Foundations of Computer Science

Second Edition

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Chapter 1
Introduction

Outlines

- Turing Model
- von Neumann Model
- Computer Components
- History
- Social and Ethical Issues
- Computer Science as a Discipline

Objectives

After studying this chapter, the student should be able to:

- Define the Turing model of a computer.
- Define the von Neumann model of a computer.
- Describe the three components of a computer: hardware, data, and software.
- List topics related to computer hardware.
- List topics related to data.
- List topics related to software.
- Discuss some social and ethical issues related to the use of computers.
- Give a short history of computers.

1-1 Turing Model

Data Processors

- A computer acts as a black box that accepts input data, processes the data, and creates output data.

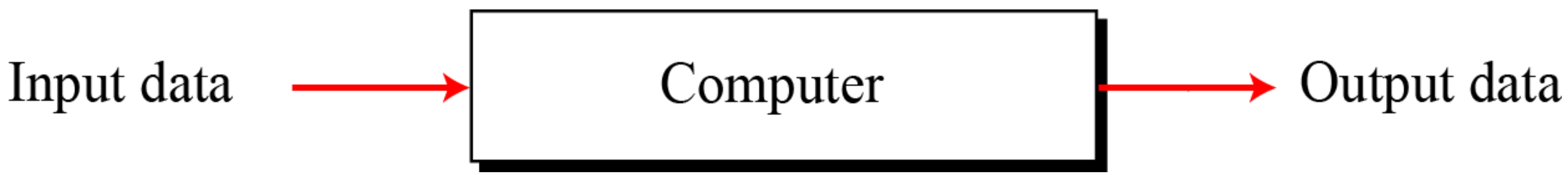


Figure 1.1 **A single purpose computing machine**

Programmable Data Processors(1)

- The idea of a universal computational device was first described by **Alan Turing** in 1937.
- He proposed that all computation could be performed by a special kind of a machine, now called a **Turing machine**.

Programmable Data Processors(2)

- The **Turing model** is a better model for a general-purpose computer. This model adds an extra element to the specific computing machine: **the program**. A program is a set of instructions that tells the computer what to do with data.

