

Preface:

How to Use This Book

As the open-source and free competitor to expensive software like Maple[™], Mathematica[®], Magma, and Matlab[®], Sage offers anyone with access to a web browser the ability to use cutting-edge mathematical software and display the results for others, often with stunning graphics. I'm sure that you will find Sage far easier to use than a graphing calculator, and vastly more powerful.



There is no need to read this entire document, just as you would never read the dictionary cover to cover. This book is ideal for self-study, but if you are assigned this book as part of a class, then your professor will tell you which section numbers correspond to what you need to be reading.

For other readers, who are reading independently of a specific class, I have the following suggestions:

- Chapter 1 contains the basics—what you really need to know. Most of the common tasks in Sage were carefully designed to be as intuitive as possible, with notation as close as possible to how mathematics is done on the whiteboard or with a pencil. I recommend that you never try to read more than 3 entire sections in one day. Otherwise there is too much for your brain to absorb while still keeping the experience fun and new. However, 1–2 sections per day should be easily digestible.

Note: Personally, I recommend just reading Chapter 1, and then start playing around on your own. The best way to learn a new bit

of computer software is to use it recreationally. Using the table of contents or the index of commands (in Appendix F), you can always look up how to do some task which you haven't learned yet. If you get flummoxed at any point, be sure to check out Appendix A, "What to Do When Frustrated!"

- Chapter 2 contains projects where you can use Sage to solve mathematics problems as they arise in other subjects—cryptography, physics, chemistry, biology, and so forth. These projects are primarily aimed to be tractable after reading Chapter 1. However, in some cases, another section from a higher numbered chapter will be required also. Of course, in those cases, the dependency is clearly marked. These projects are intended to be assigned over weekends. They are not large enough to be semester projects, but they are too large to be homework problems.
- Chapter 3 is all about making beautiful plots and graphs. I have included everything that I could. However, some types of plots, such as 3D plots, animated plots, and multicolored plots, cannot be easily represented in a printed black-and-white book. Therefore, those types of plots are covered in the electronic-only online appendix to this book "Plotting in Color, in 3D, and Animations," available on my webpage www.gregorybard.com for downloading by clicking on the link, at the left of the screen, for Sage.
- Chapter 4 is enormous and contains small sections that discuss advanced mathematical topics. Sage can handle an extraordinary variety of math problems. This chapter was designed so that the individual sections can be read independently. There is no need to read the sections in Chapter 4 in order, unless you want to.
- Chapter 5 is about how to program in Python using Sage. As a computer algebra system, Sage is built on top of the computer language Python. Therefore, you can use Python commands in Sage. Sometimes this is really useful—for example, you can write `for` loops to make tables very easily. At other times it is convenient to write entire computer programs in Python using Sage as the interface. This is even more true when using SageMathCloud™.
- Chapter 6 covers making interactive webpages (called "apps") using Sage. The process is remarkably straightforward. I have a six-stage process which I've been using myself. You can make extremely interesting interacts using Sage, and I'll bet you'll be surprised at how easy it is to make your own.
- Appendix A is "What to Do When Frustrated!" There I have a list of questions you should ask yourself if you get stuck in a situation where Sage is refusing to respond to your commands in the way that you'd like. In almost all cases, one of the listed items will present you with a way of resolving the frustration.

- Appendix B is about gaining familiarity with SageMathCloud and some of its features. Cloud computing is a new and exciting way to compute using the Internet, instead of your local machine, as a place for storing your files.

Note: Generally users will want to switch to SageMathCloud after completing Chapter 1, before tackling the projects in Chapter 2 or the advanced work of Chapters 4–6. I think the information in Chapter 3 can be learned before or after learning SageMathCloud, with no disadvantage to the user.

- Appendix C is a collection of further resources on Sage, for readers who would like to learn more than this book contains.
- Appendix D is my response to the fact that students often do not have facility with systems of linear equations that have an infinite number of solutions. This concept is often grasped as an idea, but the details are often not there when I need students to know them. Therefore, I have decided to be hyper-thorough and devote a large number of pages to explaining this (admittedly difficult) subject. I hope it will be useful to students.
- Appendix E is what you should read if you want to learn how to install Sage on your local machine.
- Appendix F is an eighteen(!)-page index of all the commands in this book, for your reference. Special thanks to Thomas Suiter, who prepared it.
- The online electronic appendix will cover plotting in color, animations, and 3D graphics. Those subjects are not suited to a black-and-white book and therefore cannot be printed within these covers. You can download that from my webpage

www.gregorybard.com

by clicking on the link, at the left of the screen, for Sage.

Let's Dive In! Right Now!

Without any hesitation whatsoever, open up a web browser at this very moment. Type in the following URL:

<https://sagecell.sagemath.org/>

You have now connected to the “Sage Cell Server.” Now you shall see a large window (called a cell) and a big button marked “Evaluate.” In that cell, type

```
solve( x^2 - 16 == 0, x )
```

and then click “Evaluate.”

You should receive back the answer

```
[x == -4, x == 4]
```

which is clearly the correct set of two solutions to the equation $x^2 - 16 = 0$. You have now solved your first math problem with Sage. Congratulations!

Welcome to Sage! You are now ready to begin reading Chapter 1.