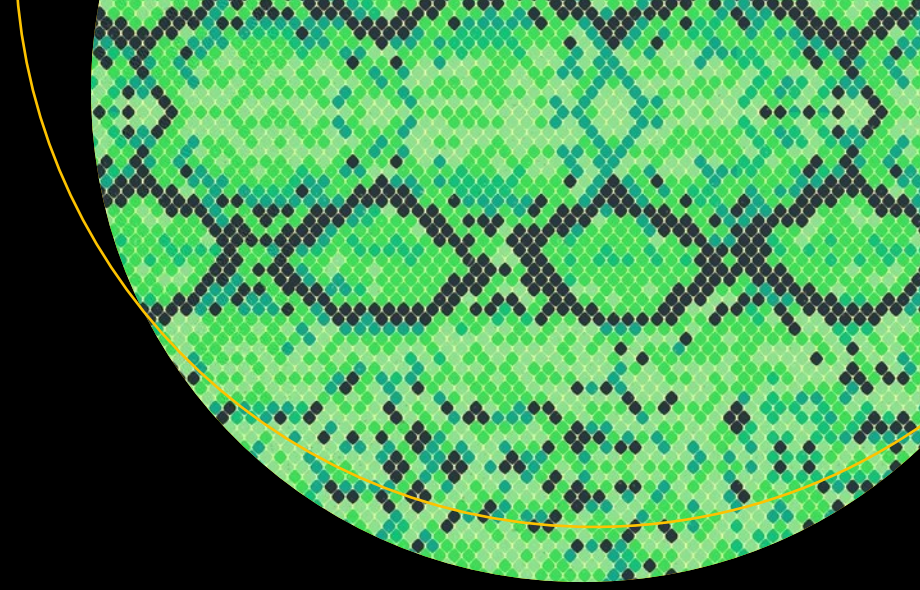

Beginning Python

From Novice to Professional

—

Fourth Edition

—

Magnus Lie Hetland
Fabio Nelli

Apress®

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Beginning Python: From Novice to Professional, Fourth Edition

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Fabio Nelli is a data scientist and consultant for companies in the scientific-pharmaceutical field and teaches Python programming and data management. He is the author of several books on programming, such as *Python Data Analytics*, now in its third edition. He gained experience in programming while working for companies such as IBM, EDS, Merck, Hewlett-Packard, and several banks and insurance companies. He has a master's degree in organic chemistry and a bachelor's degree in automation IT engineering.

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Andrea Gavana has been programming Python for more than 20 years, as well as dabbling with other languages since the late 1990s. He has a master's degree in chemical engineering, and he is now a master development planning architect working for TotalEnergies in Copenhagen, Denmark.

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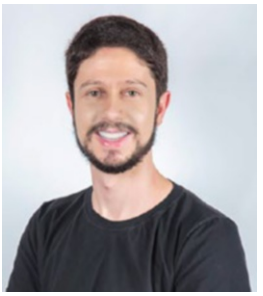

Vinícius Gubiani Ferreira is an experienced IT professional with more than 15 years of experience in IT areas such as software development, cloud computing, and DevOps. He's been working, learning, and sharing knowledge about Python for 10 years. He currently works as a QA team lead and previously worked as a software engineer in several different industries. He studied electrical engineering at UFRGS and software engineering at PUCRS, and he has an MBA in project management from FGV; he also loves to code, read other people's code, and help others achieve what they want with code, be it directly or by guiding them to figure it out for themselves.

Preface

Hello! Magnus here. Another edition—this time with less involvement from me. This time around, Fabio has entered the scene and done the heavy lifting, updating outdated material and replacing some of the rustier projects. This includes new material on using various coding environments, handling files in several specialized formats, and using Docker with databases and `asyncio` for network programming, for example. He also replaced essentially all of the (really outdated) material on packaging in Chapter 18, swapped out five of the projects with new activities (Chapters 25–29), and added a couple of appendixes (C and D). And he added lots of screenshots! Thanks to him, to the technical reviewers, and to the Apress staff for making this new edition a reality!

Introduction

A C program is like a fast dance on a newly waxed dance floor by people carrying razors.

—Waldi Ravens

C++: Hard to learn and built to stay that way.

—Anonymous

Java is, in many ways, C++ – –.

