

THE COMPLETE PYTHON DEVELOPER

FROM FIRST STEPS TO
PROFESSIONAL DEVELOPMENT



PRACTICAL
SKILLS



MODERN
TOOLS



BEST
PRACTICES



REAL-WORLD
PROJECTS

JARED NOVAK

The Complete Python Developer

From First Steps to Professional Development

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From First Steps to Professional Development

Python is one of the most widely used programming languages in the world, powering everything from web applications and data pipelines to artificial intelligence systems and scientific research. Its clarity, versatility, and massive ecosystem make it an ideal first language for beginners and a daily tool for seasoned professionals. Yet mastering Python means more than memorizing syntax; it requires understanding modern practices, tooling, and patterns that separate hobbyist scripts from production-grade software.

This book takes you on that complete journey. Starting with absolute fundamentals, each chapter builds deliberately on the last, introducing concepts through clear explanations and working code examples that follow current best practices. By the end, you will be able to design, write, test, package, and deploy professional Python applications using the latest stable release of Python and the modern toolchain that surrounds it. No prior programming experience is required, but no reader should feel talked down to. The goal is a single resource you can start with on day one and return to as your skills grow.

Introduction: Why Python, and Where to Start

Every programming language makes a promise. C promises control. JavaScript promises ubiquity in the browser. Rust promises memory safety without sacrificing speed. Python's promise is simpler but no less powerful: it promises that you can express complex ideas clearly, get things done quickly, and rely on an ecosystem of tools and libraries that have been refined over decades by millions of developers.

That promise is why Python consistently ranks among the top three most popular programming languages worldwide. It is the language of choice for data science, machine learning, and artificial intelligence. It powers web backends at companies from Instagram to Netflix. Scientists use it to analyze telescope data and model climate systems. Engineers use it to automate infrastructure, manage cloud deployments, and interact with APIs across the internet. And beginners choose it because, more than almost any other language, Python reads like English.

What This Book Will Do for You

This book is designed as a complete path from zero to professional competence. It is organized into eighteen chapters that progress logically:

The first four chapters establish your foundation. You will learn to install Python, write your first programs, understand variables and data types, control program flow with conditionals and loops, and organize code into reusable functions. By the end of this section you will be comfortable reading and writing basic Python scripts.

Chapters five through nine deepen your understanding. You will master Python's core data structures, learn to organize code across multiple files and packages, build object-oriented designs with classes, handle errors gracefully, debug interactively, write tests to verify correctness, and work with files and

external data formats. This is the transition from writing small programs to building real applications.

Chapters ten through thirteen cover advanced topics that professional developers use daily. You will explore functional programming patterns like generators and decorators, understand concurrency models including threading, multiprocessing, and asynchronous programming, build networked applications that communicate over HTTP, and integrate databases for persistent storage with performance optimization.

Chapters fourteen through fifteen focus on the professional workflow. You will learn Python's type system and how to use static analysis tools to catch errors before running code. You will configure linters and formatters, set up pre-commit hooks, generate project documentation, package your projects for distribution, manage dependencies reliably, set up continuous integration pipelines, containerize applications with Docker, and apply security best practices.

The final three chapters extend your expertise into specialized domains. You will learn to profile and optimize Python code for performance, apply design patterns to build scalable architectures, and work with the data science and AI/ML ecosystem including NumPy, pandas, scikit-learn, PyTorch, and TensorFlow.

How to Read This Book

The chapters are sequential for a reason. Each one assumes you have absorbed the previous material. If you are new to programming, read from the beginning. If you already know another language and want to learn Python efficiently, you can move quickly through the early chapters but should still review them to understand Python-specific conventions.

Every significant concept includes complete, runnable code examples. You should type these examples yourself rather than copying and pasting. The act of typing reinforces learning and helps you notice details that easy copying would hide. All code follows modern Python conventions including type hints where helpful, f-strings for formatting, pathlib for file operations, and current standard library recommendations. The book targets Python 3.12 and later; all examples are compatible with the latest stable release.

A running project threads through many chapters: a task manager application that starts as a simple script and gradually evolves into a fully featured command-line tool with database storage, tests, type checking, and packaging. This project demonstrates how concepts accumulate in real development.

