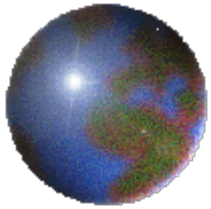


Introduction to MATLAB

MATLAB

MATLAB

- A program for doing numerical computation
- Originally designed for solving linear algebra type problems using matrices

- The name is derived from MATrix LABoratory.
- Uses extensively for data analysis, signal processing, optimization, and several other types of scientific computations

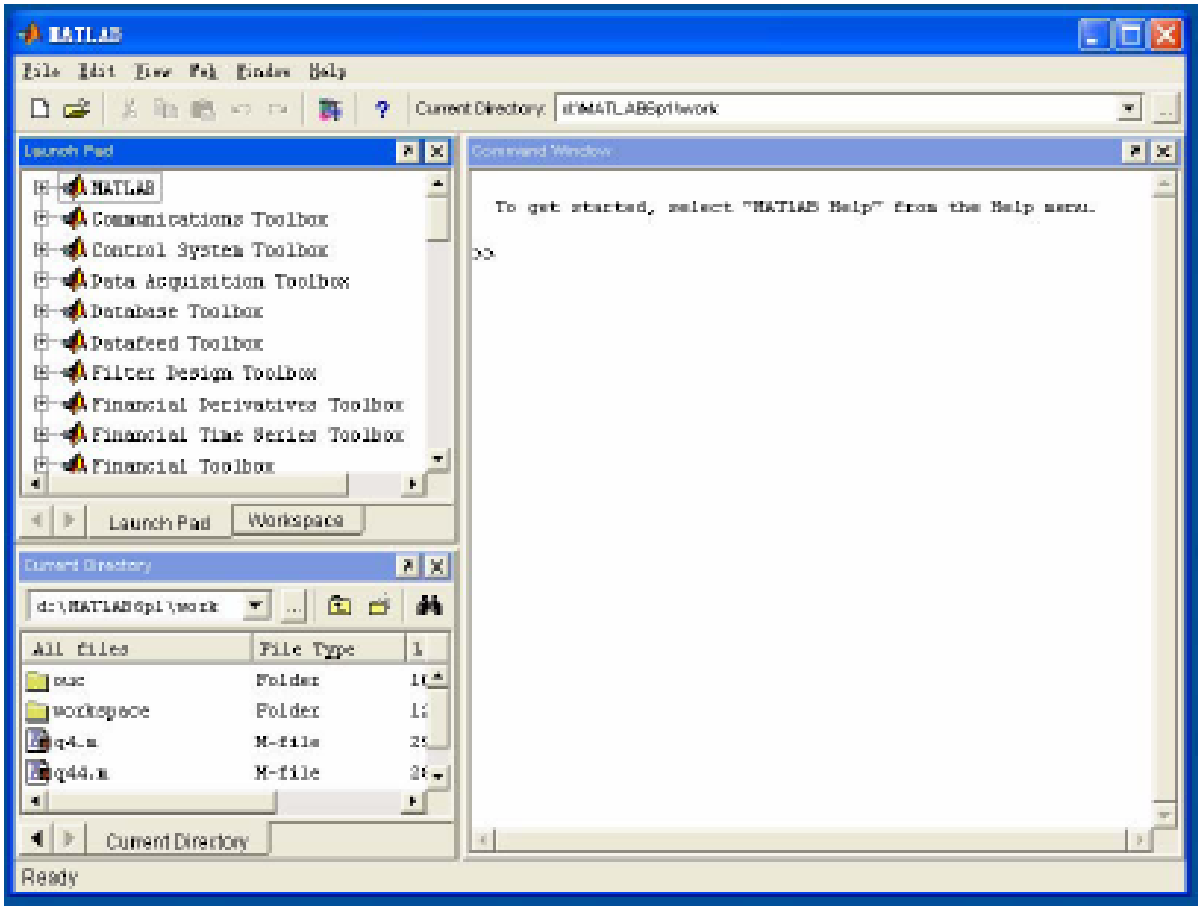
- Also contains functions for 2-D and 3-D graphics and animation.

