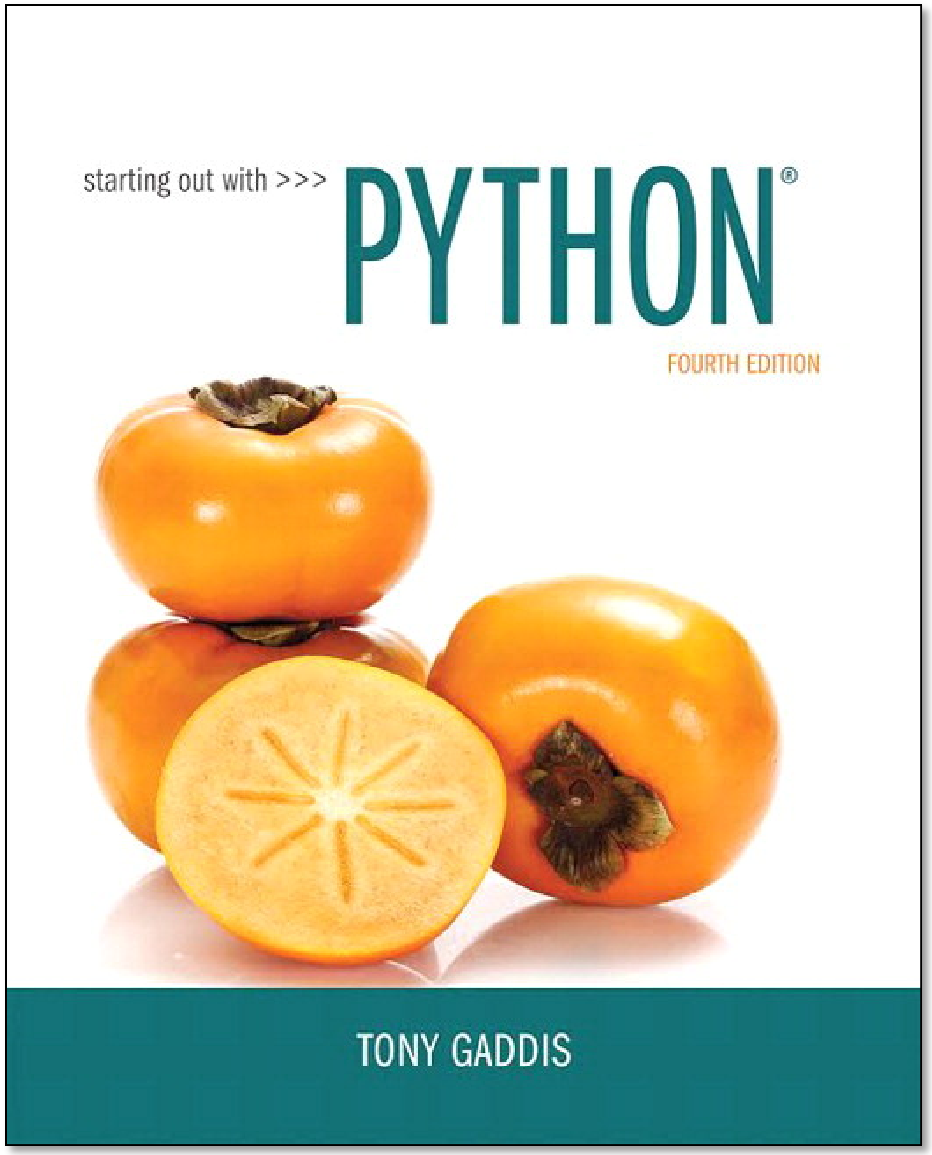
CHAPTER 1

Introduction to Computers and Programming



Topics

- Introduction
- Hardware and Software
- How Computers Store Data
- How a Program Works
- Using Python

Introduction

- **Computers can be programmed**
  - Designed to do any job that a program tells them to
- **<u>Program</u>: set of instructions that a computer follows to perform a task**
  - Commonly referred to as *Software*
- **<u>Programmer</u>: person who can design, create, and test computer programs**
  - Also known as software developer

Hardware and Software

- **<u>Hardware</u>: The physical devices that make up a computer**
  - Computer is a system composed of several components that all work together
- **Typical major components:**
  - Central processing unit
  - Main memory
  - Secondary storage devices
  - Input and output devices

The CPU

- **<u>Central processing unit (CPU)</u>: the part of the computer that actually runs programs**
  - Most important component
  - Without it, cannot run software
  - Used to be a huge device
- **<u>Microprocessors</u>: CPUs located on small chips**