A Note on Learning

Learning to program is learning to think in a new way. It is normal to feel confused at times. It is normal to write code that does not work and spend time figuring out why. Debugging is not failure; it is the core activity of programming. Every professional developer spends a significant portion of their time reading error messages, tracing through logic, and refining solutions. This book will help you develop those skills deliberately rather than accidentally.

The Python community is one of the most welcoming in software development. When you encounter a problem, chances are someone has already written about it. Official documentation at docs.python.org is excellent and should be your first reference. Stack Overflow, GitHub, and countless tutorials provide additional support. The skills you build reading this book will prepare you to use those resources effectively.

Let's get started.

Chapter 1: Welcome to Python, Your First Steps

Programming begins with a single step: getting Python installed and running your first line of code. This chapter covers everything you need to set up your environment, understand how Python executes programs, write your first script, and choose tools that will serve you throughout this book and beyond.

Why Python Matters Today

Python was created by Guido van Rossum in the late 1980s and released publicly in 1991. Its design philosophy emphasizes code readability and simplicity. The language's guiding principle, captured in the Zen of Python (PEP 20), states that “Readability counts” and that there should be “one, and preferably only one, obvious way to do it.” These principles are not just philosophical preferences; they make Python practical for real-world development.

Today Python powers critical systems across industries:

- **Web development:** Frameworks like Django, Flask, and FastAPI run backends for millions of users.
- **Data science and AI:** Libraries such as NumPy, pandas, PyTorch, and TensorFlow are industry standards.
- **Automation and DevOps:** Python scripts manage infrastructure, orchestrate deployments, and automate repetitive tasks.
- **Scientific computing:** Researchers in physics, biology, economics, and many other fields use Python for analysis and simulation.
- **Education:** Python is the most common first language taught in universities and bootcamps worldwide.

This breadth is not accidental. Python's clear syntax lowers the barrier to entry, while its extensive standard library and third-party ecosystem enable solving complex problems without reinventing foundational pieces.

Installing Python and Verifying Your Setup

The first step is installing Python on your computer. Python 3.12 or later is recommended for this book, as many examples use features introduced in recent versions. The official source is python.org.

On Windows

1. Visit <https://www.python.org/downloads/> and download the latest Python 3.x installer.
2. During installation, check the box labeled “Add Python to PATH.” This is essential; it allows you to run Python from any command prompt.
3. Complete the installation with default settings.
4. Open Command Prompt or PowerShell and type: `python --version`
5. You should see output like: Python 3.13.x

If you do not see a version number, the PATH was not set correctly. You can fix this by running the installer again and selecting “Modify,” then ensuring “Add Python to PATH” is checked.

On macOS

Modern macOS systems include Python 2, which is obsolete. Install Python 3 separately:

1. Download the installer from <https://www.python.org/downloads/> or use Homebrew:

```
1 brew install python
```

2. Verify installation by opening Terminal and typing: `python3 --version`
3. You should see output like: Python 3.13.x

On macOS, the command is `python3` rather than `python` to distinguish it from the system Python 2. This book uses `python` for brevity, but substitute `python3` on macOS if needed.

On Linux

Most Linux distributions include Python 3 in their package managers:

- Ubuntu/Debian: `sudo apt update && sudo apt install python3 python3-venv python3-pip`
- Fedora/RHEL: `sudo dnf install python3 python3-venv python3-pip`
- Arch Linux: `sudo pacman -S python`

Verify with: `python3 --version`

Linux distributions sometimes manage Python as a system component. For development work, consider using `pyenv` or `uv` to manage Python versions independently of the system installation.

The Recommended Modern Tool: uv

`uv` is a new package and project manager written in Rust by Astral, the same team behind Ruff. It is dramatically faster than traditional tools like `pip` while remaining fully compatible. For a smooth experience throughout this book, consider installing `uv`:

```
1 curl -LsSf https://astral.sh/uv/install.sh | sh
```

On Windows:

```
1 powershell -ExecutionPolicy ByPass -c "irm https://astral.sh/uv/install.ps1 |  
   ↪ iex"
```

`uv` can install Python itself, create virtual environments, manage dependencies, and run commands. You will see `uv` used in later chapters as an alternative to the traditional `pip` and `venv` workflow.