MATLAB

- **The MATLAB environment**
  - Command oriented somewhat like UNIX.
  - A prompt appears on the screen and a MATLAB statement can be entered.
  - When the <ENTER> key is pressed, the statement is executed, and another prompt appears.
  - If a statement is terminated with a semicolon (;), no results will be displayed. Otherwise results will appear before the next prompt.

MATLAB

- **Starting MATLAB**



MATLAB

To get started, type one of these commands:

helpwin, helpdesk, or demo

```
» a=5;
» b=a/2

b =

2.5000

»
```

MATLAB Variable Names

- **Variable names ARE case sensitive**
  - Variable names can contain up to 63 characters
    (as of MATLAB 6.5 and newer)
  - Variable names must start with a letter followed by letters, digits, and underscores.

MATLAB Special Variables

ans	Default variable name for results
pi	Value of π
eps	Smallest incremental number
inf	Infinity
NaN	Not a number e.g. 0/0
i and j	i = j = square root of -1
realmin	The smallest usable positive real number
realmax	The largest usable positive real number

MATLAB Math & Assignment Operators

Power	`^`	or `.^`	`a^b`	or	`a.^b`
Multiplication	`*`	or `.*`	`a*b`	or	`a.*b`
Division	`/`	or `./`	`a/b`	or	`a./b`
or	`\`	or `.\`	`b\a`	or	`b.\a`
NOTE:	`56/8 = 8\56`				

Addition	`+`	`a + b`	
Subtraction	`-`	`a - b`	
Assignment	`=`	`a = b`	**(assign b to a)**

MATLAB Operators: Example

```
>> x = 6;
```

Variables in MATLAB follow the usual naming conventions. Any combination of letters, numbers and underscore symbols ('_') can be used, as long as the first character is a letter.

All of the expected scalar arithmetic operators are available:

```
>> 3*x
ans =
        18
>> x^2
ans =
        36
```

Other MATLAB symbols

>>	prompt
. . .	continue statement on next line
,	separate statements and data
%	start comment which ends at end of line
;	(1) suppress output
	(2) used as a row separator in a matrix
:	specify range

MATLAB Matrices

- **MATLAB treats all variables as matrices.**
  - Contains rows and columns
  - Vectors are special forms of matrices and contain only one row OR one column.
  - Scalars are matrices with only one row AND one column

MATLAB Matrices

- **A matrix with only one row AND one column is a scalar.**
  - A scalar can be created in MATLAB as follows:

```
» a_value=23

a_value =

23
```

MATLAB Matrices

- **A matrix with only one row is called a row vector.**
  - A row vector can be created in MATLAB as follows (note the commas):

» rowvec = [12 , 14 , 63]

rowvec =

12 14 63

```
>> x = [1:20]
x =

  Columns 1 through 16

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

  Columns 17 through 20

   17   18   19   20
```

MATLAB Matrices

- **A matrix with only one column is called a column vector.**
  - A column vector can be created in MATLAB as follows (note the semicolons):

```
» colvec = [13 ; 45 ; -2]

colvec =

13
45
-2
```

MATLAB Matrices

- **A matrix can be created in MATLAB as follows**
  - (note the commas AND semicolons):

» matrix = [1 , 2 , 3 ; 4 , 5 ,6 ; 7 , 8 , 9]

matrix =

1 2 3
4 5 6
7 8 9

Extracting a Sub-Matrix

- **A portion of a matrix can be extracted and stored in a smaller matrix by specifying the names of both matrices and the rows and columns to extract.**
  - The syntax is:

sub_matrix = matrix (r1 : r2 , c1 : c2) ;

where r1 and r2 specify the beginning and ending rows and c1 and c2 specify the beginning and ending columns to be extracted to make the new matrix.