—Michael Feldman

And now for something completely different . . .

—Monty Python's Flying Circus

I've started this introduction with a few quotes to set the tone for the book, which is rather informal. In the hope of making it an easy read, I've tried to approach the topic of Python programming with a healthy dose of humor, and true to the traditions of the Python community, much of this humor is related to Monty Python sketches. As a consequence, some of my examples may seem a bit silly; I hope you will bear with me. (And, yes, the name Python is derived from Monty Python, not from snakes belonging to the family Pythonidae.) In this introduction, I give you a quick look at what Python is, why you should use it, who uses it, who this book's intended audience is, and how the book is organized.

So, what is Python, and why should you use it? To quote an old official blurb, it is "an interpreted, object-oriented, high-level programming language with dynamic semantics." Many of these terms will become clear as you read this book, but the gist is that Python is a programming language that knows how to stay out of your way when you write your programs. It enables you to implement the functionality you want without any hassle and lets you write programs that are clear and readable (much more so than programs in most other currently popular programming languages).

Even though Python might not be as fast as compiled languages such as C or C++, what you save in programming time will probably make it worth using it, and in most programs, the speed difference won't be noticeable anyway. If you are a C programmer, you can easily implement the critical parts of your program in C at a later date and have them interoperate with the Python parts. If you haven't done any programming before (and perhaps are a bit confused by my references to C and C++), Python's combination of simplicity and power makes it an ideal choice as a place to start.

So, who uses Python? Since Guido van Rossum created the language in the early 1990s, its following has grown steadily, and interest has increased markedly in the past few years. Python is used extensively for system administration tasks (it is, for example, a vital component of several Linux distributions), but it is also used to teach programming to complete beginners. The US National Aeronautics and Space Administration (NASA) uses Python both for development and as a scripting language in several of its systems. Industrial Light & Magic uses Python in its production of special effects for large-budget feature films. Yahoo! uses it (among other things) to manage its discussion groups. Google has used it to implement many components of its web crawler and search engine. Python is being used in such diverse areas as computer games and bioinformatics. Soon one might as well ask, "Who isn't using Python?"

This book is for those of you who want to learn how to program in Python. It is intended to suit a wide audience, from neophyte programmers to advanced computer whizzes. If you have never programmed before, you should start by reading Chapter 1 and continue until you find that things get too advanced for you (if, indeed, they do). Then you should start practicing and write some programs of your own. When the time is right, you can return to the book and proceed with the more intricate stuff.

If you already know how to program, some of the introductory material might not be new to you (although there will probably be some surprising details here and there). You could skim through the early chapters to get an idea of how Python works or perhaps read Appendix A, which is based on my online Python tutorial "Instant Python." It will get you up to speed on the most important Python concepts. After getting the big picture, you could jump straight to Chapter 10 (which describes the Python standard libraries).

The last 10 chapters present 10 programming projects and activities, which show off various capabilities of the Python language. These projects and activities should be of interest to beginners and experts alike. They touch upon a wide range of topics, most of which will be useful to you when writing programs of your own. You will learn how to do things that may seem completely out of reach to you at this point, such as creating a peer-to-peer file-sharing system or a full-fledged graphical computer game. Although much of the material may seem hard at first glance, I think you will be surprised by how easy most of it really is.

Well, that's it. I always find long introductions a bit boring myself, so I'll let you continue with your Pythoneering, either in Chapter 1 or in Appendix A. Good luck, and happy hacking.

CHAPTER 1

Instant Hacking: The Basics

It's time to start hacking.[1] In this chapter, you learn how to take control of your computer by speaking a language it understands: Python. Nothing here is particularly difficult, so if you know the basic principles of how your computer works, you should be able to follow the examples and try them out yourself. I'll go through the basics, starting with the excruciatingly simple, but because Python is such a powerful language, you'll soon be able to do pretty advanced things.