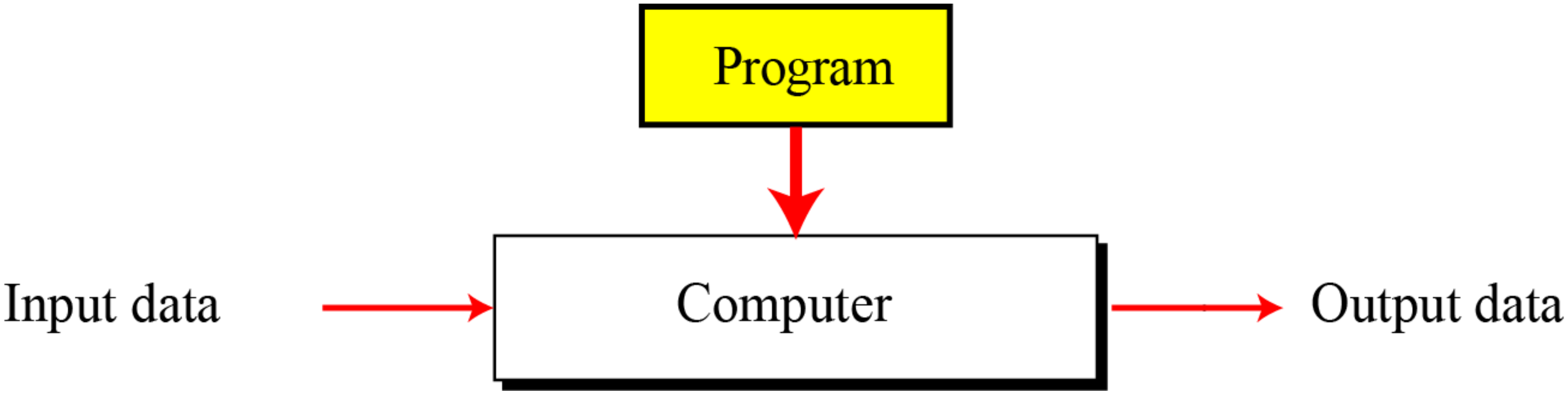


Figure 1.2 **A computer based on the Turing model**

An Example

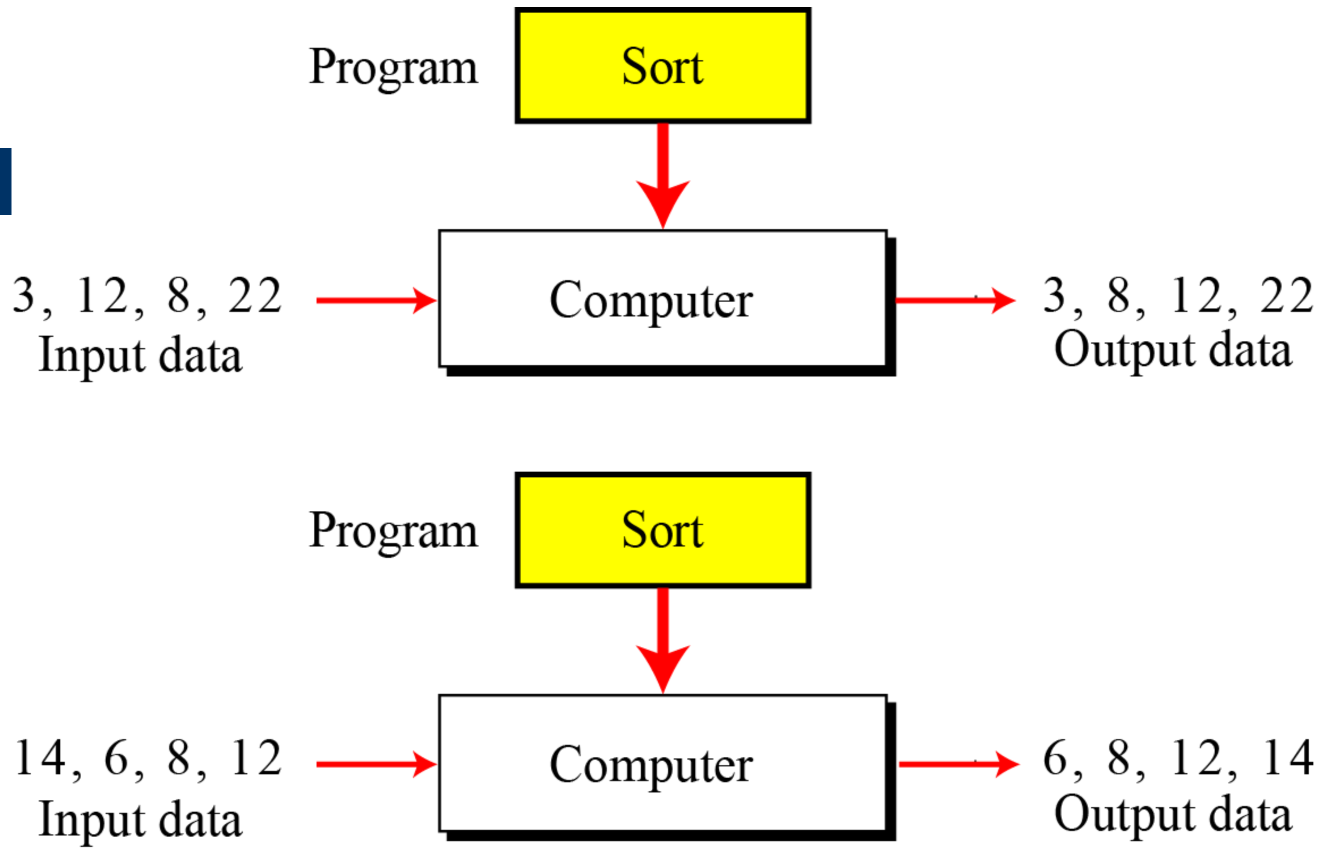


Figure 1.3 **The same program, different data**

Another Example

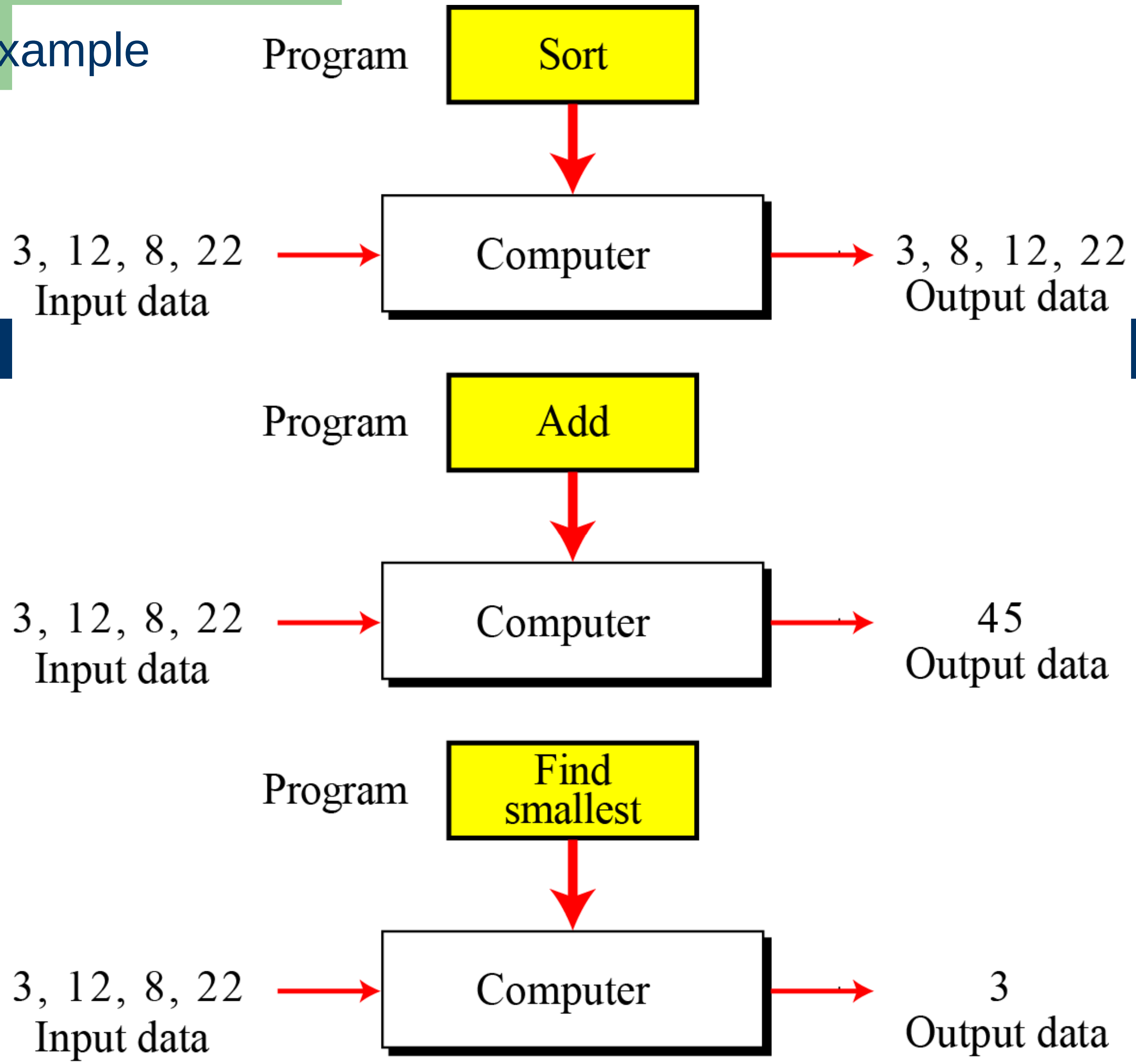


Figure 1.4 **The same data, different programs**

The Universal Turing Machine

- A **Universal Turing Machine**, a machine that can do any computation if the appropriate program is provided, was the first description of a modern computer.
- It can be proved that a very powerful computer and a universal Turing machine can compute the same thing.
- We need only provide the data and the program—the description of how to do the computation—to either machine.
- In fact, a Universal Turing Machine is capable of computing anything that is computable.

