Introduction to MATLAB and Scripts

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Abstract

Introduction to MATLAB and script files. This development of these labs was supported by the National Science Foundation under Grant No. DUE-0511635. Any opinions, conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

1 Introduction Hà Như Phương

The goal of this lab is to provide exercises that will help you get started learning MATLAB. You will learn about the help function, vectors, complex numbers, simple math operations, and 2-D plots. You may find it useful to try some of the built-in demos in Matlab. Type `demo` to see the choices. In particular, look at the demo on "Basic matrix operations" (under "Mathematics") and on "2-D" plots (under "Graphics"). We will also look at script files in MATLAB, which we will refer to as M-files and have the file extension `*.m`.

2 Getting Started

Start MATLAB by clicking on it in the start menu. Once MATLAB is running you will see a screen similar to Figure 1. The command window, (A), is where you can enter commands. The current working directory, (B), displays the directory that MATLAB will look first for any commands. For example, if you made a new MATLAB function called `myfunc.m`, then this will need to be placed in the current working directory. You can change the working directory by typing it in the box, clicking the "..." button to browse to a folder, or typing `cd [directory name]` (i.e. `cd 'H:\ee235\lab0\'`), which is similar to the DOS/Linux cd command).

> NOTE: MATLAB supports tab completion. This means that you can type part of a command and then press tab and it will fill in the rest of the command automatically.

The workspace displays information about all the variables currently active and is shown in (C). The files in the current directory can also be displayed in (C) by clicking on the tab labeled `Current Directory`. A history of your commands is shown in (D). If you find that you do not need some of these windows open you can close them by clicking on the small x in that section of the window.

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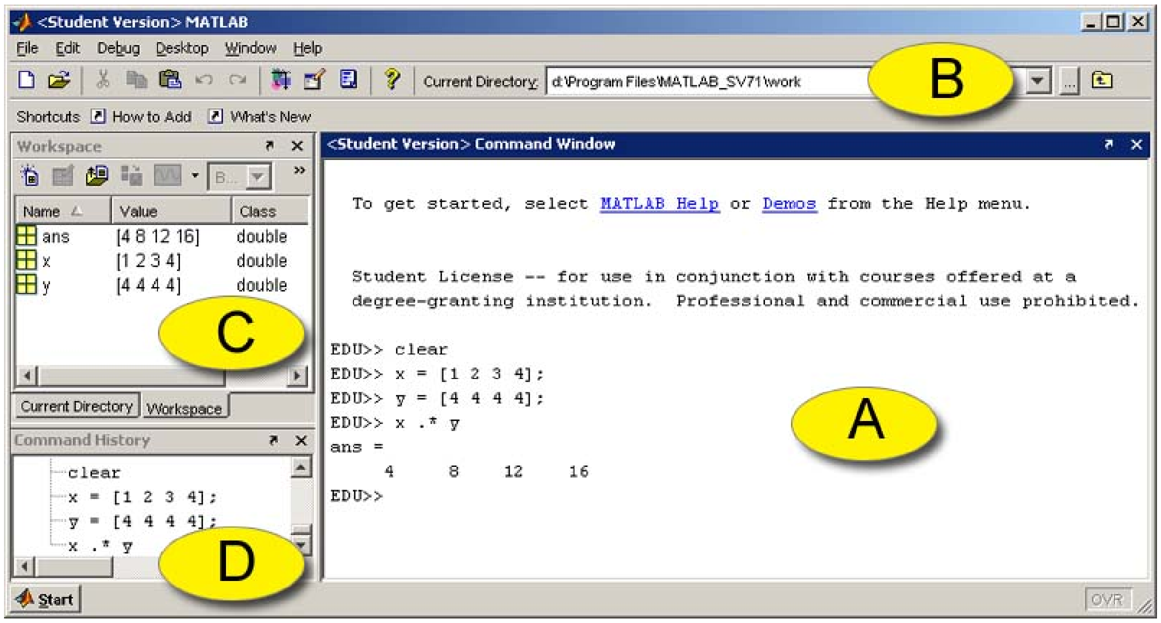
The MATLAB GUI


<Student Version> MATLAB
File Edit Debug Desktop Window Help
Current Directory: d:\Program Files\MATLAB_SV71\work
B
Shortcuts How to Add What's New
Workspace
<Student Version> Command Window
C
Current Directory Workspace
Command History
A
D
Start
OVR