To begin, you need to install Python, or verify that you already have it installed. If you're running macOS, Windows, or Linux/UNIX, open a terminal (the Terminal app on a Mac, or Command on Windows), type in `python`, and press Enter. You should get a welcome message describing the current version and operating system in which it runs. Furthermore, some commands are suggested that could be useful, such as `help`, with which you can obtain information on other commands. Finally, you'll see a prompt consisting of the three characters `>>>` as follows:

```
Python 3.11.5 (tags/v3.11.5:cce6ba9, Aug 24 2023, 14:38:34) [MSC v.1936 64 bit (AMD64)]
on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

If everything went correctly as described, then it means you have just opened an **interactive interpreter session** and the system is ready to accept any line of code in Python and execute it after pressing the Enter key.

But before we start working with it, you can immediately check the currently installed version on your system. If it is too outdated, you should update it to the latest version released. A quicker way to know the Python version, without opening an interactive interpreter session, is to write the following command in the terminal:

```
python --version
```

The details of the installation process will of course vary with your OS and preferred installation mechanism, but the most straightforward approach is to visit `https://www.python.org/downloads/`, where all versions of Python are listed, including the latest release, each with a download link. For Windows and Mac, you'll download an installer that you can run to actually install Python. For Linux/UNIX, Python is generally installed by default, but if this is not the case, it is always possible to install it via APT or other advanced package tools (depending on the distributions).

[1] *Hacking* is not the same as *cracking*, which is a term describing computer crime. The two are often confused, and the usage is gradually changing. *Hacking*, as I'm using it here, basically means "having fun while programming."

M. L. Hetland and F. Nelli, *Beginning Python*, https://doi.org/10.1007/979-8-8688-0196-9_1

■ **Note** The starting point for working with Python is to open an interactive interpreter session from the terminal and start executing commands line by line. There are, however, many other ways to develop and execute code in Python, some simpler and others more complex, which make use of additional applications or web interfaces. We will look at some of these throughout the book, but in the meantime I recommend taking a look at Appendix C, which shows an overview of these methods, with a detailed description of their use.

The Interactive Interpreter

When you start up Python, you get a prompt similar to the following:

```
Python 3.11.5 (tags/v3.11.5:cce6ba9, Aug 24 2023, 14:38:34) [MSC v.1936 64 bit (AMD64)]
on win32
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

The exact appearance of the interpreter and its error messages will depend on which version you are using. This might not seem very interesting, but believe me, it is. This is your gateway to hackerdom—your first step in taking control of your computer. In more pragmatic terms, it's an interactive Python interpreter. Just to see if it's working, try the following:

```
>>> print("Hello, world!")
```

When you press the Enter key, the following output appears:

```
Hello, world!
>>>
```

If you are familiar with other computer languages, you may be used to terminating every line with a semicolon. There is no need to do so in Python. A line is a line, more or less. You can add a semicolon if you like, but it won't have any effect (unless more code follows on the same line), and it is not a common thing to do.

So what happened here? The `>>>` thingy is the prompt. You can write something in this space, like `print("Hello, world!")`. If you press Enter, the Python interpreter prints out the string "Hello, world!" and you get a new prompt below that.

What if you write something completely different? Try it:

```
>>> The Spanish Inquisition
SyntaxError: invalid syntax
>>>
```

Obviously, the interpreter didn't understand that.[2] (If you are running an interpreter other than IDLE, such as the command-line version for Linux, the error message will be slightly different.) The interpreter also indicates what's wrong: it will emphasize the word *Spanish* by giving it a red background (or, in the command-line version, by using a caret, ^).

[2] After all, no one expects the Spanish Inquisition . . .

If you feel like it, play around with the interpreter some more. For some guidance, try entering the command `help()` at the prompt and pressing Enter. You can press F1 for help about IDLE. Otherwise, let's press on. After all, the interpreter isn't much fun when you don't know what to tell it.

Algo . . . What?

Before we start programming in earnest, I'll try to give you an idea of what computer programming is. Simply put, it's telling a computer what to do. Computers can do a lot of things, but they aren't very good at thinking for themselves. They really need to be spoon-fed the details. You need to feed the computer an algorithm in some language it understands. *Algorithm* is just a fancy word for a procedure or recipe—a detailed description of how to do something. Consider the following:

```
SPAM with SPAM, SPAM, Eggs, and SPAM: First, take some SPAM.
Then add some SPAM, SPAM, and eggs.
If a particularly spicy SPAM is desired, add some SPAM.
Cook until done -- Check every 10 minutes.
```

Not the fanciest of recipes, but its structure can be quite illuminating. It consists of a series of instructions to be followed in order. Some of the instructions may be done directly ("take some SPAM"), while some require some deliberation ("If a particularly spicy SPAM is desired"), and others must be repeated several times ("Check every 10 minutes.")