Running Python: The Interactive Shell and Scripts

Python offers two primary ways to execute code: interactively and via scripts. Both are important.

The Interactive Shell (REPL)

When you type `python` at the command line without arguments, Python starts in interactive mode, also called the REPL (Read-Eval-Print Loop). This is where Python reads what you type, evaluates it, prints the result, and loops back for more input.

Try typing:

```
1 python
```

You will see a prompt like:

```
1 >>>
```

At this prompt, type any valid Python expression and press Enter. For example:

```
1 >>> 2 + 3
2 5
3 >>> "Hello" * 3
4 'HelloHelloHello'
5 >>> print("Welcome to Python!")
6 Welcome to Python!
```

The REPL is invaluable for experimenting with syntax, testing small snippets, and understanding how Python behaves. When you are done, exit by pressing `Ctrl+D` (on Unix/macOS) or `Ctrl+Z` followed by Enter (on Windows), or by typing:

```
1 >>> exit()
```

Python 3.13 introduced significant improvements to the interactive shell, including colorized output, multiline editing, and better error messages. If you have Python 3.13 installed, try it; the experience is noticeably smoother.

Writing and Running Scripts

For anything beyond experimentation, you write Python code in files called scripts. A script is a text file with a .py extension containing Python statements. When you run the script, Python executes all the statements from top to bottom.

Create your first script:

1. Open any text editor (Notepad, TextEdit, VS Code, or even nano/vim in the terminal).
2. Type the following line:

```
1 print("Hello from Python!")
```

3. Save the file as hello.py in a folder of your choice.
4. Open a terminal, navigate to that folder, and run:

```
1 python hello.py
```

You should see:

```
1 Hello from Python!
```

Congratulations. You have written and executed your first Python program. This simple line demonstrates several core concepts at once: `print` is a built-in function that outputs text to the console; the parentheses enclose the argument being passed to the function; the string “Hello from Python!” is data of type `str`.

You can add multiple statements to a script:

```
1 # hello.py
2 print("Hello from Python!")
3 print("This is my first program.")
4 name = input("What is your name? ")
5 print(f"Nice to meet you, {name}!")
```

Run it again. The f-string (the string prefixed with `f`) embeds the value of the variable `name` directly into the output text. This feature, introduced in Python 3.6, is now the standard way to format strings.

Understanding Errors Before You Fear Them

Every programmer encounters errors. In Python, errors are called exceptions, and they provide detailed information about what went wrong. Learning to read error messages is one of the most valuable skills you can develop.

Consider this script with a mistake:

```
1 # buggy.py
2 print("Starting...")
3 result = 10 / 0
4 print(result)
```

When you run it, Python produces:

```
1 Traceback (most recent call last):
2   File "buggy.py", line 3, in <module>
3     result = 10 / 0
4 ZeroDivisionError: division by zero
```

This traceback tells you exactly what happened:

- The error occurred in the file `buggy.py`, on line 3.
- The problematic statement was `result = 10 / 0`.
- The error type is `ZeroDivisionError`, and the message explains why: division by zero is mathematically undefined.

Python's error messages have improved dramatically in recent versions. Python 3.11 introduced even more detailed tracebacks that highlight the exact expression causing the problem. Python 3.12 added suggestions when you misspell a function name or forget to import a module. These improvements make debugging significantly easier, especially for beginners.

Common error types you will encounter early:

- `SyntaxError`: Your code has invalid Python syntax (missing parenthesis, incorrect indentation, etc.)
- `NameError`: You referenced a variable that was never defined
- `TypeError`: You performed an operation on incompatible types (like adding a string to a number)

- `IndexError`: You tried to access a list element beyond its length
- `KeyError`: You looked up a dictionary key that does not exist

Do not fear these errors. Read them carefully. They are Python's way of helping you understand what is wrong.

Choosing an Editor or IDE

You can write Python in any text editor, but some tools make development significantly easier. The right choice depends on your preferences and the scale of projects you plan to build.

Visual Studio Code (VS Code)

VS Code is a free, open-source code editor from Microsoft that has become the most popular development environment for Python. Install it from <https://code.visualstudio.com/>, then add the official Python extension by Microsoft.

