Chapter 1

Getting Started with Matlab

These notes are an introduction to the computer algebra system Matlab, which will be used from time to time in this course, Introduction to Differential Equations (Math 340). These notes are specifically tailored to the course. Feedback about the effectiveness of the notes is welcome and appreciated.

Matlab is an extremely powerful (and complex) computing tool. Happily, it is relatively easy to learn the basics of Matlab, and the basics can provide you with some very impressive capabilities. These notes take a 'learn by doing' approach. They will be very light on programming theory, stressing instead examples relevant to this course. For the most part, it is assumed that you are sitting at a computer, operating in the Matlab enviroment, while you are reading the notes. There will (of course) be exercises designed to solidify and extend your understanding of the material.

To start, log on to your computer and click on the Matlab icon. You should get the standard Matlab screen, illustrated on the next page. The standard screen has three boxes: a command window on the right, a list of files in the current directory at the upper left, and a command history at the lower left.

Try entering the following commands in the command window. After typing each command, hit 'enter' or 'return' on your keyboard.

$$2 + 2$$

$$2 * 3$$

$$2 \wedge 4$$

$$16/13$$

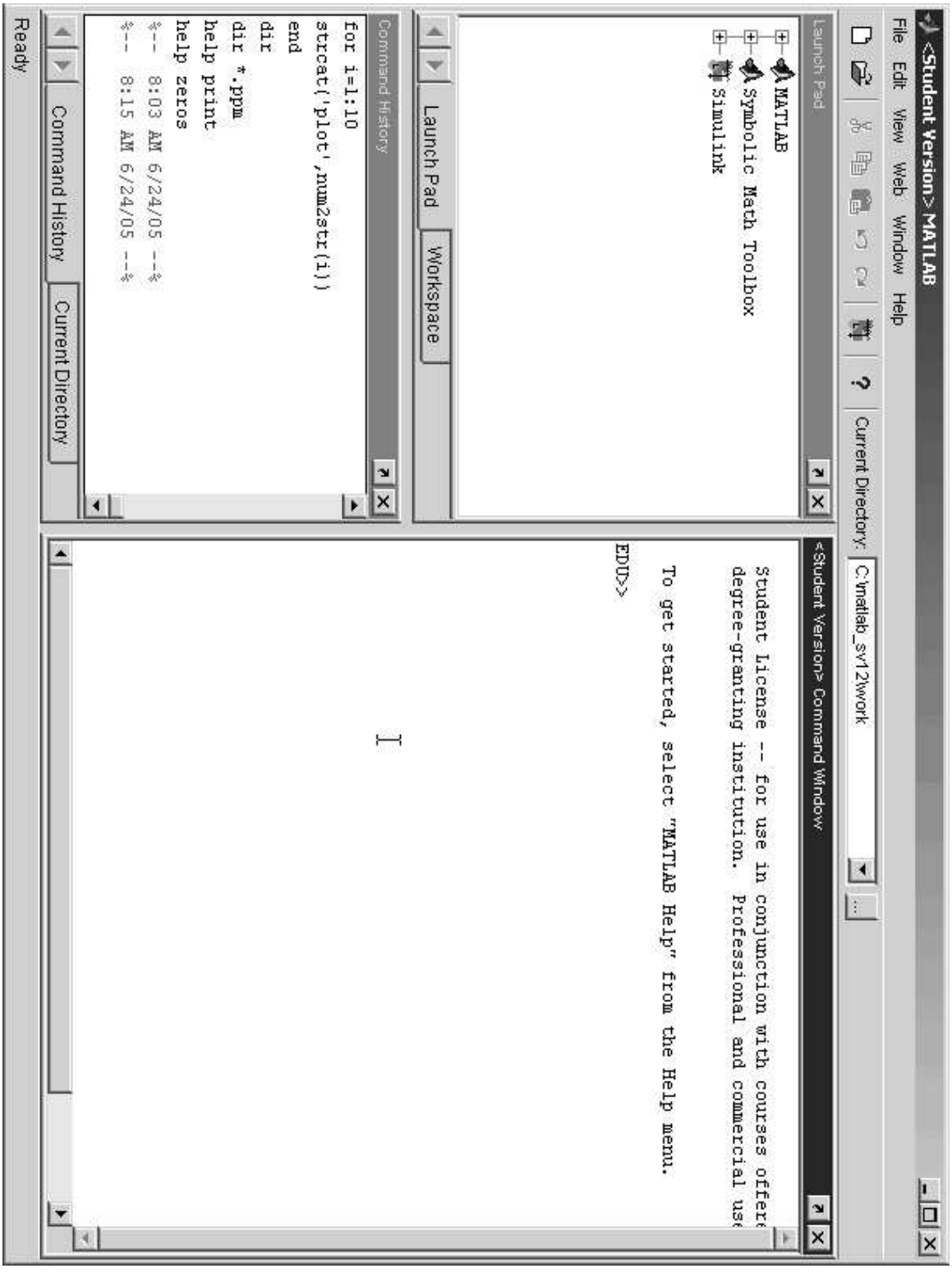

Figure 1: The standard Matlab screen

Notice there is no punctuation on these lines. Matlab does the calculation, and reports the result.

