FEEDBACK AND CONTROL SYSTEMS

LABORATORY ACTIVITY #1

INTRODUCTION TO MATLAB: MATLAB BASIC FUNCTIONS AND COMMAND

I. Learning Outcomes:

At the end of the laboratory activity, the students should be able to:
1. Familiarize MATLAB environment, its capabilities, functions and basic commands.
2. Use MATLAB in solving basic arithmetic problems.

II. Introduction:

MATrix LABoratory is a high-level technical computing environment for high performance numeric computation and analysis, which integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Applications such as modeling, data analysis, simulation, exploration, and visualization can be done with this tool.

MATLAB Familiarization

The first time MATLAB starts, the MATLAB desktop appears showing the different tools (graphical user interfaces) for managing files, variables, and applications associated with MATLAB. The following important entities in the MATLAB user interface are explained in detail.

- Command Window: The window where to input commands like entering values in variables, or running scripts (m-files). M-files are scripts that simply execute a series of MATLAB statements, or they can be functions that also accept arguments and produce output. The prompt >> is an indicator where to input values, basic expressions and scripts.
- Command History: Lines entered in the Command Window are logged in the Command History window. In the Command History, previously used functions can be viewed, and copied and selected lines can be executed. The green text %-- 12/15/11 12:12 PM --% indicates the date and time in which the command was executed and performed on that particular time.
- Start Menu: MATLAB's start menu provides easy access to tools, demos, documentation and consists of various MATLAB® Toolboxes, Blocksets, Simulink, etc.
- Workspace: The MATLAB workspace consists of the set of variables (named arrays) built up during a MATLAB session and stored in memory. You add variables to the workspace by using functions, running M-files, and loading saved workspaces. To view the workspace and information about each variable, use the Workspace browser, or use the functions “who” and “whos”.

MATLAB Fundamentals: Format, Variables, Expressions and Commands

Once you are familiar with the MATLAB environment, it is time to enter basic expressions. In the command window, all commands are straightforward; just type the expressions such as entering values in a variable or running an m-file.

Expressions and Variables

If an expression is typed without a variable name, MATLAB will immediately evaluate it and the result is stored and displayed by a variable called ans. The result of an expression can be assigned to a variable name. Variable names consist of a letter, followed by any number of letters, digits, or underscores. MATLAB uses only the first 31 characters of a variable name and MATLAB is case sensitive. MATLAB is so straightforward that you may enter also mathematical expressions and formulas as you enter the variables. Notice that MATLAB display the result with 4 decimal (default format: format short). The commands format long: 16 decimal digits, format short e: 5 digits plus exponent, format long e: 16 digits plus exponent and format bank: 2 decimal digits.

