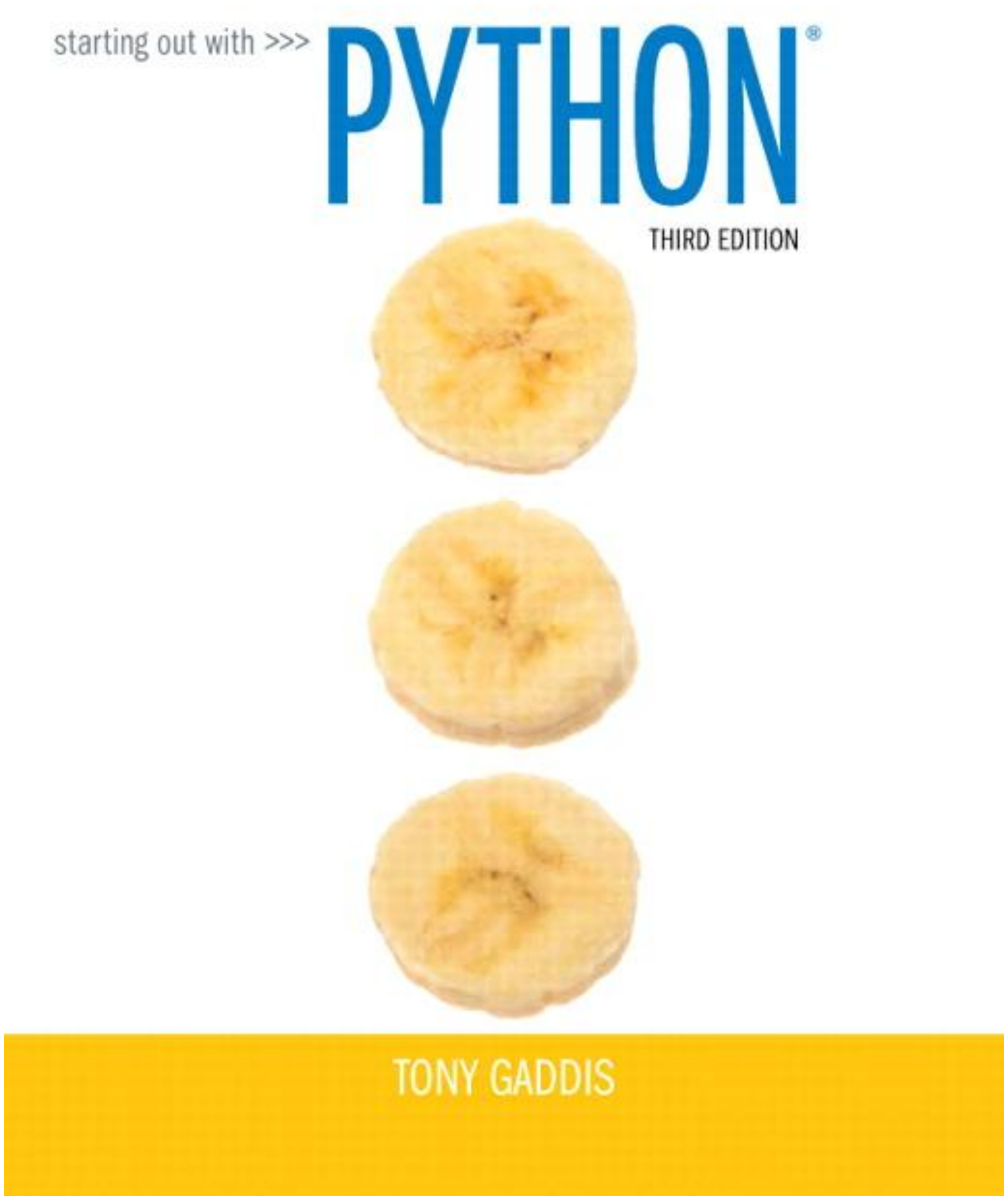
CHAPTER 1

Introduction to Computers and Programming



Topics

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

Introduction

- What is a Computer?
  - A computer is a programmable machine designed to sequentially and automatically carry out a sequence of arithmetic or logical operations. The particular sequence of operations can be changed readily, allowing the computer to solve more than one kind of problem.
- Program
  - Set of instructions that a computer follows to perform a task
- Software
  - Collection of programs
- Programmer
  - Person who writes or codes programs

