INTRODUCTION TO SCIENTIFIC & ENG. COMPUTING
BIL 108E, CRN 44448

Week.2

Dr. Feyzi HAZNEDAROĞLU

İstanbul Teknik Üniversitesi - İnşaat Fakültesi
Room : 250A, e-mail :haznedar@itu.edu.tr

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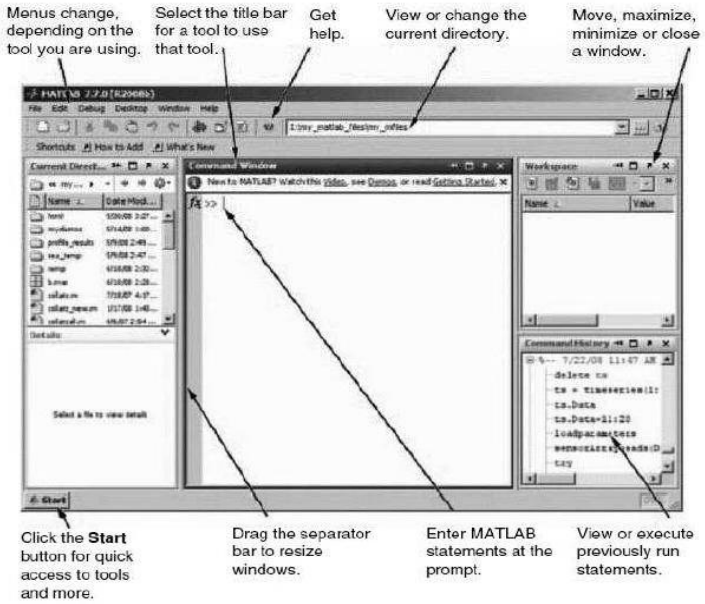
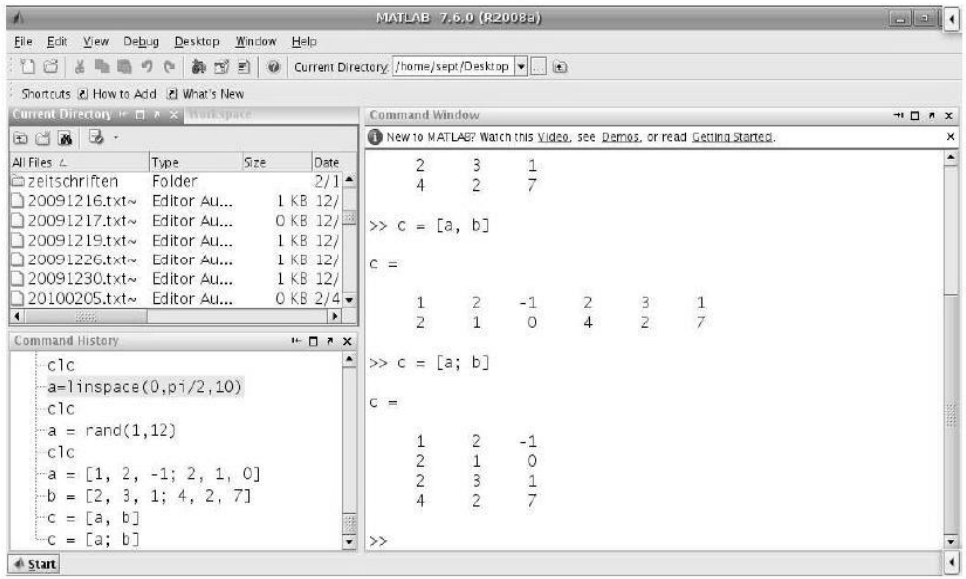
USING MATLAB

- To start from Windows,
  Double click the Matlab icon.
- To start from UNIX,
  type matlab at the shell prompt.

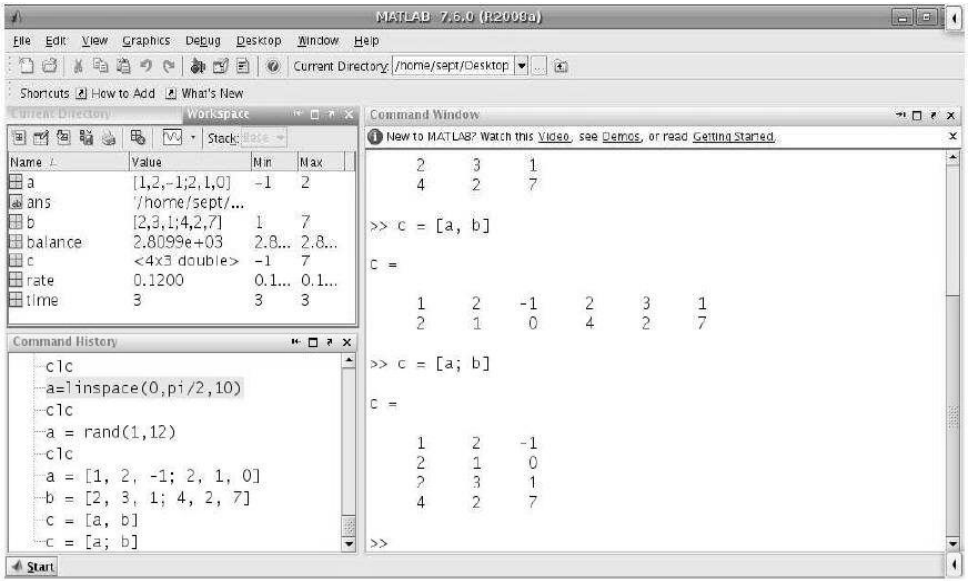
MATLAB Desktop



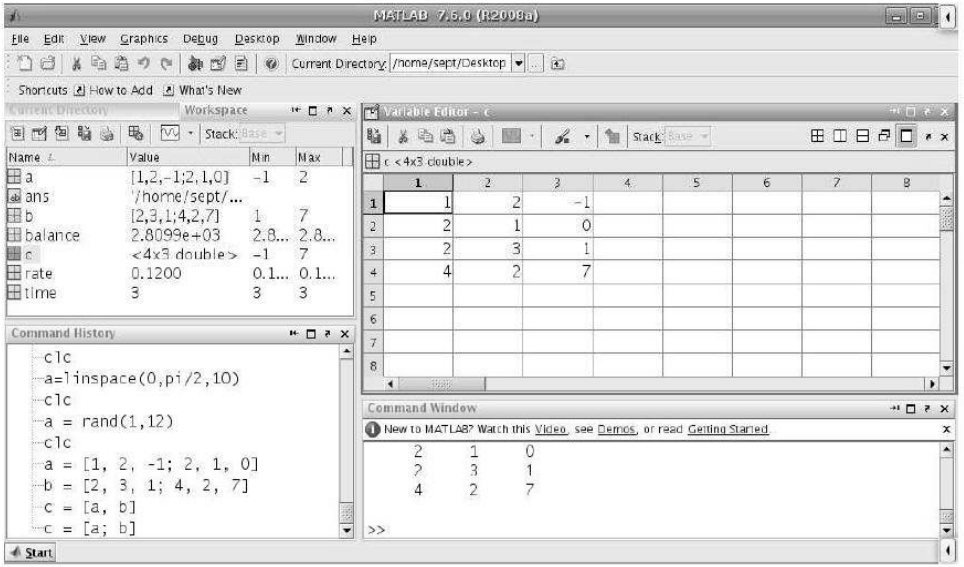
MATLAB Desktop



MATLAB Desktop



MATLAB Desktop



USING MATLAB

To end Matlab session,

1. From File pull down menu, select Exit MATLAB.
2. Enter exit or quit at the command prompt.

COMMAND LINE

≫ indicates the command prompt

- You can edit a MATLAB command before pressing Enter (executing or running) by using various combinations of the Backspace, Left-arrow, Right-arrow, and Del keys.
- You can select (and edit) commands you have entered using Up-arrow and Down-arrow.
- MATLAB has a useful editing feature called smart recall. Just type the first few characters of the command you want to recall.
  - For example, type the characters 2* and press the Up-arrow key. This recalls the most recent command starting with 2*.