Main Memory

- **<u>Main memory</u>: where computer stores a program while program is running, and data used by the program**
- **Known as *Random Access Memory* or *RAM***
  - CPU is able to quickly access data in RAM
  - Volatile memory used for temporary storage while program is running
  - Contents are erased when computer is off

Secondary Storage Devices

- **Secondary storage: can hold data for long periods of time**
  - Programs normally stored here and loaded to main memory when needed
- **Types of secondary memory**
  - Disk drive: magnetically encodes data onto a spinning circular disk
  - Solid state drive: faster than disk drive, no moving parts, stores data in solid state memory
  - Flash memory: portable, no physical disk
  - Optical devices: data encoded optically

Input Devices

- **<u>Input</u>: data the computer collects from people and other devices**
- **<u>Input device</u>: component that collects the data**
  - Examples: keyboard, mouse, touchscreen, scanner, camera
  - Disk drives can be considered input devices because they load programs into the main memory

Output Devices

- **<u>Output</u>: data produced by the computer for other people or devices**
  - Can be text, image, audio, or bit stream
- **<u>Output device</u>: formats and presents output**
  - Examples: video display, printer
  - Disk drives and USB drives can be considered output devices because data is sent to them to be saved

Software

- **Everything the computer does is controlled by software**
  - General categories:
    - Application software
    - System software
- **<u>Application software</u>: programs that make computer useful for every day tasks**
  - Examples: word processing, email, games, and Web browsers

Software (cont'd.)

- **System software: programs that control and manage basic operations of a computer**
  - Operating system: controls operations of hardware components
  - Utility Program: performs specific task to enhance computer operation or safeguard data
  - Software development tools: used to create, modify, and test software programs

How Computers Store Data

- **All data in a computer is stored in sequences of 0s and 1s**
- **Byte: just enough memory to store letter or small number**
  - Divided into eight bits
  - Bit: electrical component that can hold positive or negative charge, like on/off switch
  - The on/off pattern of bits in a byte represents data stored in the byte

Storing Numbers

- **Bit represents two values, 0 and 1**
- **Computers use binary numbering system**
  - Position of digit `j` is assigned the value 2^{j-1}
  - To determine value of binary number sum position values of the 1s
- **Byte size limits are 0 and 255**
  - 0 = all bits off; 255 = all bits on
  - To store larger number, use several bytes

Storing Characters

- **Data stored in computer must be stored as binary number**
- **Characters are converted to numeric code, numeric code stored in memory**
  - Most important coding scheme is ASCII
    - ASCII is limited: defines codes for only 128 characters
  - Unicode coding scheme becoming standard
    - Compatible with ASCII
    - Can represent characters for other languages

Advanced Number Storage

- **To store negative numbers and real numbers, computers use binary numbering and encoding schemes**
  - Negative numbers encoded using two’s complement
  - Real numbers encoded using floating-point notation

Other Types of Data

- **Digital: describes any device that stores data as binary numbers**
- **Digital images are composed of pixels**
  - To store images, each pixel is converted to a binary number representing the pixel’s color
- **Digital music is composed of sections called samples**
  - To store music, each sample is converted to a binary number

How a Program Works

- **CPU designed to perform simple operations on pieces of data**
  - Examples: reading data, adding, subtracting, multiplying, and dividing numbers
  - Understands instructions written in machine language and included in its instruction set
    - Each brand of CPU has its own instruction set
- **To carry out meaningful calculation, CPU must perform many operations**

How a Program Works (cont'd.)

- **Program must be copied from secondary memory to RAM each time CPU executes it**
- **CPU executes program in cycle:**
  - Fetch: read the next instruction from memory into CPU
  - Decode: CPU decodes fetched instruction to determine which operation to perform
  - Execute: perform the operation

How a Program Works (cont'd.)