Hardware and Software

- **Hardware: 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

- **Main memory: 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, scanner, camera
  - Disk drives can be considered input devices because they load programs into the main memory

Output Devices

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

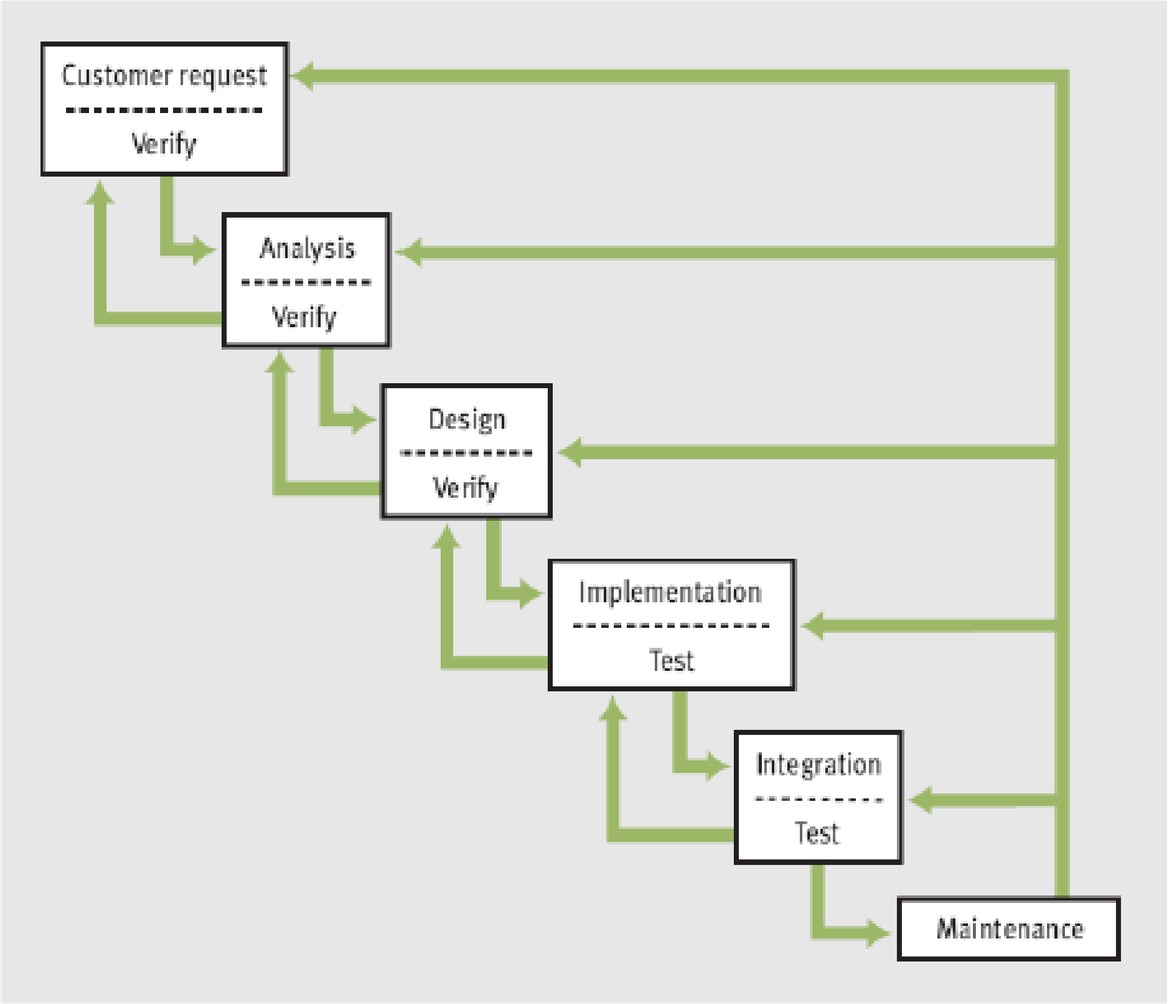
Software

- Everything the computer does is controlled by software
- General categories:
  - Application software: programs that make computer useful for every day tasks
    - Examples: word processing, email, games, and Web browsers
  - System software: programs that control and manage basic operations of a computer
    - Operating system: controls operations of hardware components
  - Utility Programs: performs specific task to enhance computer operation or safeguard data
  - Software development tools: used to create, modify, and test software programs

Software Development Process

- Software development: process of planning and organizing a program
  - Several approaches; one is the waterfall model
- Modern software development is usually incremental and iterative
  - Analysis and design may produce a prototype of a system for coding, and then back up to earlier phases to fill in more details after some testing
- Programs rarely work as hoped the first time they are run
  - Must perform extensive and careful testing
  - The cost of developing software is not spread equally over the phases