ARITHMETICS

- Matlab command prompt can be used as a calculator.

```
>> 8 + 9
>> 24 - 12
>> 8 ^ 2
>> 1 / 16
>> 16 \ 1
```

  - Backslash means the denominator is to the left of the symbol.
- Period in front of the operators means that the operation is done with single numbers.

```
>> 2 .* 6
>> 1 ./ 8
>> 3 .^ 4
>> 5 .^ 2
```

- It is important, when we deal with array of numbers.

ARITHMETIC OPERATORS

Matlab Operations

Symbol	Operation	Example	Answer
+	Addition	z = 4 + 2	z = 6
−	Subtraction	z = 4 − 2	z = 2
/	Right division	z = 4/2	z = 2
\	Left division	z = 2\4	z = 2
*	Multiplication	z = 4 * 2	z = 8
^	Exponentiation	z = 4 ^ 2	z = 16
Functions such as: sqrt, log	square root log2	z = sqrt(4)	z = 2
		z = log2(4)	z = 2

RELATIONAL OPERATORS

Operator Name	Operator Symbol	EXAMPLE
less than	<	x<y
less than equal to	<=	a<=22
equal to	==	x==100
not equal to	~=	x~=10
greater than equal to	=>	pi=>3
greater than	>	c>100

OPERATOR PRESEDENCE

Precedence	Operators
1.	(,)
2.	^, .^ , ' , .' (pure transpose)
3.	+ (unary plus), - (unary minus), ~ (NOT)
4.	*, \, /, .*, ./, .\
5.	+ (addition), - (subtraction)
6.	:
7.	>, <, >=, <=, ==, ~=
8.	& (AND)
9.	| (OR)

- Operator precedence from this table and from left to right.

NUMBERS

- Numbers can be defined in the decimal form
  - Example; 1.732050808, -24, 256.0
- In scientific notation e or E could be used to define the exponent. Exponent should be an integer.
- The mantissa is multiplied by the power of 10 indicated by the exponent. Example;

  12.35e-3

  12.35x10−3

PRECISION FORMATS

Precision Formats

MATLAB Instruction	Display	Numerical Output exp(1)
format short	4 decimal digits (default)	2.7183
format long	16 decimal digits	2.71828182845905
format short e	4 decimal digits plus exponent	2.7183e+000
format long e	15 decimal digits plus exponent	2.71828182845904e+000
format bank	2 decimal digits	2.72
format +	+, −, 0 (positive, negative, and zero)	+
format hex	Hexadecimal	4005bf0a8b14576a
format rat	Rational approximation	1457/536
format compact	Suppress extra line-feeds	2.7183
format loose	Puts the extra line-feeds back in	2.7183

DATA TYPES

- Default numeric data type is double precision.
- Matlab has 14 data types.
  - Examples: integer, unsigned integer, string, single precision

SPECIAL VALUES

- Matlab warns you in case of errors, but still gives answer.
  - Example;

    1 / 0 ⇒ Inf

    0 / 0 ⇒ NaN
- You can use these symbols in any calculation.

VARIABLES

Variable Naming Rules;

- It may consist only of the letters a–z, the digits 0–9, and the underscore .
- It must start with a letter
- The name will be as long as you like but Matlab remembers only the first 63 characters
- Matlab is case sensitive, upper and lower case variables are not the same.
  - Examples;

    r2d2, luke_filewalker, x3po ⇒ RIGHT

    _2d, luke-filewalker, balance$ ⇒ WRONG

Good Naming Techniques

- Camel Caps (dayOfTheWeek, milleniumBug, StarWars)
- Using underscore (star_wars, day_of_the_week)

RESERVED VARIABLES

List of Reserved Variable Names

Variable	Description
ans	Temporary variable that stores the most recent answer.
computer	Returns the computer type.
version	MATLAB version.
ver	Returns the information about the license and version of the MATLAB package installed in your computer.
license	License information.
pi	The number $\pi = 3.14159\ldots$.
exp(1)	The value of $e = 2.71\ldots$.
eps	Represents the accuracy of floating point, the smallest possible positive number with a magnitude of the order of 10^{-10}.
realmin	The smallest real positive number.
realmax	The largest real positive number.
bitmax	The largest positive integer, magnitude of $2^{53} - 1$.
flops	Counts of the floating-point operations. flop(0) starts the count of all algebraic operations such as $+, -, *, /$.
inf	Represents infinity, (1/0).
nan	Not a number, undefined (0/0).
i or j	The value of $\sqrt{-1}$. Denotes the imaginary part of a complex number.
input	Accepts information via keyboard.
date	Represents the current date as a string. For example, 25-Jul-00.
clock	Represents the current date and time as YYMMDDHHMMSS.
beep	Executes a beep sound.
etime (T_f, T_i)	Calculates elapse time in seconds between T_i (initial) and T_f (final). T_i and T_f are in vector form consistins of six elements (year month day hour minute second).
tic, toc	Measures the time between the `tic` and the `toc`. The `tic` starts the stopwatch, and the `toc` stops the stopwatch and outputs the elapsed time.
cputime	Total time of MATLAB used in seconds.
Pause	Stops executing a program momentarily.
Pause(*n*)	Stops executing a program during *n* seconds.

VARIABLES

To do arithmetic operations with the variables we should assign values to variables.

```
>> a = 7;
>> b = 8;
>> c = a + b;

>> t = 12; r = 32;
>> u = t * r;
```

- Several commands can be separated by comma or semicolon and output disabled with semicolon.

VARIABLES

- Names should not duplicate with built-in functions.

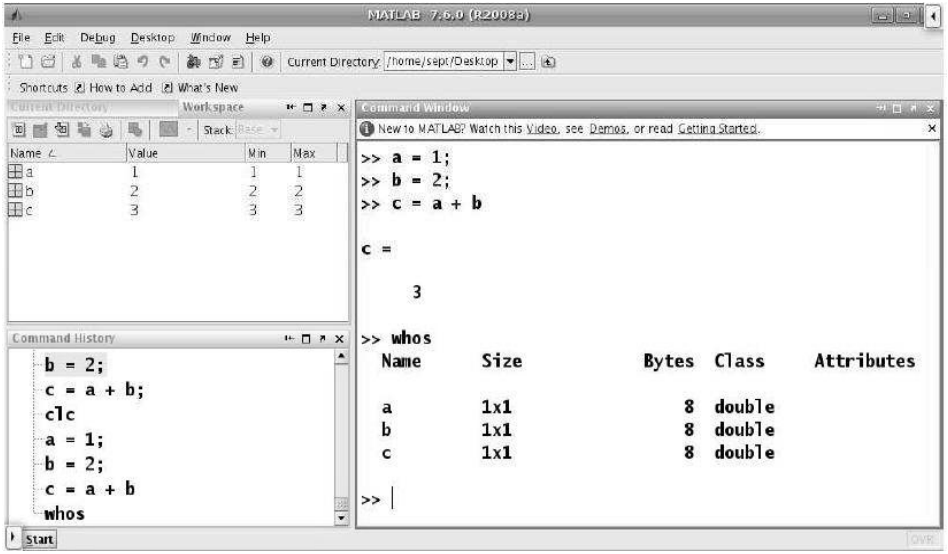
```
>> pi = 7;
>> sqrt (pi);
```

- pi has a different value then expected.

```
>> who
>> whos
>> clear pi
>> whos
>> sqrt(pi)
```

