frac{1}{3}}$

   (e) $\sin^2\left(\frac{4\pi}{3}\right)\cos\left(\frac{5\pi}{6}\right) + \frac{\tan\left(\frac{\pi}{5}\ln 7\right)}{3+2\sqrt{3}}$

2. If x is equal to 8.67, use MATLAB to calculate the followings,

   (a) $5x^3 + 2x^2 - 5x - 7.5$

   (b) $\frac{e^{\sqrt{x}} + \log_{10}(x+2)}{\sqrt[3]{0.02+3x^3}}$

   (c) $\frac{\sqrt{\sin x + \cos^2 x}}{3\log_{10}(x-2)}$ (show result as a rational number)

   (d) $\frac{e^{1.58} - \sin 3x}{5} + \log_{10}(x+x^3)$

   (e) $\arctan(2x+3) - \cot(x\pi)$

3. Given $a = -5.73$, $b = 17.54$, $c = 2a + b/a$ and $d = 4ac + 3b$, use MATLAB to calculate the followings,

(a) $c - \dfrac{d-a}{2c} + \dfrac{(a+c)^{2.5}}{\sqrt{abc}}$

(b) $\log|(a-c)(b-a)| + \dfrac{a-b+c-d}{a+b-c+d}$

(c) $a^2b - d^2c + \left(\dfrac{a}{c}\right)^2 - \left(\dfrac{b}{d}\right)^{0.5}$

4. Below are some trigonometric relations,

(a) $\sin 2x = \dfrac{2\tan x}{1+\tan^2 x}$ (b) $\cos 2x = 1 - 2\sin^2 x$

(c) $\tan 3x = \dfrac{3\tan x - \tan^3 x}{1-3\tan^2 x}$ (d) $\tan\dfrac{x}{2} = \pm\sqrt{\dfrac{1-\cos x}{1+\cos x}}$

(e) $\cot x = \dfrac{\cos ec^2 x}{1+\tan^2 x}$

Proof that these relations are valid by using an appropriate x value.

5. A sphere has a radius of 21 cm, use MATLAB to determine,

(a) side length of a cubic that has the same surface area as the sphere.

(b) side length of a cubic that has the same volume as the sphere.

6. The distance d from a point with its coordinates of x_0 and y_0 to a straight line of $Ax + By + C = 0$ is determined from

$$d = \frac{|Ax_0 + By_0 + C|}{\sqrt{A^2 + B^2}}$$

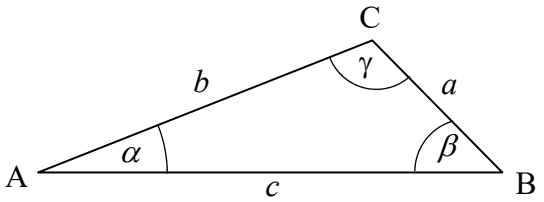
Use MATLAB to calculate the distance from the point with its coordinates of (-4, 3) to the line of $-2x + 7y - 10 = 0$. Note that the `abs` command is for determining the absolute value. As an example, `abs(-3) = 3`.

7. The base of a logarithmic function can be changed by using,

$$\log_a N = \frac{\log_b N}{\log_b a}$$

   (a) Use the `log(x)` function in MATLAB to determine $\log_6 324$
   (b) Use the `log10(x)` function in MATLAB to determine $\log_3 1024$

8. For the triangle as shown in the figure, if a = 15 cm, b = 45 cm and c = 54 cm, determine,
   (a) the angle γ in degrees by using the cosine law
   (b) the angles α and β in degrees by using the sine law
   (c) check that the summation of these angles is 180°



   Note that the trigonometric functions for angles in degrees are `acosd`, `asind` and `atand`.

9. The Richter scale for measuring the earthquake magnitude is determined from,

$$M = \frac{2}{3}\log_{10}\left(\frac{E}{E_0}\right)$$

   where M is the earthquake magnitude, E is the released energy and E_0 is a constant of $10^{4.4}$ Joule. Determine the released energy ratio between the 8.4 and 7.5 earthquake magnitudes.

10. The volume of a cylinder with the radius of r and height of h is determined from $V = \pi r^2 h$. Develop an m-file to determine the cylinder volume when r = 18 cm and h = 7 cm.