MATLAB Matrices

- A column vector can be extracted from a matrix. As an example we create a matrix below:

```
» matrix=[1,2,3;4,5,6;7,8,9]

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

- Here we extract column 2 of the matrix and make a column vector:

```
» col_two=matrix( : , 2)

col_two =

     2
     5
     8
```

MATLAB Matrices

- A row vector can be extracted from a matrix. As an example we create a matrix below:

» matrix=[1,2,3;4,5,6;7,8,9]

matrix =

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

- Here we extract row 2 of the matrix and make a row vector.

» rowvec=matrix(2 : 2 , 1 : 3)

rowvec =

```
4   5   6
```

Plotting with MATLAB

- **MATLAB will plot one vector vs. another.**
  - The first one will be treated as the abscissa (or x) vector and the second as the ordinate (or y) vector. The vectors have to be the same length.

- **MATLAB will also plot a vector vs. its own index.**
  - The index will be treated as the abscissa vector. Given a vector "time" and a vector "dist" we could say:

```
>> plot (time, dist)      % plotting versus time
>> plot (dist)            % plotting versus index
```

Plotting with MATLAB

- There are commands in MATLAB to "annotate" a plot to put on axis labels, titles, and legends. For example:

```
>> % To put a label on the axes we would use:
>> xlabel ('X-axis label')
>> ylabel ('Y-axis label')

>> % To put a title on the plot, we would use:
>> title ('Title of my plot')
```

Some Useful MATLAB commands

- **who** List known variables
- **whos** List known variables plus their size
- **help** >> help sqrt Help on using sqrt
- **lookfor** >> lookfor sqrt Search for keyword sqrt in m-files
- **what** >> what a: List MATLAB files in a:
- **clear** Clear all variables from work space
- **clear x y** Clear variables x and y from work space
- **clc** Clear the command window

Some Useful MATLAB commands

what	List all m-files in current directory
dir	List all files in current directory
ls	Same as dir
type test	Display test.m in command window
delete test	Delete test.m
cd a:	Change directory to a:
chdir a:	Same as cd
pwd	Show current directory
which test test.m	Display directory path to 'closest'

MATLAB Relational Operators

- MATLAB supports six relational operators.

Less Than	<
Less Than or Equal	<=
Greater Than	>
Greater Than or Equal	>=
Equal To	==
Not Equal To	~=

MATLAB Logical Operators

- MATLAB supports three logical operators.

```
not     ~     % highest precedence
and     &     % equal precedence with or
or      |     % equal precedence with and
```

MATLAB Logical Functions

- MATLAB also supports some logical functions.

xor (exclusive or) Ex: xor (a, b)

Where a and b are logical expressions. The xor operator evaluates to true if and only if one expression is true and the other is false. True is returned as 1, false as 0.

any (x)	returns 1 if any element of x is nonzero
all (x)	returns 1 if all elements of x are nonzero
isnan (x)	returns 1 at each NaN in x
isinf (x)	returns 1 at each infinity in x
finite (x)	returns 1 at each finite value in x

MATLAB: Some built-in functions

Some often used built-in functions are listed below:

sin – sin
cos – cosine
tan – tangent
asin – arcsin
acos – arccosin
atan – arctangent
abs – absolute value or complex magnitude
angle – phase angle
sqrt – square
real – real part
imag – imaginary
sign – signum function
exp – exponential base e
log – natural logarithm

Matlab Selection Structures

- An if - elseif - else structure in MATLAB.

Note that elseif is one word.

```
if      expression1                % is true
        % execute these commands
elseif expression2     % is true
        % execute these commands
else                           % the default
        % execute these commands
end
```

MATLAB Repetition Structures

- A for loop in MATLAB for x = array

```
for ind = 1:100
    b(ind)=sin(ind/10)
end
```

Alternative:

```
x=0.1:0.1:10; b=sin(x);
```

Most of the loops can be avoided!!!

- A while loop in MATLAB while expression

```
while x <= 10
    % execute these commands
end
```

Scalar - Matrix Addition

```
» a=3;
» b=[1, 2, 3;4, 5, 6]
b =
    1    2    3
    4    5    6
» c= b+a          % Add a to each element  of b
c =
    4    5    6
    7    8    9
```

Scalar - Matrix Subtraction