- whos represent the locally defined variables and commands in the workspace with size info.
- clear deletes the defined variable

MATLAB Desktop



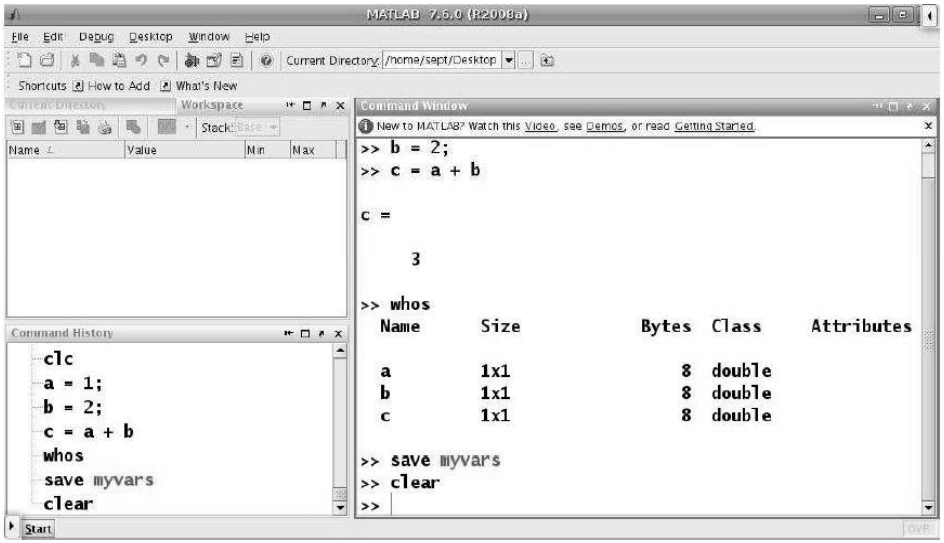
VARIABLES

save filename

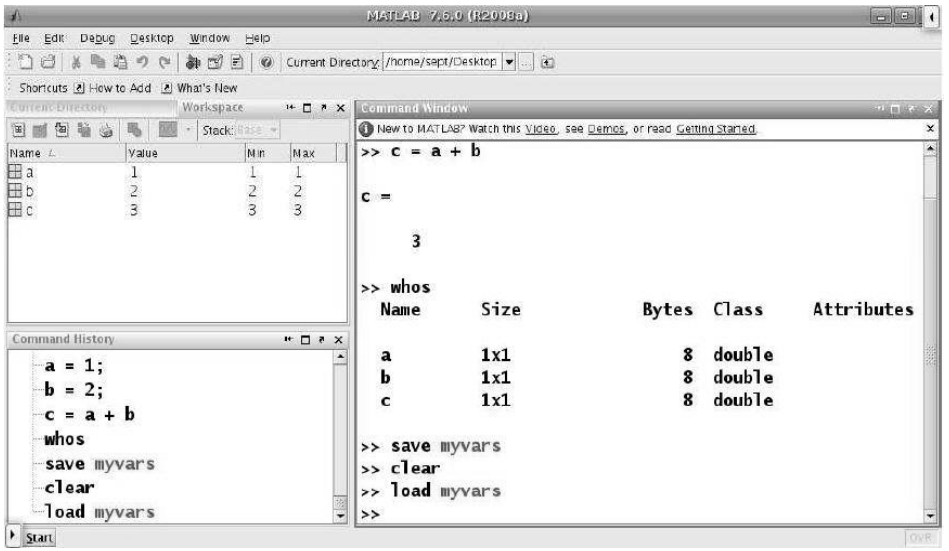
load filename

- These commands are used to save and load the variables in the current workspace to a file.