VS Code provides:

- Syntax highlighting and code completion
- Integrated terminal for running scripts
- Debugging with breakpoints and variable inspection
- Git integration for version control
- Linting and formatting support (including Ruff, Black, and mypy)

For most readers of this book, VS Code is the recommended choice. It is powerful without being overwhelming.

PyCharm

PyCharm by JetBrains is a dedicated Python IDE available in a free Community edition and a paid Professional edition. It offers deeper integration with Python features including advanced refactoring, database tools, and web framework support.

PyCharm is excellent for large projects but can feel heavy for simple scripts. The Community edition is fully capable for learning and most development tasks.

Other Options

- Sublime Text: Fast and lightweight with Python plugins.
- Vim/Neovim: Powerful terminal-based editors with steep learning curves.
- Jupyter Notebook/Lab: Interactive notebooks ideal for data science and exploration.

Whatever you choose, ensure your editor supports Python syntax highlighting, has a way to run scripts, and can integrate with linters. VS Code with the Python extension satisfies all these requirements out of the box.

Your First Development Workflow

Before moving on, let us establish a basic workflow that you will use throughout this book:

1. Create a dedicated folder for your Python projects.
2. Inside it, create a virtual environment to isolate project dependencies (you will learn about this in detail later; for now, run: `python -m venv .venv`).
3. Activate the environment:
 - Windows: `.venv\Scripts\activate`
 - macOS/Linux: `source .venv/bin/activate`
4. Write your code in a `.py` file.
5. Run it with: `python filename.py`
6. When done, deactivate with: `deactivate`

This workflow keeps your projects organized and prevents dependency conflicts between different pieces of work.

Chapter Summary

In this chapter you learned how to install Python, verify your installation, run Python interactively and via scripts, read error messages constructively, choose a development environment, and establish a basic project workflow.

You wrote your first program and saw how Python executes code from top to bottom.

The next chapter introduces the fundamental building blocks of every Python program: variables, data types, and operations. With those tools you will be ready to write programs that do more than print fixed messages.

Chapter 2: The Building Blocks: Variables, Types, and Operations

Every program manipulates data. In Python, data comes in different types, and understanding those types is essential to writing correct code. This chapter covers variables, the core data types (numbers, strings, and booleans), type conversion, and the operators you use to work with values.

Variables and Names: How Python Stores Values

A variable is a name that refers to a value stored in memory. In Python, you create a variable simply by assigning a value to a name using the equals sign:

```
1 # Creating variables
2 name = "Alice"
3 age = 30
4 height = 5.7
5 is_student = False
```

The statement `name = "Alice"` does not mean “name equals Alice.” It means “bind the name ‘name’ to the string value ‘Alice.’” Python handles the memory allocation automatically; you do not need to declare types or reserve space.

Naming Rules and Conventions

Variable names in Python must follow specific rules:

- They can contain letters (a-z, A-Z), digits (0-9), and underscores (_).
- They cannot start with a digit.
- They are case-sensitive: `age` and `Age` are different variables.
- They cannot be Python keywords: `def`, `class`, `if`, `for`, `while`, `return`, `import`, etc.

Beyond the rules, Python has strong conventions captured in PEP 8, the official style guide:

- Use lowercase with underscores for variable and function names: `user_name`, `total_count`.
- Use uppercase with underscores for constants: `MAX_SIZE`, `API_KEY`.
- Choose descriptive names that explain what the value represents.
- Avoid single-letter names except in short loops (like `i` for an index) or mathematical contexts.

Good names make code readable:

```
1  # Clear
2  days_until_deadline = 14
3  total_price = quantity * unit_price
4
5  # Unclear
6  d = 14
7  t = q * u
```

Dynamic Typing

Python is dynamically typed, meaning you do not declare the type of a variable when you create it. Python determines the type based on the value assigned:

```
1  x = 10          # x is an integer
2  x = "ten"       # now x refers to a string
3  x = 10.0        # now x is a float
```

The same name can refer to values of different types at different times. This flexibility is convenient but also means you must be careful: if your code expects `x` to be a number and it is actually a string, operations will fail with a `TypeError`.

Python's type system is duck-typed: "If it walks like a duck and quacks like a duck, it's a duck." What matters is what operations a value supports, not its declared type. Later chapters will show how type hints help document intended types without losing Python's dynamism.