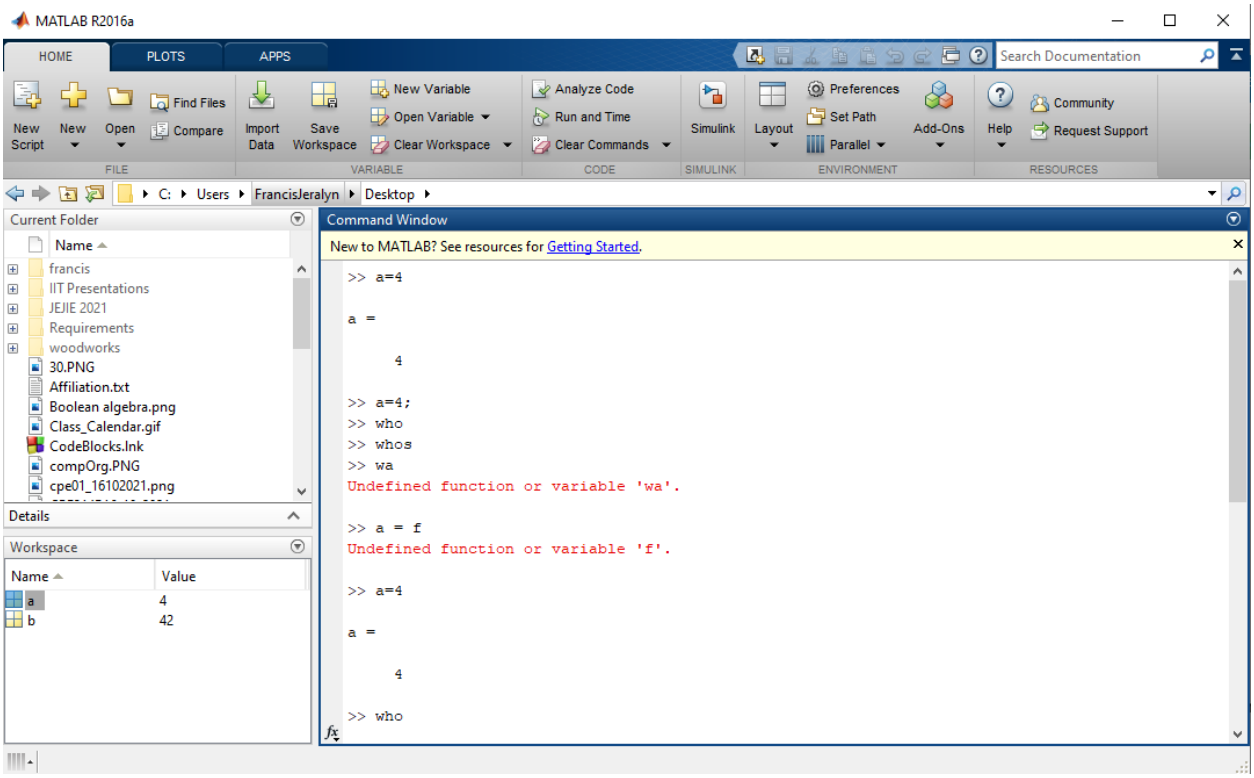

Figure 1. MATLAB Environment

The example below shows a 'no typed variable' expressions, answer is automatically stored in ans. The first expression involves direct values of adding two numbers, while the second one shows a direct mathematical expression using the function sin.

```
>> 102 + 3
ans =
        105
>> sin(3.1416/6)
ans =
        0.5000
```

The second example shows an expression with values stored in variables a and b.

```
>> a = 5.215
a =
   5.2150
>> b = a*cos(3.1416/3)
b =
   2.6075
```

A percent symbol (%) is typed in the beginning of line to designate a comment. Typing a semicolon (;) after a mathematical expression omits the MATLAB response or does not display the result. An example is shown in basic display manipulation. The first expression does not display the value of A but it is still in the workspace while the second expression is converted into a comment.

```
>> A = 9.135;
>> %Program to solve the value of x
```

The command fprintf can directly manipulate the format of the output of an expression or function. This command displays the result with a desired format on the screen or to specified filename. The %8.4f, indicates that the output value is a float number that has 4 decimal values and has 8 characters in length, if length of characters is less than 8 (7 in the example) the 8th would be a space. All expressions inside the single quote sign are the ones to be displayed. The \n indicates that the next output to be displayed (if there's any) would be on the next line. The expression to be evaluated is typed after the comma , sign.

```
>> fprintf('Area of a circle is %8.4f square meters\n', 3.1416*3^2)
Area of a circle is 28.2744 square meters
```

MATLAB has several predefined variables and are listed below. Try the following variables in the Command Window to check their functionality.

		Special Variables and Commands
ans	:	most recent answer
eps	:	floating point relative accuracy
i, j	:	imaginary unit
inf	:	infinity
NaN	:	not – a – number
pi	:	π

There are several commands that perform specific functions. These commands are listed below. It is recommended to try them to see how it works.

	Special Commands
clc	: clears the screen
clear "variable"	: clears the content and the variable itself
exit	: exits MATLAB
help "command"	: asks help on a particular command
who	: displays variables in workspace
who "variable"	: displays the number of elements in a variable

Character String

A sequence of characters in single quotes is called a character string or text variable. Characters can be augmented or combined by using a vector "['first character','second character']" An example is shown below.

```
>> c='Manila'
c =
        Manila
>> cs=[c,',Philippines']
cs =
        Manila,Philippines
```

Vectors can be generated by just specifying the first, last and the increment desired for each element. For example, to create a row vector with a first element of '1' and a last element of 9' and an increment of '1', use the syntax in the example below. The default increment is '1' so even without the second parameter '1', >>F = (1:9), still the result is the same. Try to experiment and change the increment, and see what happens.

Elementary Mathematics Functions and Operators in MATLAB

Elementary Math functions and operators in MATLAB are very easy to use since they are basic and straightforward in nature. Basic operations like addition, subtraction, multiplication, division can be represented by "+, -, *, /" respectively. In order to raise a number to a certain exponent, just insert ^ after the number and before the exponent. For example, to evaluate 2^6, just type >>2^6.