Now enter the following commands in the command window.

$$x = 6$$

$$x = 6;$$

$$x$$

$$y = 3.14159;$$

Notice that output is supressed if the line ends in a semicolon. Let's multiply x and y.

$$xy$$

Oops. Computers typically do not allow you to omit the multiplication sign. If you want the product of x and y you have to enter

$$x * y$$

Matlab has the constant π built in, with the name 'pi'. It also has the elementary functions you are familiar with from Calculus. For example, type

$$x = exp(1)$$

and

$$ln(x)$$

Another oops. In Matlab the natural logarithm function is

$$log(x)$$

Here is an illustrative example. Type

$$pi$$

and

$$sin(pi)$$

Since $\sin(\pi) = 0$, Matlab has not exactly computed the requested value.

This may be a good time to introduce a basic distinction between what Matlab does and what students usually do in a mathematics class. When doing mathematical calculations, Matlab is oriented toward decimal or binary

representations of numbers, while students are mainly working symbolically. For a student, π means the exact area of a circle of radius 1. For Matlab, π is a high precision approximation of that number. When Matlab computes $\sin(\pi)$ it does not recall that the exact value of $\sin(\pi)$ is 0. Instead, it puts the high precision approximation of π into an algorithm for high precision computation of $\sin(x)$ for 'any' number x. The result is a very accurate value which may not be exact.

Try typing

$$f = (x^2 + x)^2$$

Another oops. We've already given x a numerical value, so this command merely computes a number. We could try unassigning x, which is done with the command

$$clear\ x$$

or we can try typing

$$f = (z^2 + z)^2$$

This is not working the way you might expect. Matlab needs help to understand that you want a symbolic expression. Here is a way to define a function symbolically.

$$f = inline('x^2 + 2 * x + exp(x)')$$

Now try $f(0)$ or $f(10)$.

One really nice feature of computer algebra systems like Matlab is that they generate nice graphics with minimal effort. Here is a simple command that will plot our function f.

$$ezplot(f, [0, 5])$$

If you want to plot a simple function without the intermediate step of defining an inline function, you can do that too, but the character string defining the function should be put in single quotes, like this.

$$ezplot('sin(x^2)', [0, 20])$$

If your computer is connected to a printer, you can print the plot by using the task bar.

When computer algebra systems were being developed, there was a fairly sharp distinction between numerical packages like Matlab, and symbolic packages like Maple. Currently, Matlab has absorbed much of Maple, so

it is possible to manipulate symbols in the style of algebra or calculus. You let Matlab know your intentions by declaring symbolic variables.

$$x = sym('x');$$

Then we can define more complex symbolic expressions

$$y = 5 * x^3 + 4 * x^2 + sin(x)$$

Let's differentiate symbolically.

$$g = diff(y, x)$$

Then integrate

$$h = int(g)$$

and plot the result

$$ezplot(h, [0, 10])$$

More information about the symbolic cabablities of Matlab can be found in the documentation for the Symbolic Toolbox. In fact, this would be a good time to familiarize yourself with the online documentation that comes with Matlab. You can access this documentation by clicking on the Help icon at the top of the page.

1.1 Exercises

Here is a (somewhat frustrating) exercise which illustrates some limitations of Matlab.

1. Define the 'inline' functions $x = t$ and $y = t^2$. We'd like to display the two functions on the same graph. Try

```
ezplot(x,y,[0 10])
```

Does this command give you what you want? Use the online documentation to find out what ezplot is doing. Write a brief description of the problem.

2. It is not unusual to want a plot of a function with a very large range of values. Use ezplot to plot the function

```
f = exp(x^4) - 100
```

for $0 \leq x \leq 10$. What do you see? What is the problem?

3. One trick for plotting data with a large range of values is to use logarithmic scaling. Can we define

```
g = log(f)
```

and plot g? What happens?

4. Try defining

```
g = inline('log(exp(x^4) - 100)')
```

Use ezplot to plot the graph for $0 \leq x \leq 10$. What happened to the graph for small and large values of x?

5. Explain how the problems for small values of x in the previous problem can be solved by plotting

```
h = inline('sign(exp(x^4) - 100)*log(1 + abs(exp(x^4) - 100))')
```

6. Explain the difficulty in problem 4 with large values of x. (Hint: have Matlab evaluate $exp(10^4)$)