Software Development Process



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

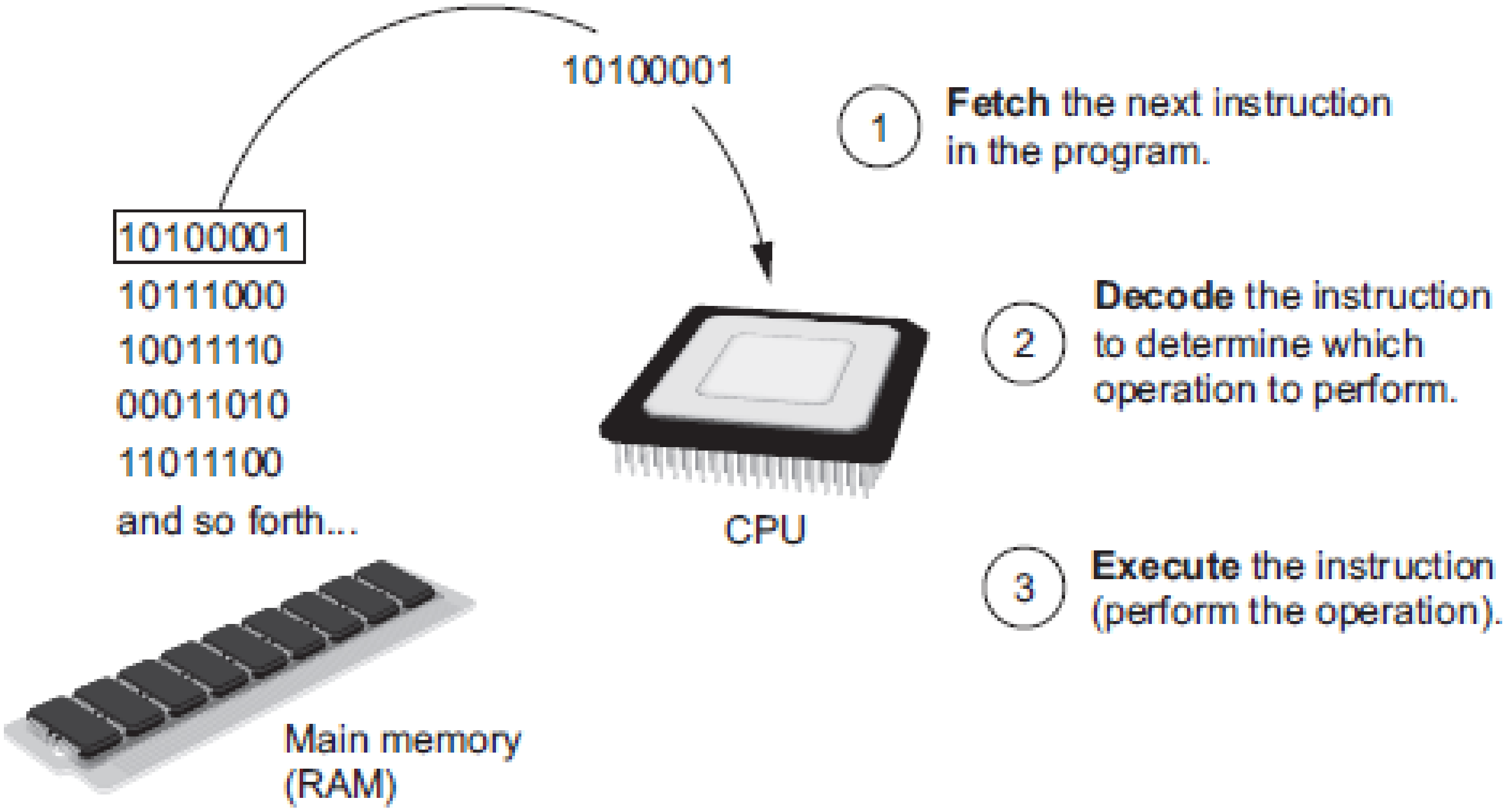
Other Types of Data

- **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

- 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
  - Store:
    - Data from result is stored

How a Program Works (cont’d.)



Fetch the next instruction in the program.

Decode the instruction to determine which operation to perform.