Name	Value	Class
ans	[4 8 12 16]	double
x	[1 2 3 4]	double
y	[4 4 4 4]	double

```
  To get started, select MATLAB Help or Demos from the Help menu.


  Student License -- for use in conjunction with courses offered at a
  degree-granting institution.  Professional and commercial use prohibited.

EDU>> clear
EDU>> x = [1 2 3 4];
EDU>> y = [4 4 4 4];
EDU>> x .* y
ans =
     4     8    12    16
EDU>>
```

```
clear
x = [1 2 3 4];
y = [4 4 4 4];
x .* y
```

Figure 1: (a) Command window, (b) working directory, (c) workspace, (d) command history.

MATLAB IN LINUX: There are a number of different ways to use MATLAB on Linux. Typing `matlab` at the command prompt will run MATLAB in X-Windows (warning, MATLAB in X-Windows can be slow when connecting off campus). To run MATLAB without X-Windows type `matlab -nodisplay`. You can also run MATLAB using the current terminal for commands and use X-Windows for everything else (like figures) by typing `matlab -nodesktop`.

3 MATLAB Commands

MATLAB works with matrices and therefore treats all variables as a matrix. To enter the matrix

$$x = \begin{pmatrix} 3 & 1 & 5 \\ 6 & 4 & 1 \end{pmatrix}$$

type the command `x = [3 1 5; 6 4 1]`. We can represent an array with a vector, which is a special case of a matrix. A vector can be entered in by typing `y = [1 2 3]`. Now try entering `z = [1 2 3]'`. Is the output what you expect?

1. Familiarize yourself with the help command. Typing `help` gives you a list of all help topics. Typing `help <topicname>` gives help on a specific MATLAB function. For example, use `help plot` to learn about the plot command.

   MATLAB Tips 1: More useful commands

   - `whos` lists all variables
   - `clear` clears all variables

2. Perform the following operations in MATLAB:

(a) Generate the following column vectors as MATLAB variables: $x = \begin{pmatrix} 2 \\ 4 \end{pmatrix}$ and $y = \begin{pmatrix} 3 \\ 1 \end{pmatrix}$

(b) Using the computer, issue the following MATLAB commands

```
x * y'
x' * y
x .* y
```

Be sure you understand the differences between each of these and you know what the `'`, `*`, and `.*` operators do.

(c) Convince yourself that the answer makes sense by checking the matrix dimension and computing each result by hand.

3. **MATLAB Tips 2:** Plot and Subplot
The Matlab command `plot` allows you to graphically display vector data (in our case here, the two signals). For example, if you had the variables `t` for time, and `y` for the signal, typing the command `plot(t, y);` will display a plot of `t` vs. `y`. See `help plot` for more information. Annotating your plots is very IMPORTANT! Here are a few annotation commands.

- `title('Here is a title');` - Adds the text "Here is a title" to the top of the plot.
- `xlabel('Control Voltage (mV)');` - Adds text to the X-axis.
- `ylabel('Current (mA)');` - Adds text to the Y-axis.
- `grid on;` - Adds a grid to the plot.

In order to display multiple plots in one window you must use the `subplot` command. This command takes three arguments, `subplot(m, n, p)`. The first two breaks the window into a m by n matrix of smaller plot windows. The third argument, p, selects which plot is active. For example, if we have three signals x, y, and z, that we want to plot against time, t, then we can use the subplot command to produce a single window with three plots stacked on top of each other.

```
subplot(3,1,1);
plot(t,x);
subplot(3,1,2);
plot(t,y);
subplot(3,1,3);
plot(t,z);
```

See `help subplot` and `help plot` for much more information.

