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Programming Tools for Mathematics

Courses and Practical Work

First year MI

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Abstract

Since the 1970s, the use of computer software has become absolutely essential in the scientific field, for technicians, engineers and researchers alike.

This course introduces you to computational software called MATLAB, which is one of the most popular choices for quantitative analysis in a field such as engineering, statistics, economics, and artificial intelligence, to name a few.

MATLAB was developed by Mathworks. MATLAB (MATrix LABoratory) is an interactive programming environment for scientific computation, programming and data visualization. Free alternatives exist such as Scilab, R or Octave.

For numerical calculation, MATLAB is much more concise than the old languages (C, Pascal, Fortran, Basic). An example: no need to program loops to modify the elements of a matrix one by one. The matrix can be treated as a simple variable. MATLAB also contains a powerful GUI, as well as a wide variety of scientific algorithms.

This course material is intended for students in the first year of the common foundation of mathematics and computer science. The main objective of this course is to provide the most relevant basics to master the MATLAB calculation software. This course is broken down into two parts.

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Part one Courses

Introduction to MATLAB

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1.1 MATLAB Environmental Overview

- MATLAB is a numerical calculation software produced by MathWorks (see website <http://www.mathworks.com/>).
- It is available on multiple platforms.
- MATLAB is *a simple* and *very efficient* language, optimized for matrix processing, hence its name. The name derives from this representation: MATLAB = MATrixLABoratory.
- MATLAB is not the only existing scientific computing environment because there are other competitors, the most important of which are: MAPLE and MATHEMATICA. There is even free software that are clones of MATLAB like SCILAB and OCTAVE.
- For numerical calculation, MATLAB is much more concise than the old languages (C,Pascal, Fortran, Basic). An example: no need to program loops to modify the elements of a matrix one by one. The matrix can be treated as a simple variable.
- MATLAB also contains a powerful GUI, as well as a wide variety of scientific algorithms.
- MATLAB can be enriched by adding toolboxes which are sets of additional functions, profiled for particular applications.

1.2 MATLAB interface

Before we start the actual course, we will familiarize ourselves with the MATLAB interface. Depending on the version used, the interface may change slightly but the central points will remain the same. Figure 5 illustrates the general interface of Matalab. By default, there are four windows:

1. Command Window.
2. Command History
3. current directory.
4. Workspace

1.2.1 Command Window

One of the most important windows in MATLAB, the Command Window deals with instructions given. It is after the *prompt* that the requested instructions must be entered. The results will be displayed as soon as the line returns. does not always start with ". Try the following command:

```
1+2
ans=
3
clc
```

The **clc** command empties the Command Window screen to return to a clean window.