Numbers: Integers, Floats, and Complex Numbers

Python provides three numeric types: `int` (integers), `float` (floating-point numbers), and `complex` (complex numbers).

Integers

Integers are whole numbers without a fractional part. Python integers have arbitrary precision, meaning they can represent values as large as your memory allows:

```
1 # Integer examples
2 population = 8_000_000_000    # underscores for readability
3 result = 2 ** 100             # 2 to the power of 100
4 print(result)                 # 1267650600228229401496703205376
```

Underscores in numeric literals (available since Python 3.6) improve readability of large numbers without affecting the value. The expression `8_000_000_000` is identical to `8000000000`.

Floats

Floats represent real numbers with fractional parts:

```
1 # Float examples
2 pi = 3.14159
3 temperature = -4.2
4 scientific = 6.022e23          # scientific notation: 6.022 x 10^23
```

Floats use IEEE 754 double-precision representation, which means they have limited precision. This can lead to surprising results:

```
1 >>> 0.1 + 0.2
2 0.30000000000000004
3 >>> 0.1 + 0.2 == 0.3
4 False
```

This is not a Python bug; it is a fundamental property of binary floating-point arithmetic. The decimal fraction 0.1 cannot be represented exactly in binary, just as $1/3$ cannot be represented exactly in decimal. For most applications this imprecision is acceptable, but when exact decimal arithmetic is required (such as financial calculations), use the decimal module:

```
1 from decimal import Decimal
2 >>> Decimal("0.1") + Decimal("0.2")
3 Decimal('0.3')
```

Note the quotes around “0.1” and “0.2”. Writing `Decimal(0.1)` would first create an imprecise float and then convert that to a `Decimal`, defeating the purpose.

Complex Numbers

Complex numbers have a real part and an imaginary part, written with `j` as the imaginary unit:

```
1 z = 3 + 4j
2 print(z.real)    # 3.0
3 print(z.imag)    # 4.0
```

Complex numbers are primarily used in scientific and engineering applications. For most general programming, `int` and `float` cover your needs.

Strings: Text, Formatting, and Manipulation

Strings are sequences of characters used to represent text. Python strings are immutable, meaning once created, their contents cannot be changed. You create strings using single quotes, double quotes, or triple quotes:

```

1 # All of these create valid strings
2 greeting = 'Hello'
3 name = "World"
4 message = """This is a
5 multiline string."""

```

Single and double quotes are interchangeable. Use whichever makes your code clearer, especially when the string itself contains quote characters:

```

1 sentence = "She said, 'Hello!'"
2 quote = 'The sign read: "Open"'

```

Triple quotes (“” or ’’) allow strings to span multiple lines and are commonly used for docstrings, which document functions and classes.

String Operations

Strings support several useful operations:

```

1 # Concatenation
2 first = "Hello"
3 second = "World"
4 combined = first + " " + second      # "Hello World"
5
6 # Repetition
7 dash_line = "-" * 40                  # "-----"
8
9 # Length
10 text = "Python"
11 print(len(text))                     # 6
12
13 # Indexing (zero-based)
14 print(text[0])                       # "P"
15 print(text[-1])                      # "n" (negative index from end)
16
17 # Slicing: text[start:end] where end is exclusive
18 print(text[0:3])                     # "Pyt"
19 print(text[:2])                      # "Py" (from start)
20 print(text[2:])                      # "thon" (to end)
21 print(text[::-1])                   # "nohtyP" (reversed)

```

Slicing is one of Python’s most distinctive features. The syntax `text[start↵endstep]` extracts a substring starting at index `start`, ending before index `end`, taking every `step`-th character. Omitted values default to the beginning, end, or step of 1 respectively.

String Formatting

Formatting strings to include variable values is a common task. Python offers several approaches, with f-strings being the modern standard.