1-2 von Neumann Model

Overview

- Computers built on the Turing universal machine store data in their memory.
- Around 1944–1945, **John von Neumann** proposed that, since program and data are logically the same, programs should also be stored in the memory of a computer.

von Neumann Model

- Every computer today is based on the von Neumann Model.
- It is based on 3 ideas:
  1. Four subsystems
  2. Stored Program Concept
  3. Sequential Execution of Instructions

Four Subsystems

- ***Memory*** – the storage area of programs and data.
- ***ALU*** – arithmetic/logic operations take place
- ***Control Unit*** – control Memory, ALU, and I/O
- ***I/O*** – accept input data/send output data

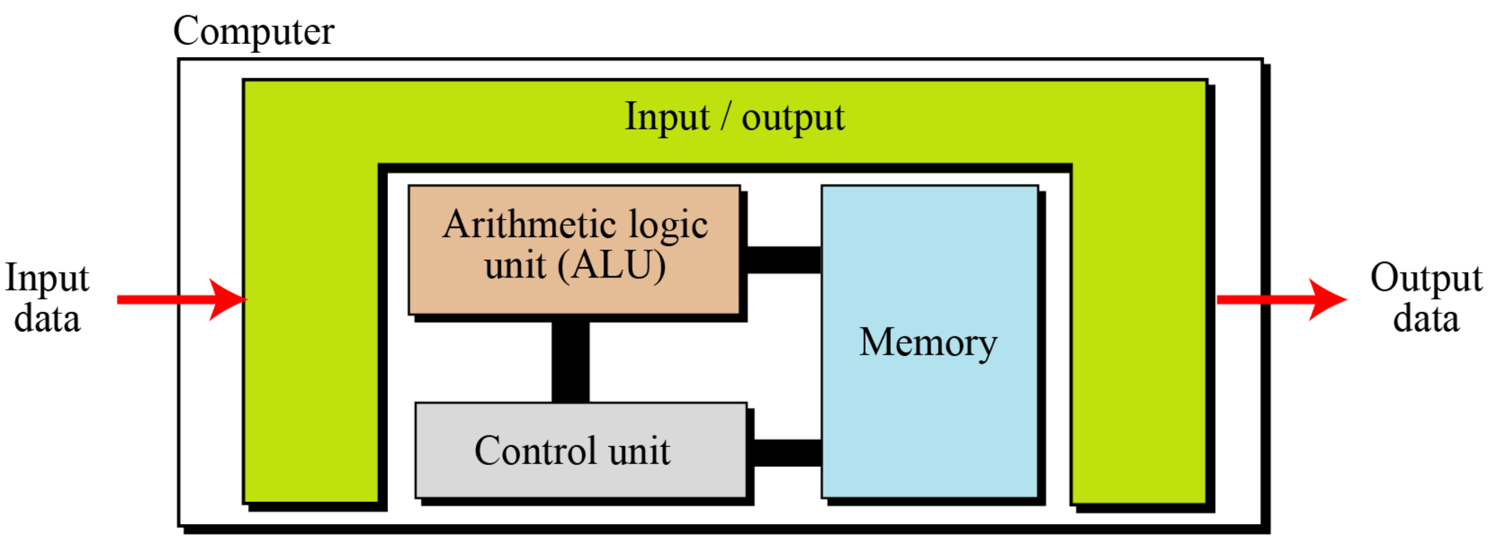


Figure 1.5 **The von Neumann model**

Stored Program Concept

- The von Neumann model states that the program must be stored in memory.
- The memory of modern computers hosts both
  - a program
  - its corresponding data