```
» a=3;
» b=[1, 2, 3;4, 5, 6]
b =
     1     2     3
     4     5     6
» c = b - a %Subtract a from each element of b
c =
    -2    -1     0
     1     2     3
```

Scalar - Matrix Multiplication

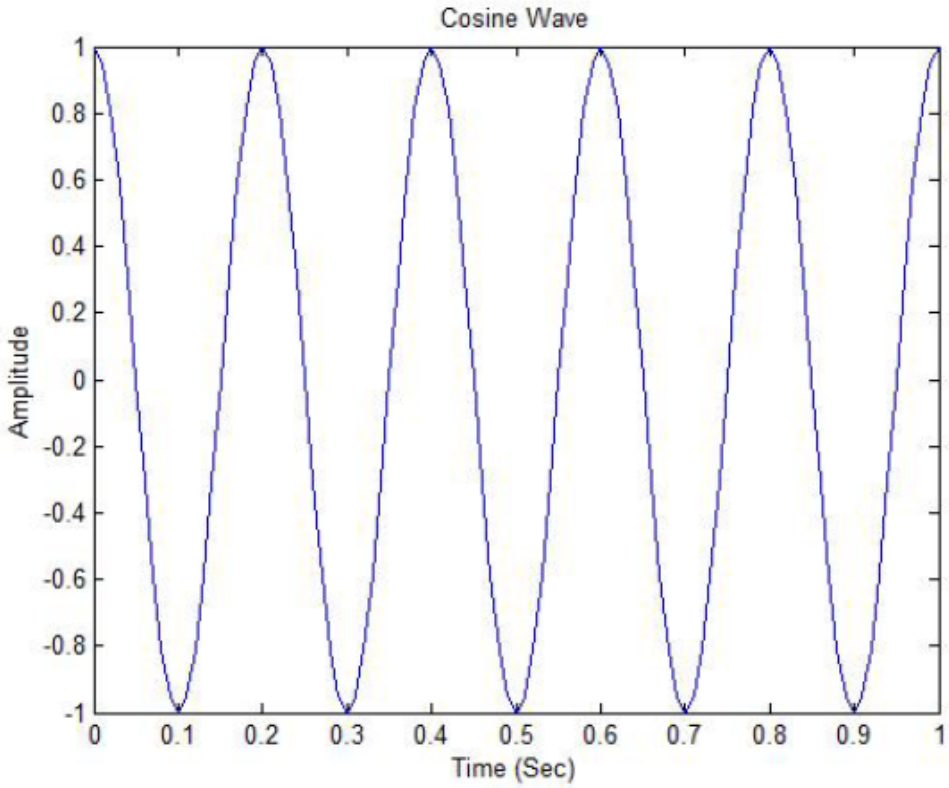
```
» a=3;
» b=[1, 2, 3; 4, 5, 6]
b =
     1     2     3
     4     5     6
» c = a * b  % Multiply each element of b by a
c =
     3     6     9
    12    15    18
```

Scalar - Matrix Division

```
» a=3;
» b=[1, 2, 3; 4, 5, 6]
b =
     1     2     3
     4     5     6
» c = b / a      % Divide each element of b by a
c =
    0.3333    0.6667    1.0000
    1.3333    1.6667    2.0000
```

MTLAB: Example

```
t = 0:0.01:1;
f = 5;
y = cos(2*pi*f*t);
plot( t, y)
title('Cosine Wave');
xlabel('Time (seconds)');
ylabel('Amplitude');
```



MTLAB: Example

- **Plot sin() and cosine() functions in one figure:**

```
t = 0:0.01:1;
f = 5;
y1 = sin(2*pi*f*t);
y2 = cos(2*pi*f*t);
figure
subplot(2, 1, 1)
plot( t, y1)
subplot(2, 1, 2)
plot(t, y2)
title('Cosine Wave');
xlabel('Time (secor
ylabel('Amplitude');
```