Math Operators and Special Character

Item	Description
+	Plus; addition operator
–	Minus; subtraction operator
*	Scalar & matrix multiplication operator
.*	Array multiplication operator
^	Scalar and matrix exponentiation operator

Item	Description
.^	array exponentiation operator
/	Right division operator
./	Array right division operator
\	Left division operator
.\	Array left division operator

Item	Description
:	Colon; generates regularly spaced elements & represents an entire row or column
( )	Parentheses; enclosure function argument & array indices
[ ]	Bracket; encloses cell elements
,	Comma; separates commands in a line, & elements in a row of an array

Item	Description
;	Semicolon; separates columns in an array, & suppresses display
%	Percent sign; designates a comment
'	Quote sign and transpose operator

Exponential and Logarithmic Functions

Item	Description
exp(*x*)	Exponential; e^x
log(*x*)	Natural logarithm; lnx
log10(*x*)	Common (base 10) logarithm; $\log x = \log_{10} x$
sqrt(*x*)	$\sqrt{x}$
factorial(x)	Factorial of number x

Complex Numbers

Item	Description
abs(x)	Absolute value; /x/
angle(x)	Angle of a complex number x
conj(x)	Complex conjugate of x
imag(x)	Imaginary part of a complex number x
real(x)	Real part of a complex number x

Relational and Logical Operators

Item	Description
==	Equal to
~=	Not equal to
<	Less than
<=	Less than or equal to
>	Greater than

Item	Description
>=	Greater than or equal to
&	AND
|	OR
~	NOT

Trigonometric Functions

Item	Description	Item	Description
sin(x)	Sine, $\sin x$	asin(x)	Inverse sine, $\sin^{-1} x$
cos(x)	Cosine, $\cos x$	acos(x)	Inverse cosine, $\cos^{-1} x$
cot(x)	Cotangent, $\cot x$	acot(x)	Inverse cotangent, $\cot^{-1} x$
csc(x)	Cosecant, $\csc x$	acsc(x)	Inverse cosecant, $\csc^{-1} x$
sec(x)	Secant, $\sec x$	asec(x)	Inverse secant, $\sec^{-1} x$
tan(x)	Tangent, $\tan x$	atan(x)	Inverse tangent, $\tan^{-1} x$

Hyperbolic Functions

Item	Description	Item	Description
sinh(x)	Hyperbolic Sine, $\sinh x$	asinh(x)	Inverse Hyperbolic Sine
cosh(x)	Hyperbolic Cosine, $\cosh x$	acosh(x)	Inverse Hyperbolic Cosine
coth(x)	Hyperbolic Cotangent, $\coth x$	acoth(x)	Inverse Hyperbolic Cotangent
csch(x)	Hyperbolic Cosecant, $\operatorname{csch} x$	acsch(x)	Inverse Hyperbolic Cosecant
sech(x)	Hyperbolic Secant, $\operatorname{sech} x$	asech(x)	Inverse Hyperbolic Secant
tanh(x)	Hyperbolic Tangent, $\tanh x$	atanh(x)	Inverse Hyperbolic Tangent

Polynomial Functions

Item	Description
conv	Computes products of two polynomials
deconv	Computes ratio of polynomials
poly	Computes polynomial from roots
polyval	Evaluates polynomial
roots	Computes polynomial roots
eig	Computes the eigenvalues of a matrix (characteristic root of a matrix)

Miscellaneous Math Functions

Item	Description
cross	Computes cross product
dot	Computes dot product

III. Laboratory Exercises:

1. Suppose that x=2 and y=5. Define these variables in MATLAB and construct a program to compute the following expressions:

a. $\frac{yx^3}{x-y}$

b. $\frac{3}{2}xy^2$

2. Define x and y as vectors x = 2,4,6,8,10 and y = 3,6,9,12,15 (Use shortcuts if applicable). Then use them in the following expression to solve for z.

$$\frac{xy + \frac{y}{x}}{x + y} + 12^{x/y}$$

3. Define the variables a, b, c, and d as: a=15.62, b=-7.08, c=6.25 and d=0.5(ab – c). Evaluate:

$$y = a + \frac{ab}{c}\frac{(a+b)^2}{\sqrt{|ab|}}$$

4. By defining first the variable x, construct the MATLAB program to evaluate the following equations:

a. $y = 2\frac{sin2x}{5}$, $x = \pi$

b. $y = 7\left(\frac{1}{x^3}\right) + 4x^{0.58}$, $x = 20$

5. Write MATLAB commands to solve the following equations.

a. $x = 4\cos 30° + \sqrt{10}\sin^2 30°$

b. $y = \ln 10 + \sqrt{30}\sin 25°$

6. Two vectors are given $\hat{a} = 6\hat{\imath} + 8\hat{\jmath} - 5\hat{k}$ and $\hat{b} = \hat{\imath} - 2\hat{\jmath} + 4\hat{k}$. Calculate their dot product and cross product.

7. Using the *linspace* function, create the following row vectors:

a. 2 4 6 8 10 12 14 16 18 20

b. –3.0000 –0.4444 2.1111 4.6667 7.2222 9.7778 12.3333 14.8889 17.4444 20.0000

8. If the volume of a cylinder of height h and radius r is $V = \pi r^2 h$, use MATLAB to find the volume enclosed by a cylinder that is 2 m in high with a diameter of 25 cm.