MATLAB Desktop



MATLAB Desktop



GENERAL FUNCTIONS

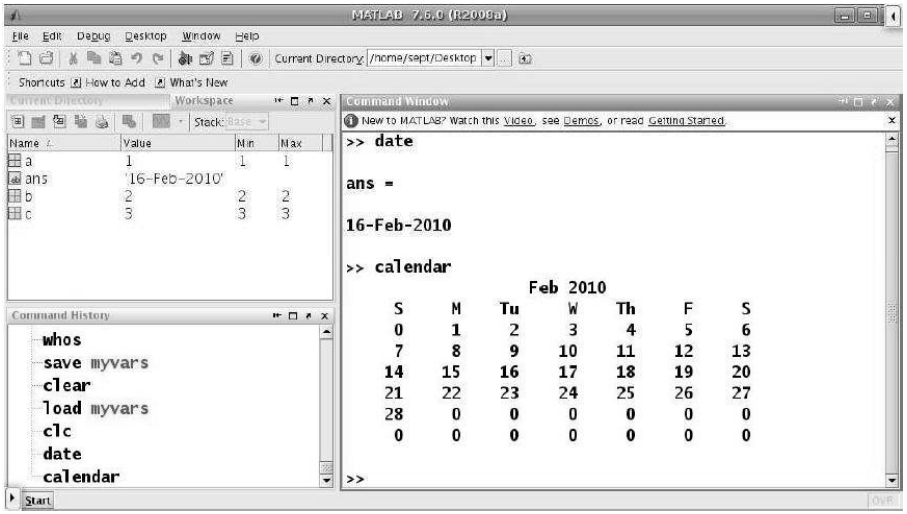
Date & Calendar

clc clear → command window

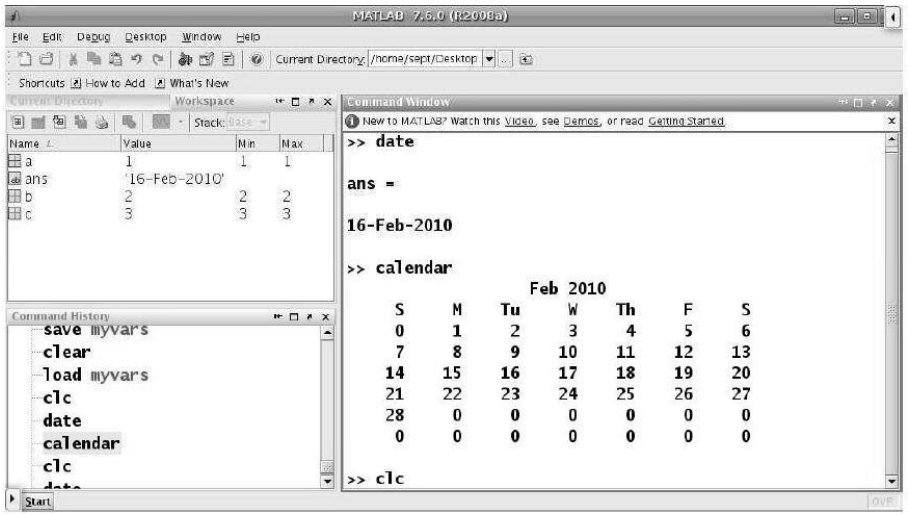
clf clear → figure window

help

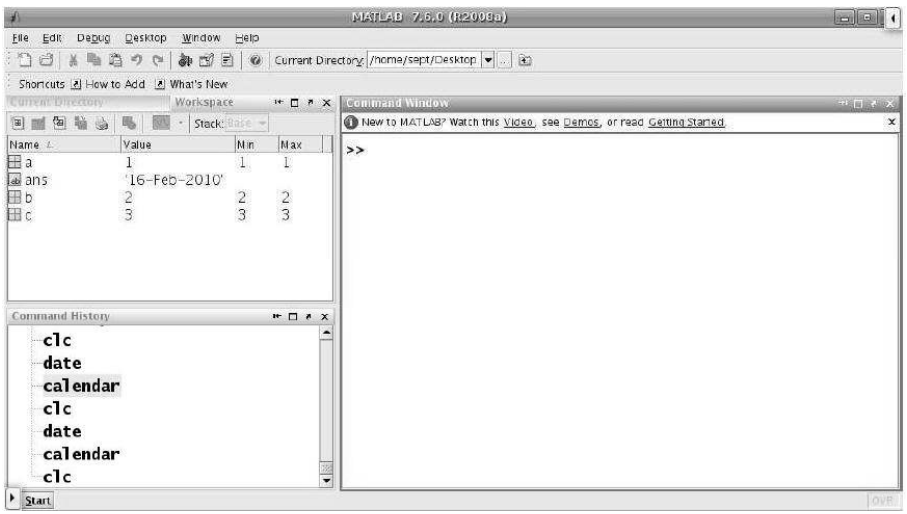
MATLAB Desktop



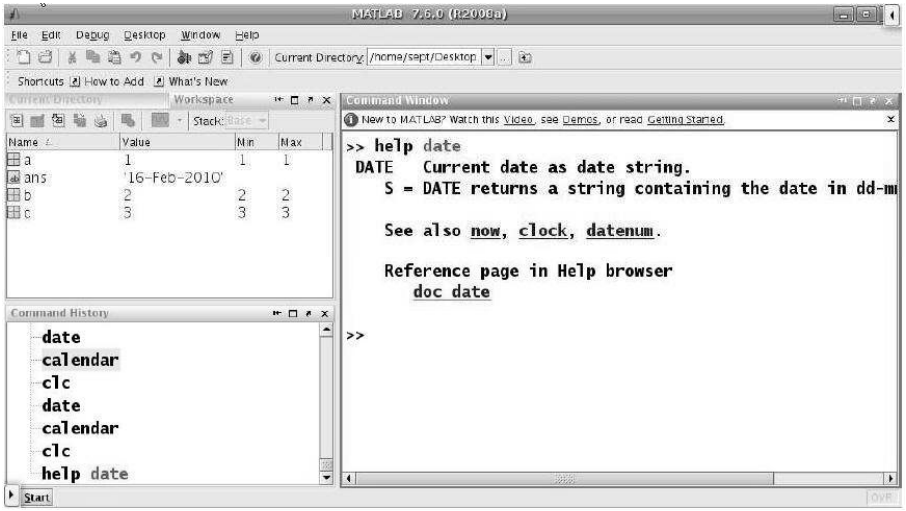
MATLAB Desktop



MATLAB Desktop



MATLAB Desktop



BUILT–IN FUNCTIONS

MATLAB offers a wealth of built-in math functions that can be quite helpful for many computational problems

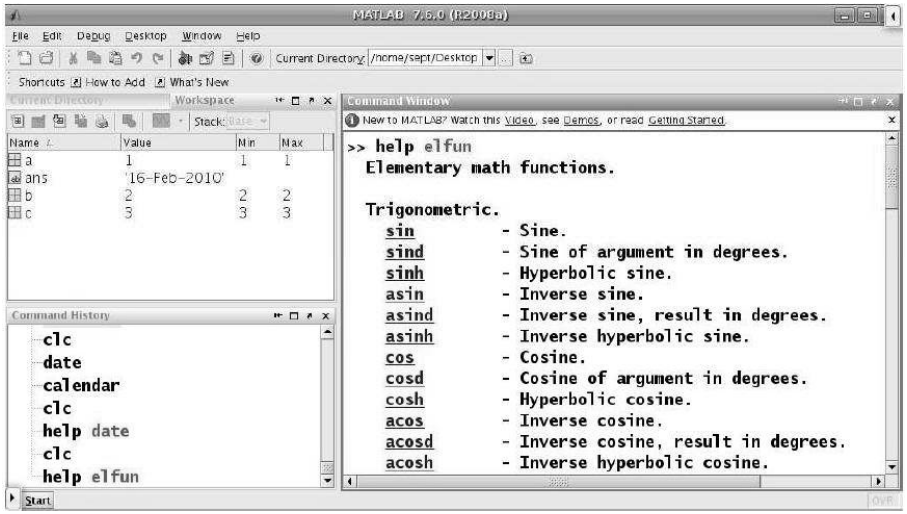
Elementary MATLAB functions (help elfun)

- Trigonometric functions
- Exponential functions
- Complex functions
- Rounding and remainder functions

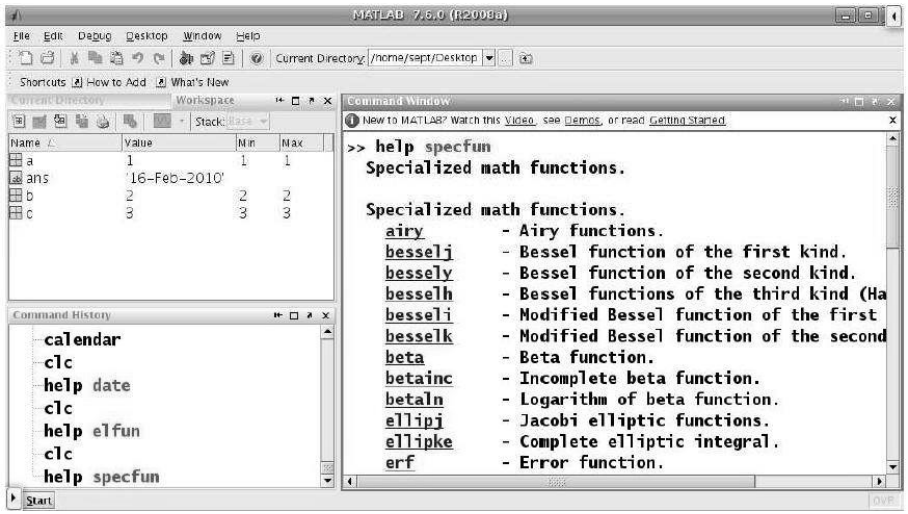
Specialized MATLAB functions (help specfun)

- Specialized math functions
- Number theoretic functions
- Coordinate transformations

MATLAB Desktop



MATLAB Desktop



MATHEMATICAL FUNCTIONS (1)

abs	Absolute value
acos, acosh	Inverse cosine and inverse hyperbolic cosine
acot, acoth	Inverse cotangent and inverse hyperbolic cotangent
acsc, acsch	Inverse cosecant and inverse hyperbolic cosecant
angle	Phase angle
asec, asech	Inverse secant and inverse hyperbolic secant
asin, asinh	Inverse sine and inverse hyperbolic sine
atan, atanh	Inverse tangent (two quadrant) and inverse hyperbolic tangent
atan2	Inverse tangent (four quadrant)
bessel	Bessel function
ceil	Round up
conj	Complex conjugate
cos, cosh	Cosine and hyperbolic cosine
cot, coth	Cotangent and hyperbolic cotangent
csc, csch	Cosecant and hyperbolic cosecant

MATHEMATICAL FUNCTIONS (2)

erf	Error function
exp	Exponential
fix	Round toward zero
floor	Round down
gamma	Gamma function
imag	Imaginary part
log	Natural logarithm
log2	Dissect floating point numbers into exponent and mantissa
log10	Common logarithm
mod	Modulus (signed remainder after division)
rat	Rational approximation
real	Real part
rem	Remainder after division
round	Round toward nearest integer
sec, sech	Secant and hyperbolic secant
sign	Signum function
sin, sinh	Sine and hyperbolic sine
sqrt	Square root
tan, tanh	Tangent and hyperbolic tangent

LINEAR EQUATIONS

$$2x - y = 4$$

$$-x + 2y = 3$$

$$\begin{pmatrix} 2 \\ -1 \end{pmatrix} x + \begin{pmatrix} -1 \\ 2 \end{pmatrix} y = \begin{pmatrix} 4 \\ 3 \end{pmatrix}$$

Column picture

Scalars are not enough to define this kind of data.