Execute the instruction (perform the operation).

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

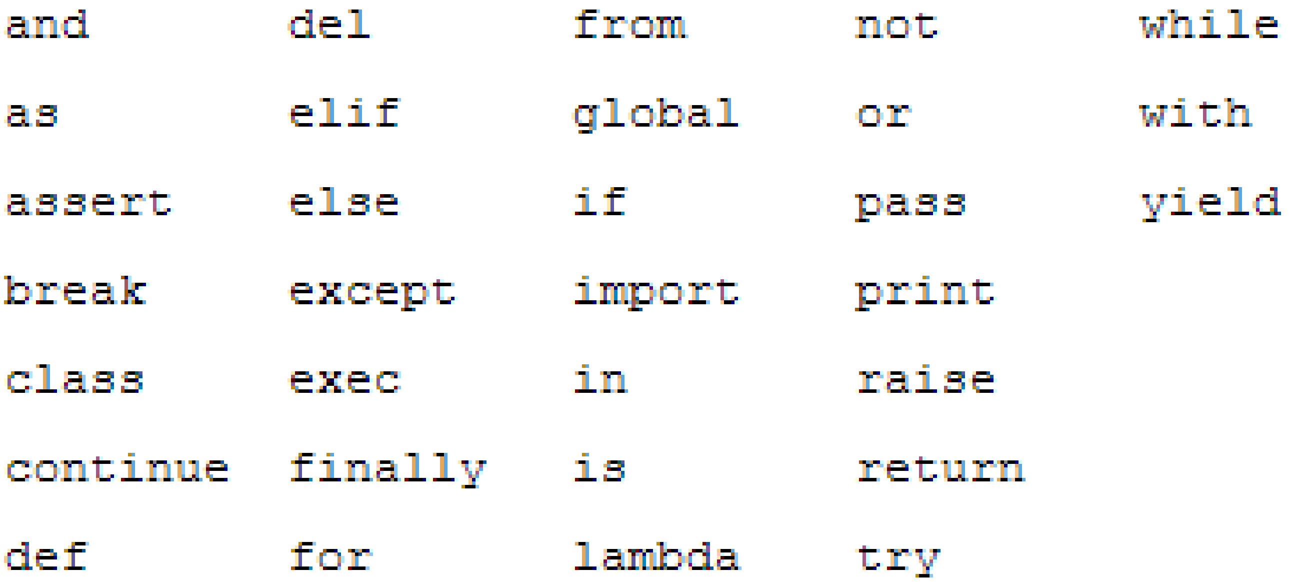
- **Low-level language: close in nature to machine language**
  - Example: assembly language
- **High-Level language: allows simple creation of powerful and complex programs**
  - No need to know how CPU works or write large number of instructions
  - More intuitive to understand