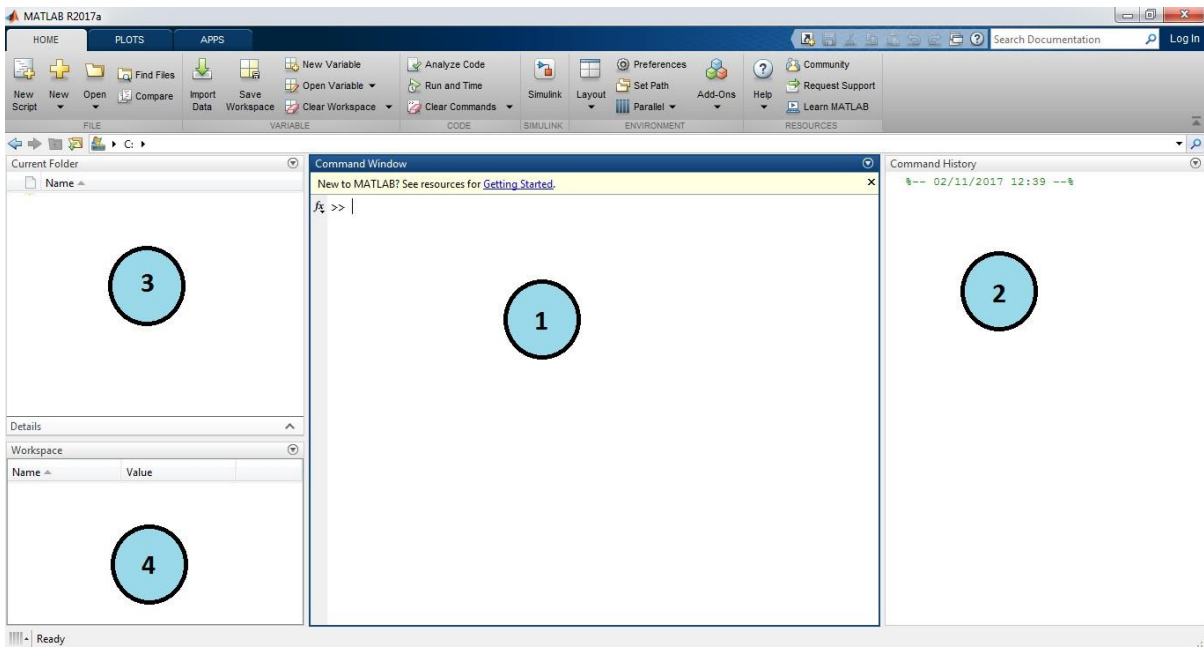


Figure 1.1: MATLAB interface (R2017a).

1.2.2 Workspace

The window named Workspace allows you to view the variables stored in memory. We find their name, their dimensions as well as the type of variable. Since MATLAB is based on matrices, all variables are made up of several dimensions:

- a scalar is a 1×1 matrix.
- a vector is a $1 \times n$, $n \times 1$ matrix.
- A matrix of size $n \times m$.

It is possible to double-click on a variable to display it. Right-clicking on variables offers many options such as: Copy, Paste, Delete etc.

It is possible to erase some variables as well as edit them. To clear them all, use the **Clear Workspace** command in the Edit menu.

Figure 1.2 illustrates an example of variables in the Workspace.

Name	Value	Size
A	5	1x1
B	[1 2 3 4]	1x4
C	[1 2 3;4 5 6;7 8 9]	3x3

Scalar

Vector

Matrix

Figure 1.2: Example of a variable in the Workspace.

1.2.3 Current Directory.

The Current Directory is the common directory where M-files are saved. It is strongly recommended to create a directory other than the one provided by MATLAB in order to better manage the files contained therein (See Figure 1.3).

- To compile an M-file, it must be saved in the current directory.
- If an M-file calls a function other than a MATLAB function (i.e. a user-created function), the M-file calling the function as well as the M-file defining the function must be in the same current directory.

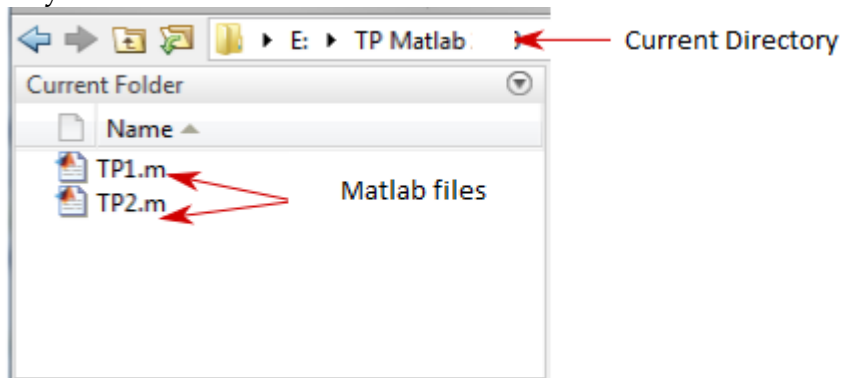


Figure 1.3: Example of .m files saved in the Current Directory named TP MATLAB 2020.

1.2.4 Command History

When analyzing data on the results of an experiment, it is essential to keep a record of all the operations that have been carried out. This is the basis for the traceability and reproducibility of scientific results.

It is possible to click on a command in this window to run it again. You can also go up the list of commands by placing yourself in the Command Window and pressing the direction arrows.

MATLAB is also able to move up the list of orders by only taking into account orders that start with certain characters. If we search for a command that we entered previously, we can type the beginning of this command then the up arrow and MATLAB will search only among the commands with the same beginning.

In addition, it is sometimes important to save the list of commands used in an independent file. To do this, we use:

```
»diary filename
```

This command will create a *filename* file that will record all commands entered until diary off is used.

1.2.5 Editor/Debugger

To process M-files, use the MATLAB editor/debugger. This window is not part of the MATLAB core interface and opens when opening an M-file or creating a new M-file.