VECTORS

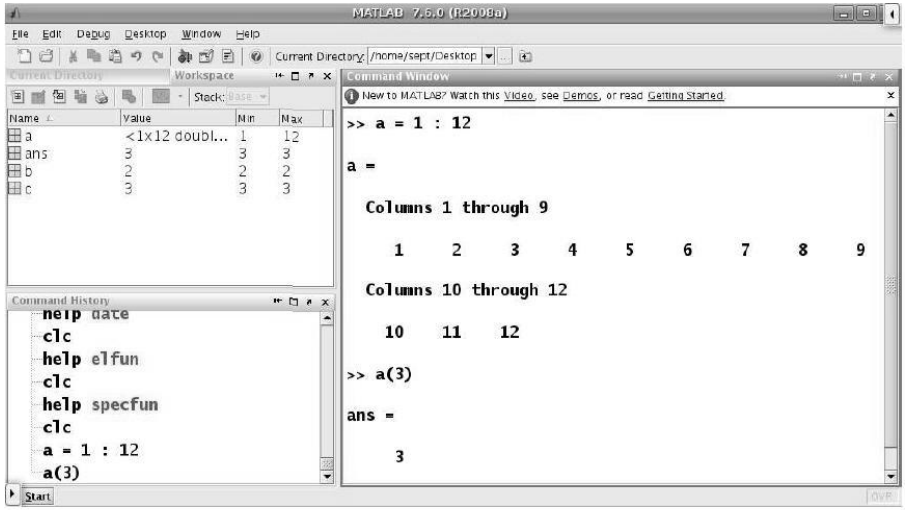
A vector is an ordered list of numbers (one-dimensional). In MATLAB they can be represented as a row-vector or a column-vector (1 x n) or (n x 1).

Simple vector definition;
COLON **:** is used to define row vectors in Matlab.

```
>> a = 1 : 12;
>> size(a)
```

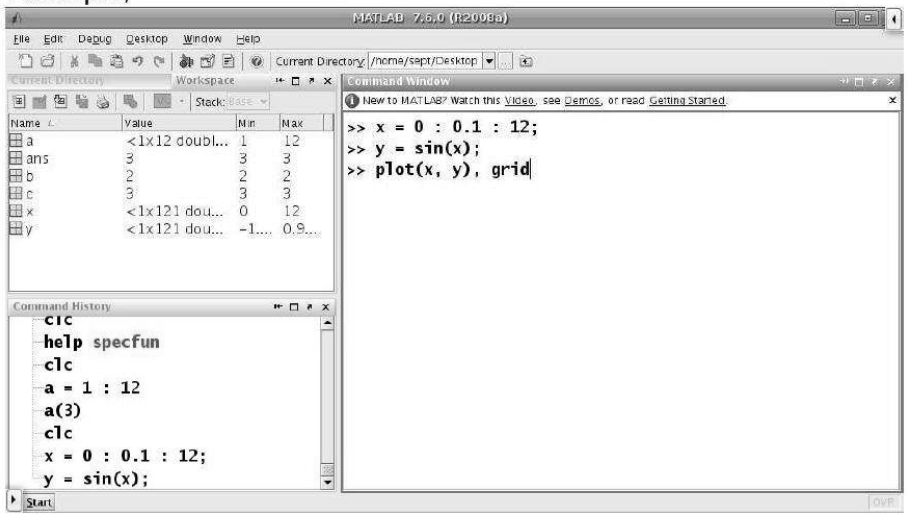
`size` command shows dimension of the variable, here the size of vector *a*.

MATLAB Desktop

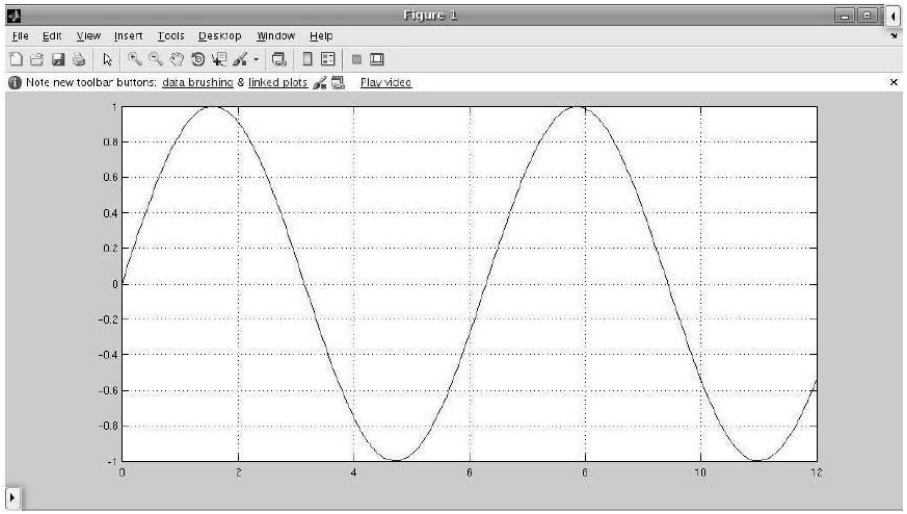


VECTORS

Example;



VECTORS



EXAMPLES

Given : Balance 2000 USD, 12% rate per year

Find : Bank Balance after 3 years?

Formula : $balance(1 + r)^n$

First write down a rough algorithm.

1. Get the data into Matlab.
2. Calculate the balance after 3 years
3. Display the new balance

EXAMPLES

Given : Balance 2000 USD, 12% rate per year

Find : Bank Balance after 3 years?

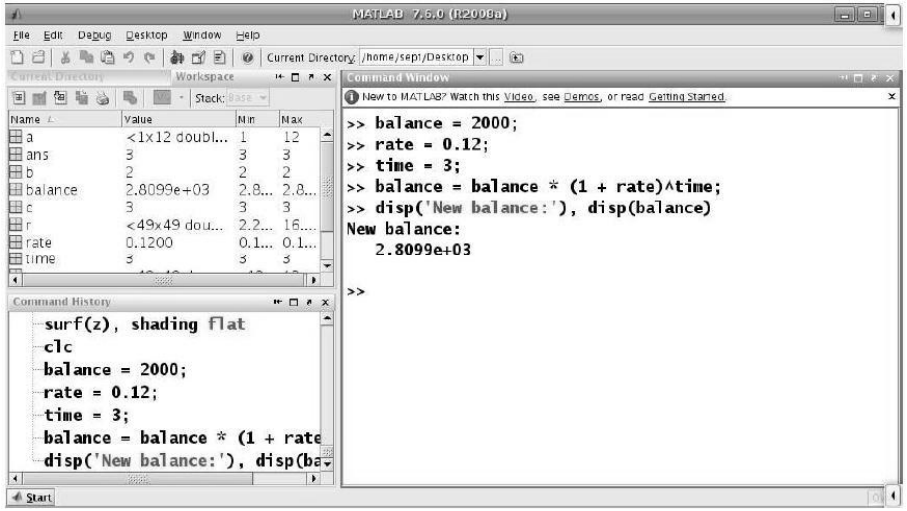
Formula : $balance(1 + r)^n$

First write down a rough algorithm.