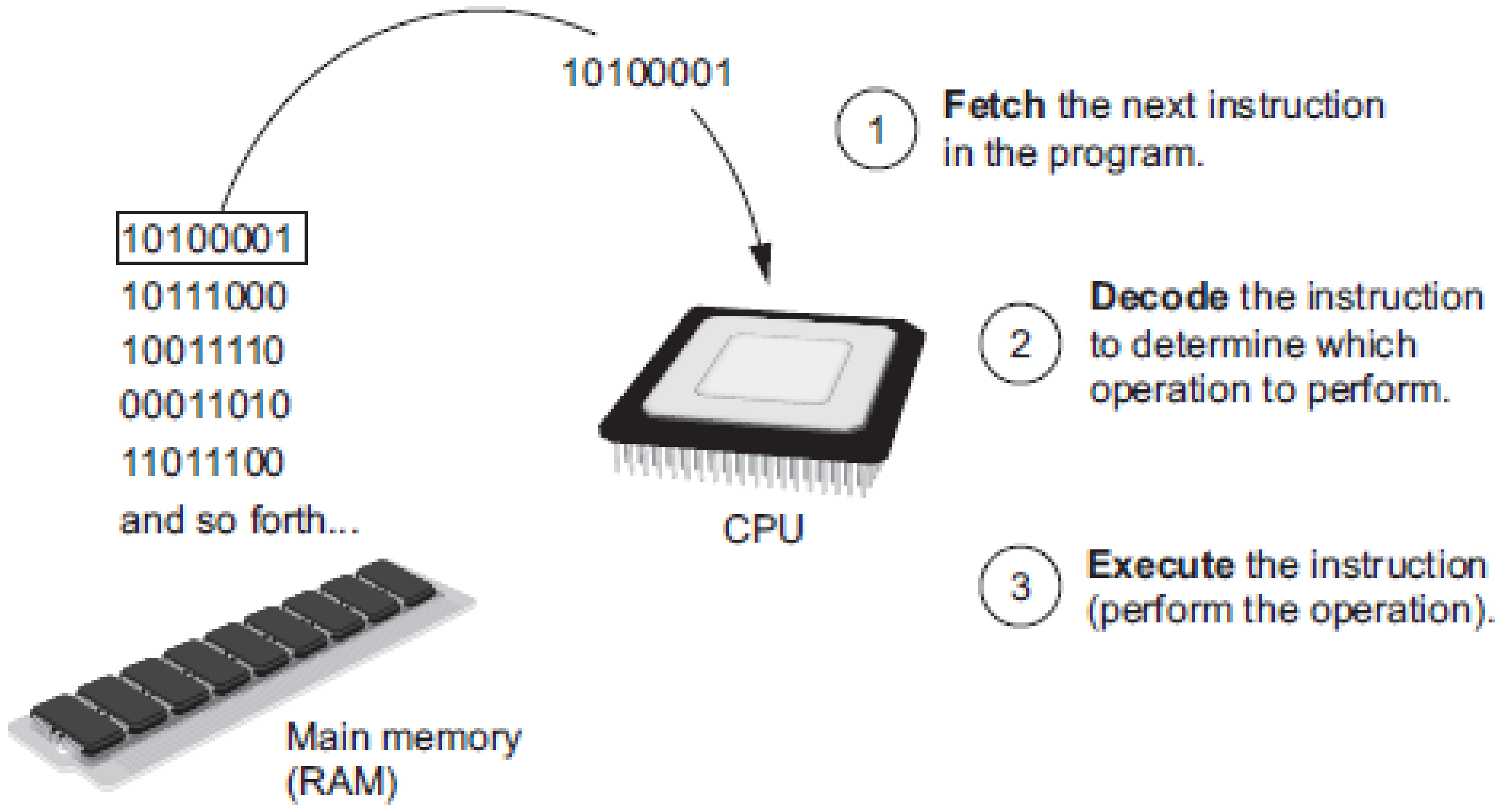

10100001
1 Fetch the next instruction in the program.
10100001
10111000
10011110
00011010
11011100
and so forth...
CPU
2 Decode the instruction to determine which operation to perform.
3 Execute the instruction (perform the operation).
Main memory (RAM)

Figure 1-16 The fetch-decode-execute cycle

From Machine Language to Assembly Language

- **Impractical for people to write in machine language**
- **<u>Assembly language</u>: uses short words (mnemonics) for instructions instead of binary numbers**
  - Easier for programmers to work with
- **<u>Assembler</u>: translates assembly language to machine language for execution by CPU**

High-Level Languages

- **<u>Low-level language</u>: close in nature to machine language**
  - Example: assembly language
- **<u>High-Level language</u>: allows simple creation of powerful and complex programs**
  - No need to know how CPU works or write large number of instructions
  - More intuitive to understand

Key Words, Operators, and Syntax: an Overview

- **Key words: predefined words used to write program in high-level language**
  - Each key word has specific meaning
- **Operators: perform operations on data**
  - Example: math operators to perform arithmetic
- **Syntax: set of rules to be followed when writing program**
- **Statement: individual instruction used in high-level language**

Compilers and Interpreters

- **Programs written in high-level languages must be translated into machine language to be executed**
- **<u>Compiler</u>: translates high-level language program into separate machine language program**
  - Machine language program can be executed at any time

Compilers and Interpreters (cont'd.)

- **Interpreter: translates and executes instructions in high-level language program**
  - Used by Python language
  - Interprets one instruction at a time
  - No separate machine language program
- **Source code: statements written by programmer**
  - Syntax error: prevents code from being translated

Compilers and Interpreters (cont'd.)