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**

Python Keywords

- Python is a dynamic language. It changes during time. The list of keywords may change in the future.



and	del	from	not	while
as	elif	global	or	with
assert	else	if	pass	yield
break	except	import	print	
class	exec	in	raise	
continue	finally	is	return	
def	for	lambda	try	

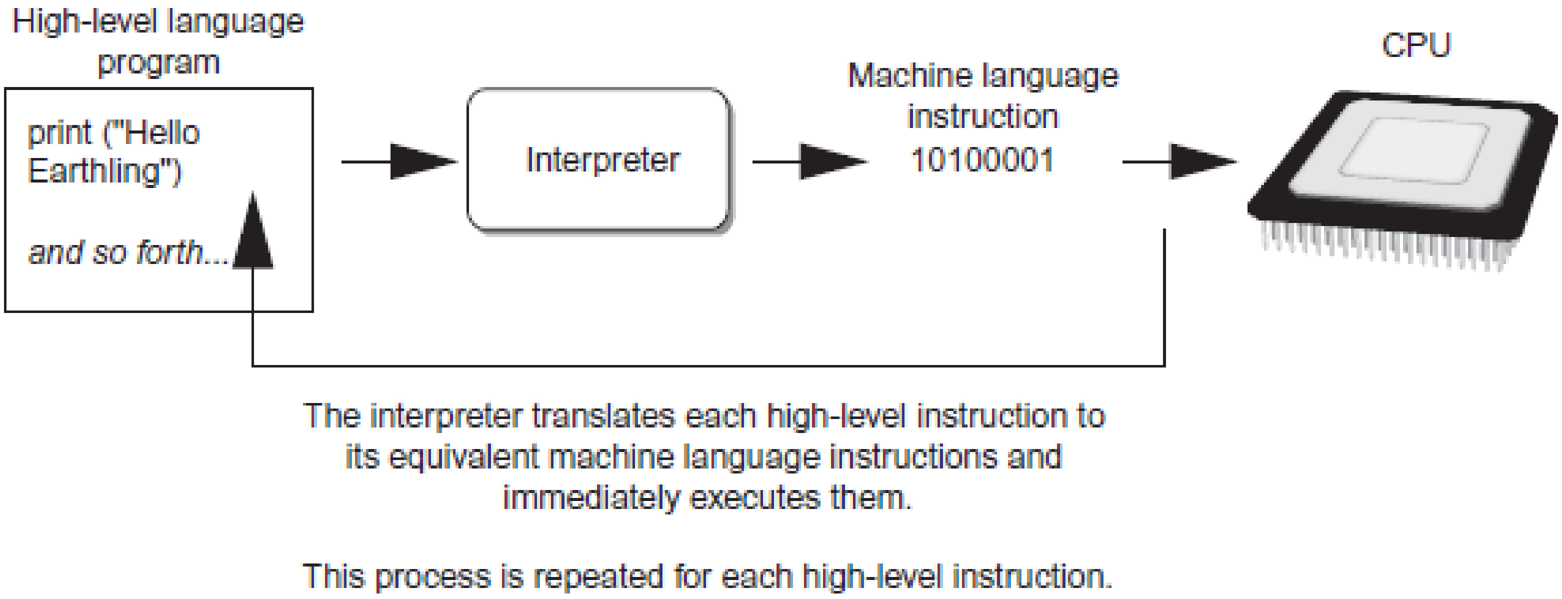
Compilers and Interpreters

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

Compilers and Interpreters

- **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



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

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