On the button bar, a button is essential: the *RUN* button compiles the program, i.e. executes the program's commands. It can also be run with **F5** (See Figure 3.3).

Another interesting element of the editor is to leave the cursor on a variable, and its value appears (if the program has been compiled at least once).

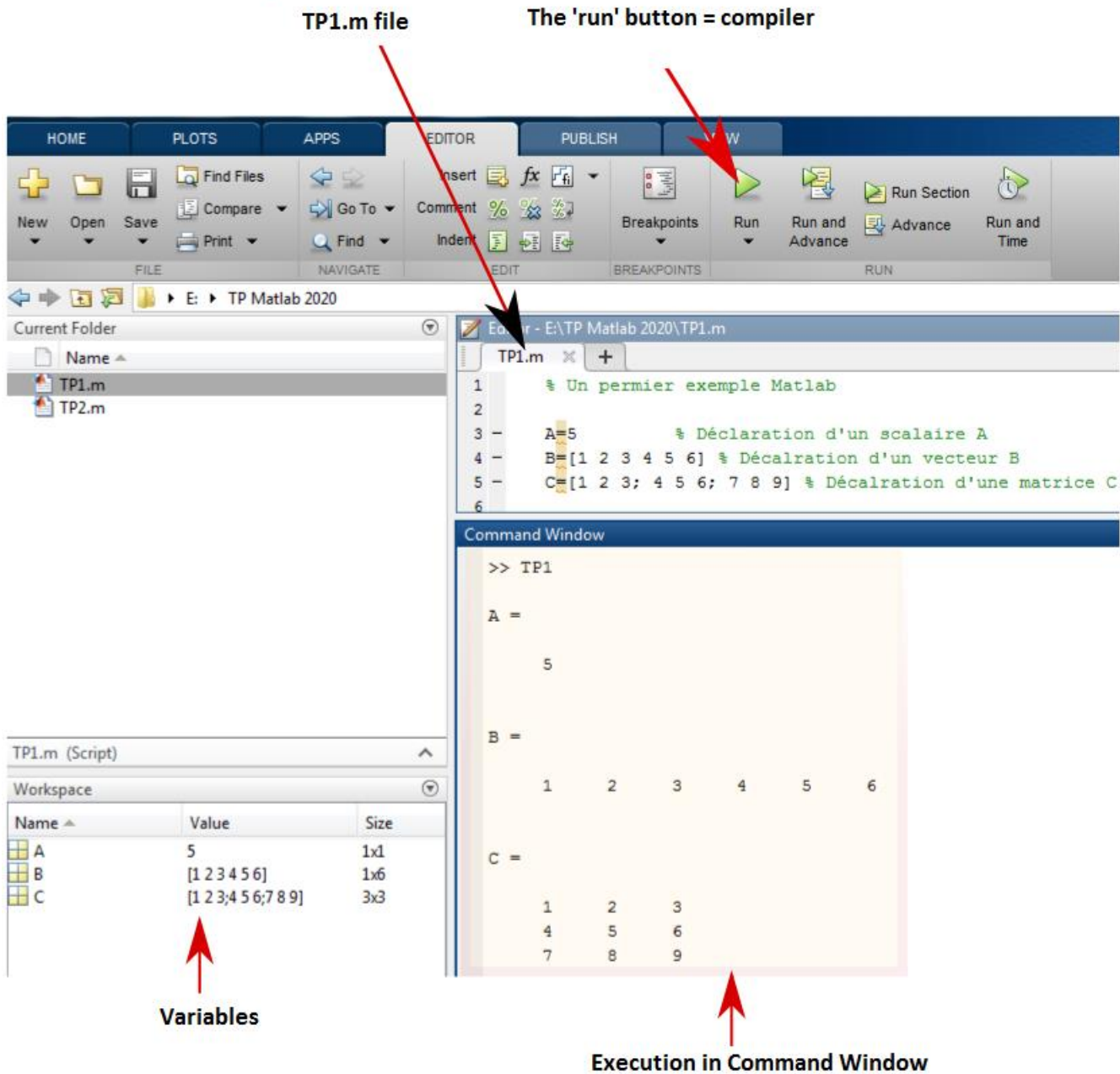


Figure 1.4: Execution of a MATLAB file.

1.2.6 Aide

MATLAB's help menu is one of the foundations of its success. Indeed, help is essential when programming with a high-level language like MATLAB, where the number of functions is very large and the syntax is sometimes complex.