1. Get the data into Matlab.
2. Calculate the balance after 3 years
3. Display the new balance

```
balance = 2000; % USD
rate = 0.12; % bank rate
time = 3; % years
balance = balance * (1 + rate)^time;
disp('New balance:');
disp(balance)
```


MATLAB Desktop

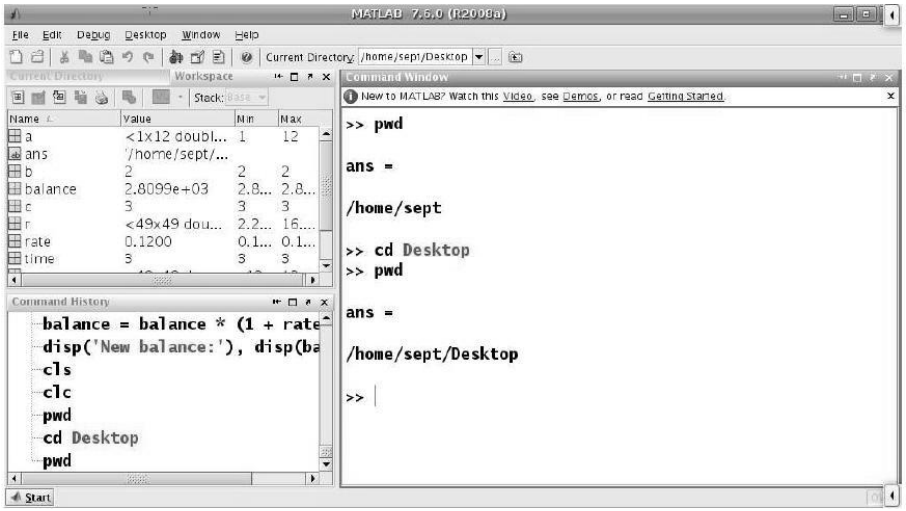


RUNNING SCRIPT FILES

- Use file extension **.mat** for Workspace files and can be opened from Matlab Desktop File menu.
- Use file extension **.m** for function files

- `pwd` shows the current directory of matlab
- `cd` change directory to run the script file
- change directory with Matlab desktop Directory Browser.

MATLAB Desktop



linspace FUNCTION

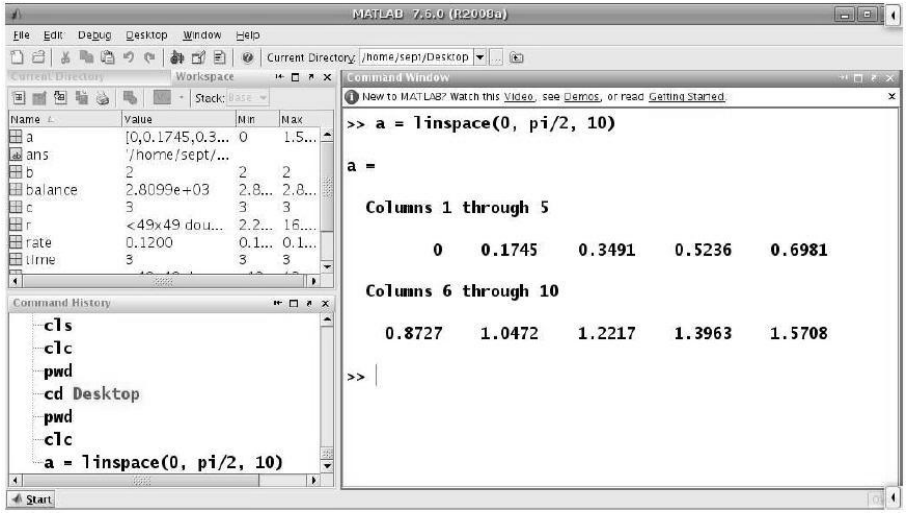
The function `linspace` creates a vector of equally spaced values.

Example;

`linspace(0 , pi/2, 20)`

creates a vector with the size of 1 x 20 from 0 to *pi*/2

MATLAB Desktop



TRANSPOSE OF A VECTOR

`a = [ 1 2 3 5 8 13 ]` is a row vector.

"[" and "]" used to define a vector.

To generate the column vector, transpose the vector.

`b = [ 1 2 3 5 8 13 ]'` (') apostrophe is used to transpose vector a. Size of a is 1 x n

Size of b is n x 1

In mathematics a column vector is shown as a^i
and a row vector is shown as a_j.
A matrix could be shown as a_{ij}, *ora*^i_j

SUBSCRIPT

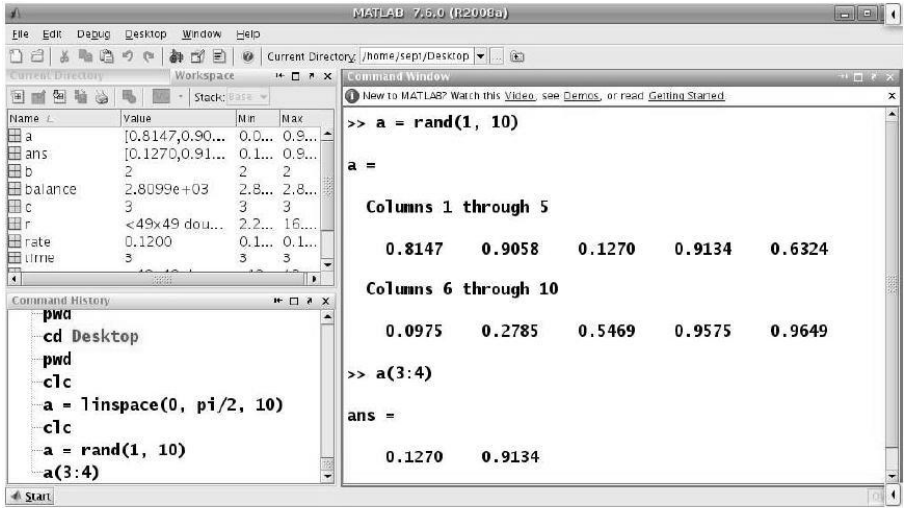
`rand(i,j)` command is used for creating a random variable matrix with values between 0 and 1.

`a=rand(1,12)` creates a 1x12 row vector.

a(3) gives the third element of the vector

a(3:5) gives the elements between 3 and 5

MATLAB Desktop



MATRIX

A matrix is a rectangular array of numbers (multidimensional). In MATLAB, a two-dimensional matrix is defined by its number of rows and columns (n x m) or (m x n).

A matrix can be created like a vector.

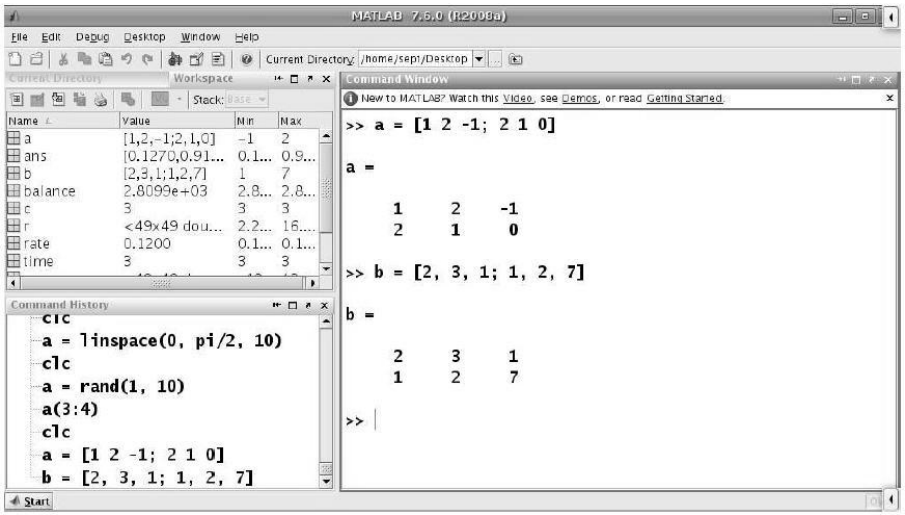
Examples;

- a = [1 2 -1; 2 1 0]
- b = [2, 3, 1 ; 4, 2, 7]