Recipes and algorithms consist of ingredients (objects, things) and instructions (statements). In this example, SPAM and eggs are the ingredients, while the instructions consist of adding SPAM, cooking for a given length of time, and so on. Let's start with some reasonably simple Python ingredients and see what you can do with them.

Numbers and Expressions

The interactive Python interpreter can be used as a powerful calculator. Try the following:

```
>>> 2 + 2
```

This should give you the answer 4. That wasn't too hard. Well, what about this:

```
>>> 53672 + 235253
288925
```

Still not impressed? Admittedly, this is pretty standard stuff. (I'll assume that you've used a calculator enough to know the difference between `1 + 2 * 3` and `(1 + 2) * 3`.) All the usual arithmetic operators work as expected. Division produces decimal numbers, called *floats* (or *floating-point numbers*).

```
>>> 1 / 2
0.5
>>> 1 / 1
1.0
```

If you'd rather discard the fractional part and do integer division, you can use a double slash.

```
>>> 1 // 2
0
>>> 1 // 1
1
>>> 5.0 // 2.4
2.0
```

Now you've seen the basic arithmetic operators (addition, subtraction, multiplication, and division), but I've left out a close relative of integer division.

```
>>> 1 % 2
1
```

This is the remainder (modulus) operator. `x % y` gives the remainder of `x` divided by `y`. In other words, it's the part that's left over when you use integer division. That is, `x % y` is the same as `x - ((x // y) * y)`.

```
>>> 10 // 3
3
>>> 10 % 3
1
>>> 9 // 3
3
>>> 9 % 3
0
>>> 2.75 % 0.5
0.25
```

Here `10 // 3` is 3 because the result is rounded down. But `3 × 3` is 9, so you get a remainder of 1. When you divide 9 by 3, the result is exactly 3, with no rounding. Therefore, the remainder is 0. This may be useful if you want to check something "every 10 minutes" as in the recipe earlier in the chapter. You can simply check whether `minute % 10` is 0. (For a description on how to do this, see the sidebar "Sneak Peek: The if Statement" later in this chapter.) As you can see from the final example, the remainder operator works just fine with floats as well. It even works with negative numbers, and this can be a little confusing.

```
>>> 10 % 3
1
>>> 10 % -3
-2
>>> -10 % 3
2
>>> -10 % -3
-1
```

Looking at these examples, it might not be immediately obvious how it works. It's probably easier to understand if you look at the companion operation of integer division.

```
>>> 10 // 3
3
>>> 10 // -3
-4
```

```
>>> -10 // 3
-4
>>> -10 // -3
3
```

Given how the division works, it's not that hard to understand what the remainder must be. The important thing to understand about integer division is that it is rounded *down*, which for negative numbers is *away from zero*. That means `-10 // 3` is rounded *down* to `-4`, not *up* to `-3`.

The last operator we'll look at is the exponentiation (or power) operator.

```
>>> 2 ** 3
8
>>> -3 ** 2
-9
>>> (-3) ** 2
9
```

Note that the exponentiation operator binds tighter than the negation (unary minus), so `-3**2` is in fact the same as `-(3**2)`. If you want to calculate `(-3)**2`, you must say so explicitly.

Hexadecimals Octals and Binary

To conclude this section, I should mention that hexadecimal, octal, and binary numbers are written like this:

```
>>> 0xAF
175
>>> 0b10
2
>>> 0b1011010010
722
```

The first digit in both of these is zero. (If you don't know what this is all about, you probably don't need this quite yet. Just file it away for later use.)

Variables

Another concept that might be familiar to you is *variables*. If algebra is but a distant memory, don't worry: variables in Python are easy to understand. A variable is a name that represents (or refers to) some value. For example, you might want the name `x` to represent `3`. To make it so, simply execute the following:

```
>>> x = 3
```

This is called an *assignment*. We assign the value `3` to the variable `x`. Another way of putting this is to say that we *bind* the variable `x` to the value (or object) `3`. After you've assigned a value to a variable, you can use the variable in expressions.

```
>>> x * 2
6
```