Create and plot a signal $x_0(t) = te^{-|t|}$ over the time range [-10,10] using the following MATLAB commands:

```
t = -10:0.1:10;
xo = t .* exp(-abs(t));
plot(t, xo); grid;
```

The first command defines an array with time values having an 0.1 increment. The ";" is used to suppress printout of the arrays (which are large), and the "`grid`" command makes the plot easier to read. Now create the signals:

$$x_e(t) = |t|e^{-(|t|)} \tag{1}$$

$$x(t) = 0.5 * [x_0(t) + x_e(t)] \tag{2}$$

Plot all signals together using 3 plots stacked on top of each other with the subplot command.

```
subplot(3,1,1);
plot(t,xo);
subplot(3,1,2);
plot(t,xe);
subplot(3,1,3);
plot(t,x);
```

Note that $x_o(t)$ and $x_e(t)$ are the odd and even components, respectively, of $x(t) = te^{-t}u(t)$

4. *Complex Numbers:* One of the strengths of MATLAB is that most of its commands work with complex numbers. Perform the following computations in MATLAB.
   (a) MATLAB recognizes `i` as an imaginary number. Try entering `sqrt(-1)` into MATLAB, does the result make sense?
   (b) MATLAB uses the letter `i` instead of `j` by default. Electrical Engineers prefer using `j` however, and MATLAB will recognize that as well. Try entering `i+j`, does this make sense.

       NOTE: If you are using complex numbers in your code, it's a good idea to avoid using `i` and `j` as variables to prevent confusion.
   (c) Define $z_1 = 1 + j$. Find the magnitude, phase, real and imaginary parts of z (using `abs()`, `angle()`, `real()`, `imag()`, respectively). Is the phase in radians or degrees?
   (d) Find the magnitude of $z_1 + z_2$ where $z_2 = 2e^{\frac{j\pi}{3}}$
   (e) Compute the value of j^j . Is the result what you expect?
5. *Complex Functions:* MATLAB also handles complex time functions in the same way (again, implemented as vectors) . Create a signal $x_1(t) = te^{\mathrm{j}t}$ over the range [-10,10], as in part 3. Next plot the real and imaginary parts of the signal in two plots, one over the other using the subplot command. Notice that one plot is odd and one is even. Try proving to your self analytically that this is what you would expect.
6. *Playing and Plotting a Sound* Load the built-in data named "handel" and play it:

```
load handel;
plot(linspace(0,9,73113),y);
sound(y);
```

NOTE: You can use the `clear` command in MATLAB to clear all of the varibles

4 Script Files

Scripts are `m-files` files that contain a sequence of commands that are executed exactly as if they were manually typed into the MATLAB console. Script files are useful for writing things in MATLAB that you want to save and run later. You can enter all the commands into a script file that you can run at a later time, and have the ability to go back and edit it later.

You need to use a text editor to create script files, e.g. `Notepad` on the PC's (`pico`, `emacs`, or `vi` on Linux machines). MATLAB also has an internal editor that you can start by clicking on a `.m` file within MATLAB's file browser. All are easy to learn and will produce text files that MATLAB can read.

Click here[1] to download the `dampedCosine.m` script and be sure to save it with that name to follow the instructions here exactly. It is very important that script filenames end in `.m`. Be sure that MATLAB's working directory is set to the location of where you saved the script file. Type dampedCosine at the MATLAB prompt. Look at the m-file in a text editor and verify that you get the plot predicted in the comment field of the script.

NOTE: The `%` character marks the rest of the line as a comment.

Exercise 1

Scripts Now we are going to edit the `dampedCosine.m` file to create our own script file. At the top of the file, you will see the following commands

```
diary 'your_name_Lab1.txt'
disp('NAME: your name')
disp('SECTION:your section')
```

1. Edit the dampedCosine.m (download from link above) script and enter your name and section where indicated. Save this new version of the script as `yourName_dampedCosine.m`
2. Edit the script to create a second signal where the cosine with twice the period (which gives half the frequency) of the first.
3. Add to the script the commands to plot these together with the first signal on top and the second on the bottom. In other words, you should have a single figure with two different plots, one on top and one on bottom. You will need to use `subplot` and `plot`. Save this plot as `yourName_dampedCosine.fig`.
4. Show the TA your dampedCosine plot. What is the period of the cosine?

Exercise 2

Complex exponentials Download and run compexp.m[2] , which includes a 3-D plot of a complex exponential, $y(t)$, as well as 2-D magnitude/phase and real/imaginary plots. You need 2 2-D plots to have the same information as the 3-D plot. How would you change the script to make the oscillation frequency lower by half? How would you change the script to make the decay faster? Show the TA your plots.

[1]http://cnx.org/content/m13554/latest/dampedCosine.m
[2]http://cnx.org/content/m13554/latest/compexp.m