F-strings (Recommended)

Introduced in Python 3.6, f-strings (formatted string literals) are the most readable and efficient way to embed expressions in strings:

```
1 name = "Alice"
2 age = 30
3 greeting = f"Hello, {name}! You will be {age + 1} next year."
4 print(greeting)    # Hello, Alice! You will be 31 next year.
```

F-strings evaluate any valid Python expression inside curly braces. Python 3.12 expanded what is allowed inside f-string expressions, making them even more flexible:

```
1 # Python 3.12+ allows more complex expressions
2 value = 42
3 message = f"The answer is {value!r}"           # repr formatting
4 print(f"Price: ${9.99:.2f}")                  # format specifier
5 print(f"Binary: {255:b}")                     # binary representation
```

Other Methods (Legacy)

You may encounter these older approaches in existing code:

```
1 # str.format() method
2 greeting = "Hello, {}! You are {} years old.".format(name, age)
3
4 # Percent formatting (oldest, borrowed from C)
5 greeting = "Hello, %s! You are %d years old." % (name, age)
```

Both work but are more verbose and error-prone than f-strings. Use f-strings for all new code.

String Methods

Strings have many built-in methods for manipulation:

```

1 text = " Hello, Python World! "
2
3 # Case conversion
4 print(text.lower())          # " hello, python world! "
5 print(text.upper())          # " HELLO, PYTHON WORLD! "
6 print(text.title())          # " Hello, Python World! "
7
8 # Stripping whitespace
9 print(text.strip())           # "Hello, Python World!"
10 print(text.lstrip())          # left strip only
11 print(text.rstrip())          # right strip only
12
13 # Searching
14 print("Python" in text)       # True
15 print(text.find("Python"))    # 9 (index of first occurrence)
16 print(text.count("o"))        # 3
17
18 # Splitting and joining
19 words = text.strip().split()  # ['Hello,', 'Python', 'World!']
20 joined = " ".join(words)      # "Hello, Python World!"
21
22 # Replacement
23 print(text.replace("Python", "Java")) # " Hello, Java World! "

```

These methods return new strings; they do not modify the original because strings are immutable.

Booleans and Comparison Operators

Booleans represent truth values: True and False. Note the capitalization: true and false (lowercase) are not valid in Python.

Booleans arise naturally from comparison operations:

```
1  # Equality and inequality
2  print(5 == 5)                # True
3  print(5 == "5")              # False (different types)
4  print(5 != 3)                # True
5
6  # Ordering
7  print(10 > 5)                 # True
8  print(10 >= 10)               # True
9  print(3 < 7)                  # True
10 print(3 <= 2)                 # False
11
12 # Chained comparisons (Pythonic!)
13 x = 5
14 print(1 < x < 10)             # True (equivalent to 1 < x and x < 10)
15 print(10 < x < 20)           # False
```

Chained comparisons are a Python feature that makes range checks readable and natural. The expression `1 < x < 10` is not just syntactic sugar; Python evaluates it efficiently as a single operation.

Identity vs Equality

Python distinguishes between equality (`==`) and identity (`is`):

- `==` checks if two values are equal.
- `is` checks if two names refer to the exact same object in memory.

```
1  a = [1, 2, 3]
2  b = [1, 2, 3]
3  c = a
4
5  print(a == b)                # True (same contents)
6  print(a is b)                # False (different objects)
7  print(a is c)                # True (c refers to the same object as a)
```

For most comparisons, use `==`. The `is` operator is primarily used to check against `None`:

```
1 value = None
2 if value is None:
3     print("No value provided")
```

Avoid using `is` to compare values like numbers, strings, or lists. While Python caches small integers and some strings, relying on identity for value comparison is fragile and confusing.

Type Conversion and Dynamic Typing

Python provides functions to convert between types when needed:

```
1 # String to number
2 age_str = "25"
3 age_int = int(age_str)           # 25
4 price_float = float("9.99")     # 9.99
5
6 # Number to string
7 count = 42
8 count_str = str(count)          # "42"
9
10 # Between numeric types
11 whole = int(3.7)                # 3 (truncation, not rounding)
12 decimal = float(5)              # 5.0
```

Conversion can fail if the value is not valid:

```
1 >>> int("hello")
2 ValueError: invalid literal for int() with base 10: 'hello'
```

Always validate user input before converting, especially when reading from files or network sources.

Arithmetic, Logical, and Bitwise Operations

Python supports a full set of operators for manipulating values.