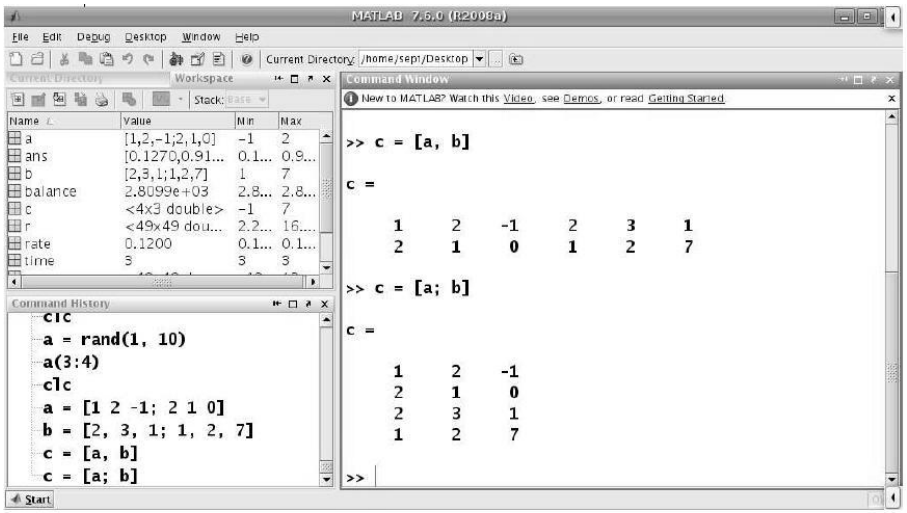
A matrix can also be constructed from other matrices.

- c = [a , b]
- c = [a ; b]

MATLAB Desktop



MATLAB Desktop



Capturing Output

`diary` *FILENAME*

It creates a file with the name *FILENAME* and appends all the output to this file till we end it with the command

```
diary off
```


VERTICAL MOTION UNDER GRAVITY

EXAMPLE: VERTICAL MOTION UNDER GRAVITY

If a stone is thrown vertically upward with an initial speed u its vertical displacement s after an elapsed time t is given by the formula $s = ut - gt^2/2$, where g is the acceleration due to gravity. Air resistance is ignored.

We would like to compute the value of s over a period of about 12.3 seconds at intervals of 0.1 seconds, and plot the distance versus time graph over this period.

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```
% Assign the data (g, u, and t) to MATLAB variables
% Calculate the value of s according to the formula
% Plot the graph of s against t
% Stop
```


VERTICAL MOTION UNDER GRAVITY

This plan may seem trivial and a waste of time to write down. Yet you would be surprised how many beginners, preferring to rush straight to the computer, start with step 2 instead of step 1. It is well worth developing the mental discipline of structure–planning your program first. You can even use cut and paste to plan as follows:

VERTICAL MOTION UNDER GRAVITY

1. Type the structure plan into the Editor
2. Paste a second copy of the plan directly below the first.
3. Translate each line in the second copy into a MATLAB statement or statements
4. Finally, paste all the translated MATLAB statements into the Command Window and run them
5. If necessary, go back to the Editor to make corrections

VERTICAL MOTION UNDER GRAVITY