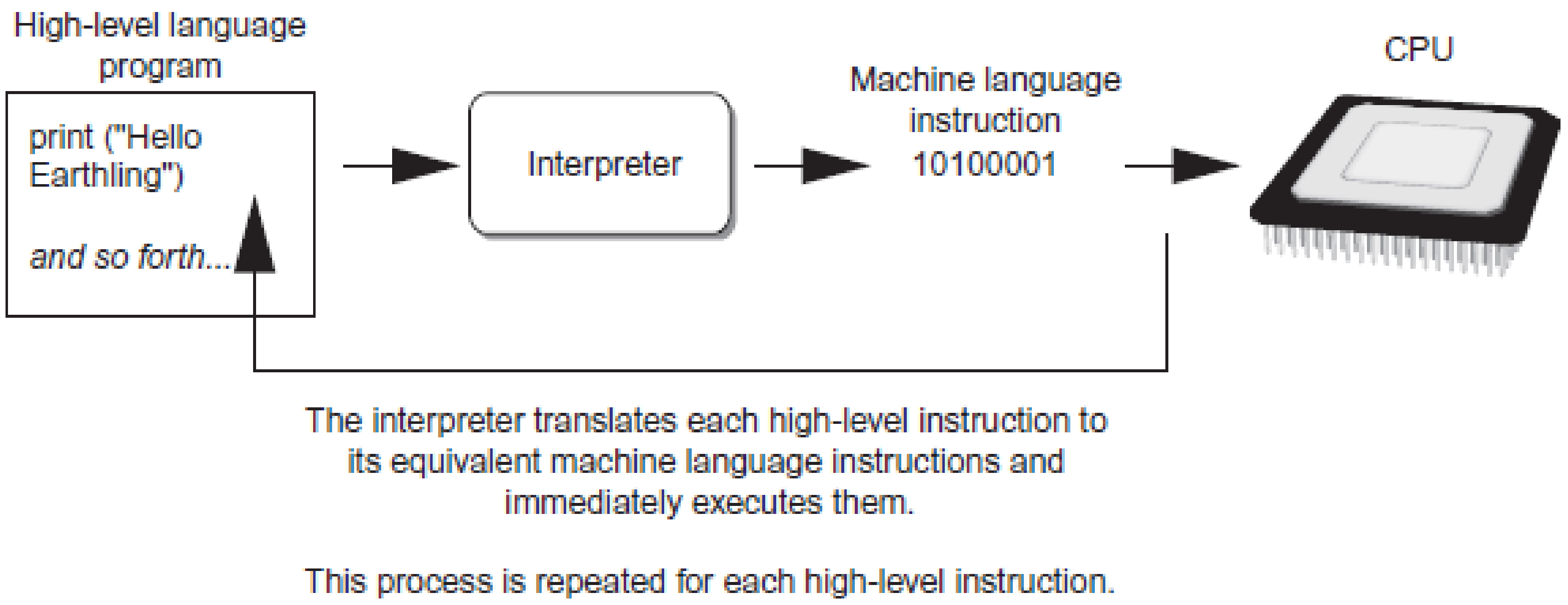

High-level language program
print ("Hello Earthling")
and so forth...
Interpreter
Machine language instruction
10100001
CPU
The interpreter translates each high-level instruction to its equivalent machine language instructions and immediately executes them.
This process is repeated for each high-level instruction.

Figure 1-19 Executing a high-level program with an interpreter

Using Python

- **Python must be installed and configured prior to use**
  - One of the items installed is the Python interpreter
- **Python interpreter can be used in two modes:**
  - Interactive mode: enter statements on keyboard
  - Script mode: save statements in Python script

Interactive Mode

- **When you start Python in interactive mode, you will see a prompt**
  - Indicates the interpreter is waiting for a Python statement to be typed
  - Prompt reappears after previous statement is executed
  - Error message displayed If you incorrectly type a statement
- **Good way to learn new parts of Python**

Writing Python Programs and Running Them in Script Mode

- **Statements entered in interactive mode are not saved as a program**
- **To have a program use script mode**
  - Save a set of Python statements in a file
  - The filename should have the .py extension
  - To run the file, or script, type

    `python` *`filename`*

    at the operating system command line

The IDLE Programming Environment

- **IDLE (Integrated Development Program): single program that provides tools to write, execute and test a program**
  - Automatically installed when Python language is installed
  - Runs in interactive mode
  - Has built-in text editor with features designed to help write Python programs

Summary

- **This chapter covered:**
  - Main hardware components of the computer
  - Types of software
  - How data is stored in a computer
  - Basic CPU operations and machine language
  - Fetch-decode-execute cycle
  - Complex languages and their translation to machine code
  - Installing Python and the Python interpreter modes