Arithmetic Operators

```
1 a = 17
2 b = 5
3
4 print(a + b)          # 22 (addition)
5 print(a - b)          # 12 (subtraction)
6 print(a * b)          # 85 (multiplication)
7 print(a / b)          # 3.4 (true division, always float)
8 print(a // b)         # 3 (floor division, integer result)
9 print(a % b)          # 2 (modulo, remainder)
10 print(a ** b)         # 1419857 (exponentiation)
```

The difference between `/` and `//` is important: `/` always produces a float, while `//` performs floor division and returns the largest integer less than or equal to the exact quotient. For negative numbers, `//` rounds toward negative infinity:

```
1 >>> -7 // 3
2 -3
3 >>> -7 % 3
4 2
```

Logical Operators

Logical operators combine boolean values:

```
1 # and: True only if both operands are True
2 print(True and True)    # True
3 print(True and False)   # False
4
5 # or: True if at least one operand is True
6 print(True or False)    # True
7 print(False or False)   # False
8
9 # not: negates the value
10 print(not True)        # False
11 print(not False)       # True
```

Python uses short-circuit evaluation: in an expression like `a and b`, if `a` is `False`, Python does not evaluate `b` because the result cannot be `True`. Similarly, in `a or b`, if `a` is `True`, `b` is not evaluated. This behavior is useful:

```

1  # Safe attribute access pattern
2  if user and user.is_active:
3      print("User is active")

```

If `user` is `None` (which evaluates as `False`), the second condition is never checked, avoiding an `AttributeError`.

Bitwise Operators

Bitwise operators work on the binary representation of integers:

```

1  x = 5      # binary: 0101
2  y = 3      # binary: 0011
3
4  print(x & y)    # 1 (bitwise AND:  0001)
5  print(x | y)    # 7 (bitwise OR:   0111)
6  print(x ^ y)    # 6 (bitwise XOR:  0110)
7  print(~x)       # -6 (bitwise NOT)
8  print(x << 1)   # 10 (left shift:  1010)
9  print(x >> 1)   # 2 (right shift:  0010)

```

Bitwise operators are essential for low-level programming, flags, and certain algorithms. For most general application code, you will use them rarely.

Operator Precedence

When multiple operators appear in an expression, Python follows a precedence order:

1. Parentheses `()`
2. Exponentiation `**`
3. Unary `+`, `-`, `~`
4. `*`, `/`, `//`, `%`
5. Binary `+`, `-`
6. `<<`, `>>`
7. `&`
8. `^`
9. `|`
10. Comparison operators (`<`, `>`, `==`, etc.)

11. not
12. and
13. or

Use parentheses to make precedence explicit and improve readability:

```

1  # Unclear without parens
2  result = a + b * c - d / e
3
4  # Clear with parens
5  result = (a + (b * c)) - (d / e)

```

Building a Small Example: A Unit Converter

Let us combine what we have learned into a practical example: a simple unit converter.

```

1  # unit_converter.py
2  """A simple unit converter for common measurements."""
3
4  print("=== Unit Converter ===")
5  print("1. Kilometers to Miles")
6  print("2. Celsius to Fahrenheit")
7  print("3. Pounds to Kilograms")
8
9  choice = input("\nSelect an option (1-3): ")
10
11 if choice == "1":
12     km = float(input("Enter kilometers: "))
13     miles = km * 0.621371
14     print(f"{km} km = {miles:.2f} miles")
15 elif choice == "2":
16     celsius = float(input("Enter Celsius: "))
17     fahrenheit = celsius * 9/5 + 32
18     print(f"{celsius} C = {fahrenheit:.2f} F")
19 elif choice == "3":
20     pounds = float(input("Enter pounds: "))
21     kilograms = pounds * 0.453592
22     print(f"{pounds} lbs = {kilograms:.2f} kg")
23 else:
24     print("Invalid option. Please run again and choose 1, 2, or 3.")

```

This script uses variables, multiple data types, input/output, f-string formatting, comparison operators, and conditional branching (which we will cover in detail next chapter). Run it and experiment with different inputs.

Chapter Summary

This chapter established the fundamental building blocks of Python programs. You learned how variables bind names to values, the core data types (integers, floats, strings, booleans), how to convert between types, and the operators for arithmetic, comparison, and logic. You saw Python's dynamic typing in action and practiced with a small unit converter program.

With these foundations, you are ready to control program flow. The next chapter covers conditionals, loops, comprehensions, and pattern matching: the tools that make programs do interesting things rather than just execute the same steps every time.

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