To access help you can select a function and press **F1**, type **help *FunctionName*** or use the drop-down menus.

The lookfor **command** makes it possible to find in the documentation directories all the functions containing the searched word. For example, to see the list of functions related to randomness, we enter lookfor random and we get 13 functions using randomness.

1.3 First interaction with MATLAB

There are two Malab operating modes:

1. **Interactive mode:** MATLAB executes instructions as they are given by the user.

The easiest way to use MATLAB is to write directly in the Command Window right after the cursor (prompt) "`>>`".

To calculate a mathematical expression just write it like this (see figure 1.5): **The ";" and the "..."**: The semicolon at the end of a line signals MATLAB not to return the result of the operation on the screen.

```
>> A = 1 + 3;
A = 4
>> B = 2 * 3;
>>
```

In the editor/debugger as well as in the command window, the use of "." ..." is useful to continue on the line below the current instruction.

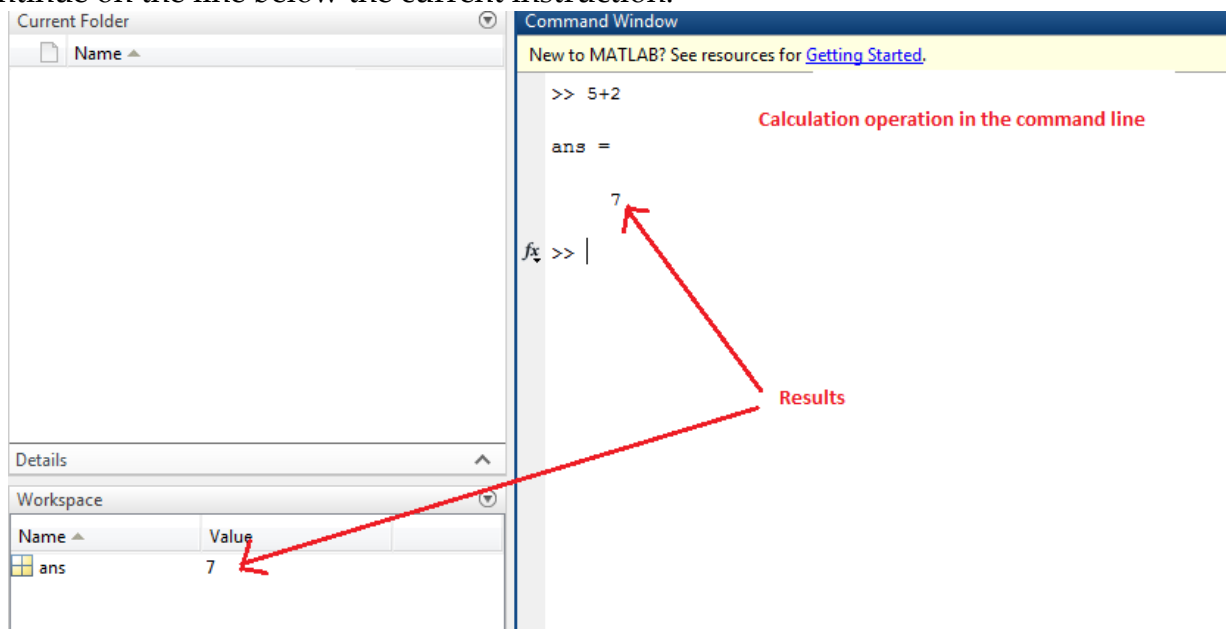


Figure 1.5: Example of execution in interactive mode.

2. **Executive mode:** MATLAB executes a MATLAB (.m extension) program line by line. A MATLAB (or 'm-file') program is a series of MATLAB instructions written in a text editor and saved in a file with an .m extension (see example 1.6).



The screenshot shows the MATLAB Editor interface. The title bar indicates the file path: 'Editor - C:\Users\Norsine\Desktop\Exemple.m'. The editor window displays the following code:

```
1  
2  
3  
4  
5  
6  
7  
8  
9 % Un premier Exemple du code matlab  
10 %Ceci est un commentaire  
11  
12 X=4 %X est une variable
```

Two red arrows point to specific elements: one points to the file name 'Exemple.m' in the tab, and another points to the code lines 9-12, which are labeled as 'Instructions'.

Figure 1.6: Execution example in executive mode (.m file).