```
% Vertical motion under gravity
g = 9.81; % acceleration due
          % to gravity
u = 60; % initial velocity in
        % metres/sec
t = 0 : 0.1 : 12.3;          % time in seconds
s = u * t - g / 2 * t .^ 2; % vertical displacement
                             % in metres
plot(t, s), title( 'Vertical motion under gravity' )
xlabel( 'time' ), ylabel( 'vertical displacement' )
grid
disp( [t' s'] )              % display a table
```

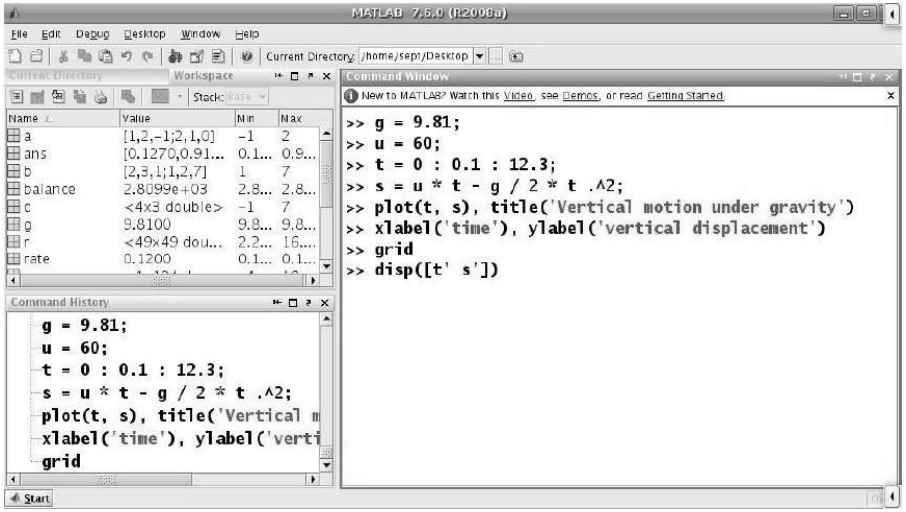

VERTICAL MOTION UNDER GRAVITY

1. Anything in a line following the symbol % is ignored by MATLAB and may be used as a comment (description).
2. The statement `t = 0 : 0.1 : 12.3` sets up a vector.
3. The formula for s is evaluated for every element of the vector t, making another vector.
4. The expression `t.^ 2` squares each element in `t`. This is called an array operation and is different from squaring the vector itself.

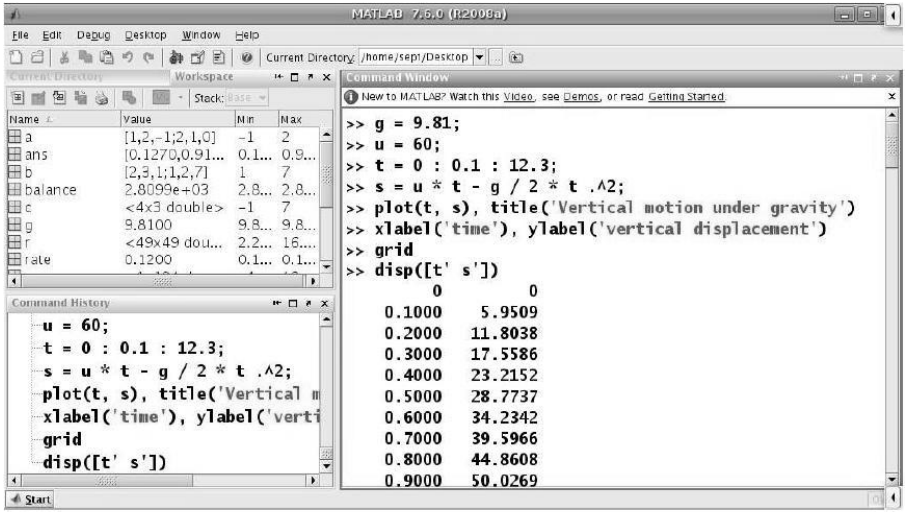
VERTICAL MOTION UNDER GRAVITY

5. More than one statement can be entered on the same line if the statements are separated by commas.
6. A statement or group of statements can be continued to the next line with an ellipsis of three or more dots `(...)`.
7. The statement `disp([t' s'])` first transposes the row vectors t and s into two columns and constructs a matrix from them, which is then displayed.

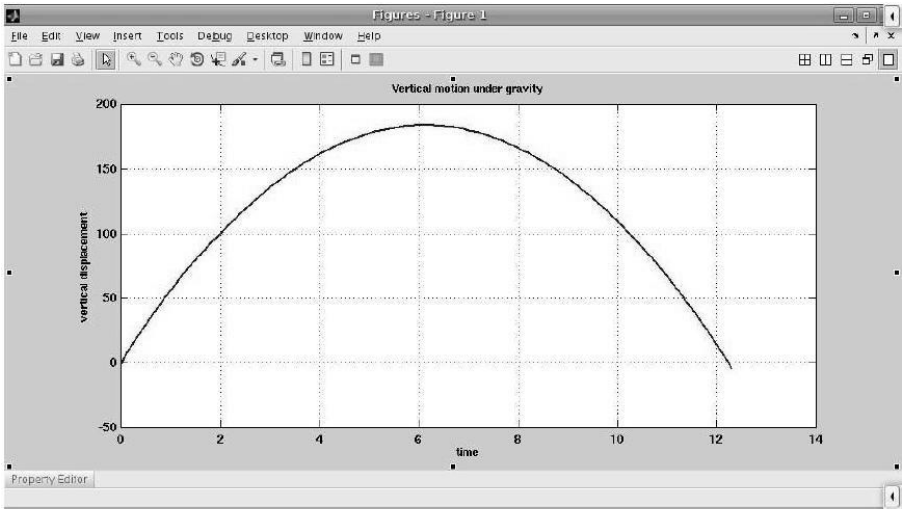
VERTICAL MOTION UNDER GRAVITY



VERTICAL MOTION UNDER GRAVITY

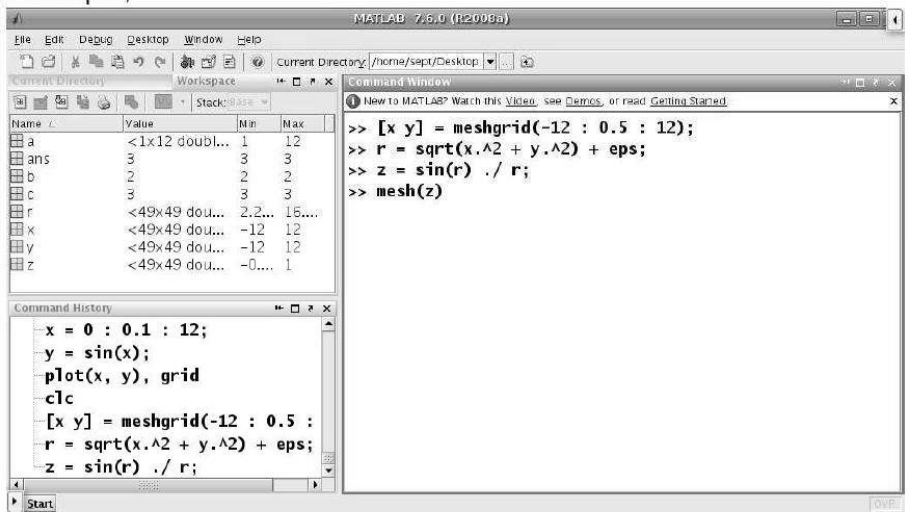


VERTICAL MOTION UNDER GRAVITY

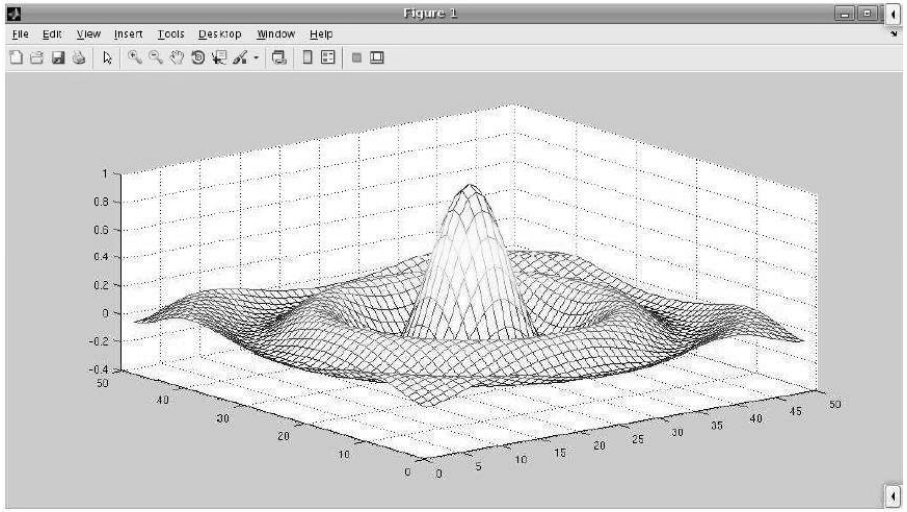


EXAMPLES

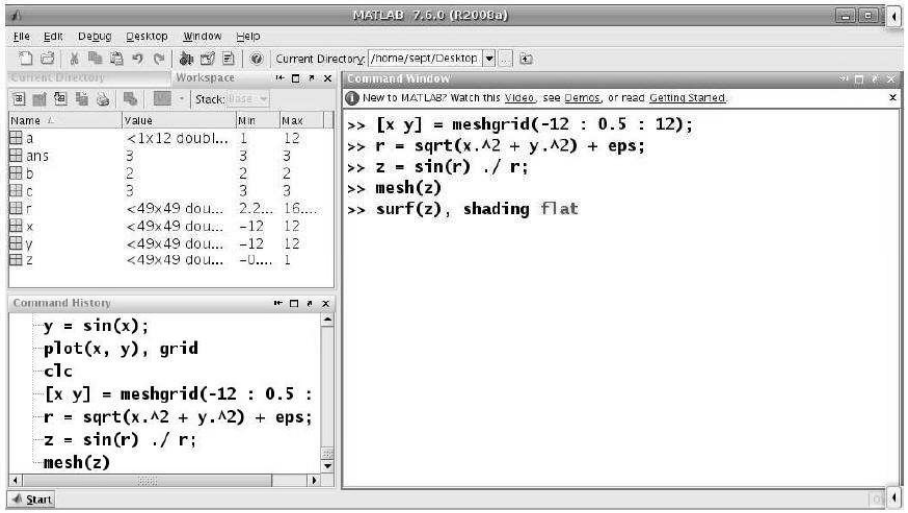
Example;



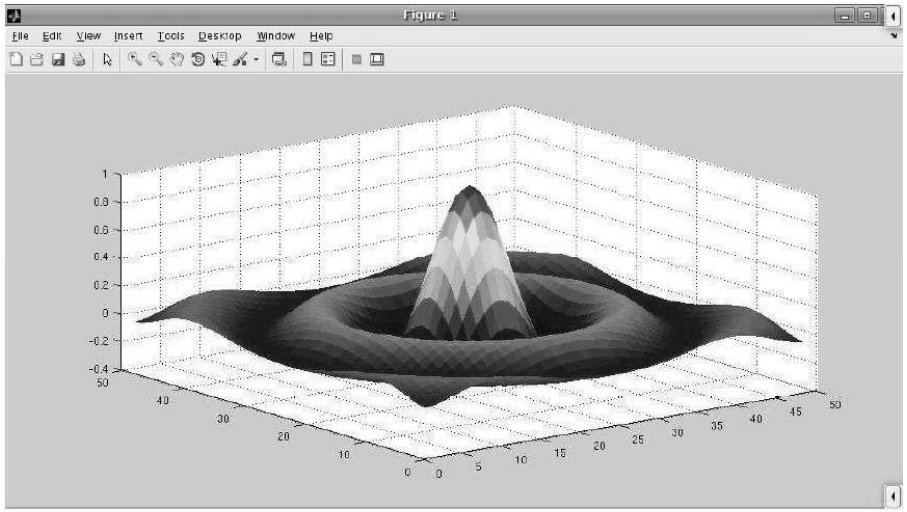
EXAMPLES



EXAMPLES



EXAMPLES



References for Week 2

1 Brian Hahn, Daniel T.Valentine, Essential Matlab for Engineers and Scientists, Elsevier, 2010.

2 Misza Kalechman, Practical Matlab Basics for Engineers, CRC Press, 2009.

Have a nice Week End