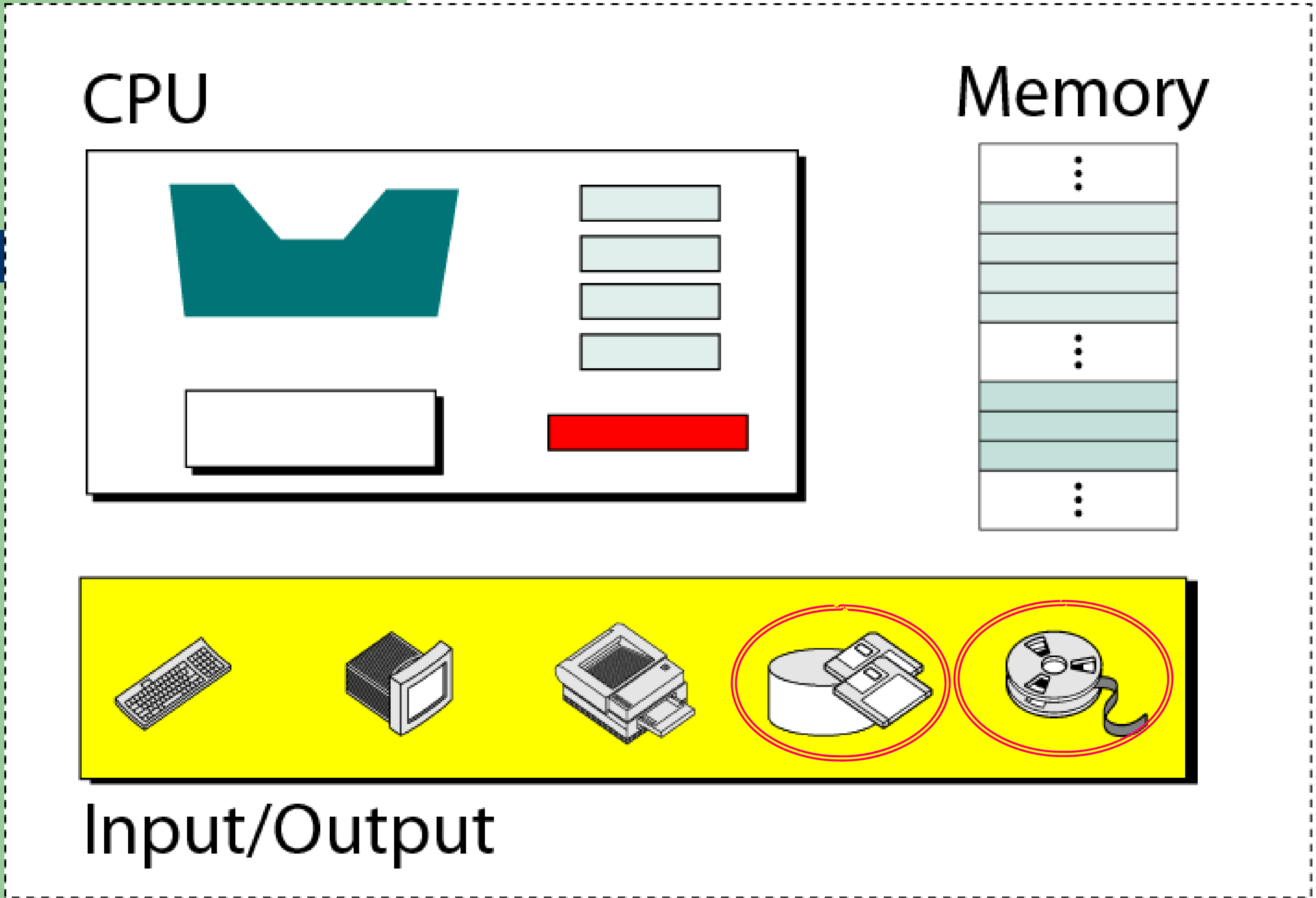
Sequential Execution of Instructions

- A program is made of a finite number of instructions.
- The control unit
  - fetches one instruction from memory
  - interpret it
  - execute it
- The instructions are executed one after another.

1-3 Computer Components

Overview

- A computer is made up of three components: **computer hardware**, **data**, and **computer software**.
- Computer hardware today has four components under the von Neumann model



Computer Hardware

Storing Data

- Store data in the form of an electrical signal, specifically its presence or absence.
- This implies that a computer can store data in one of two states.
- Binary number system

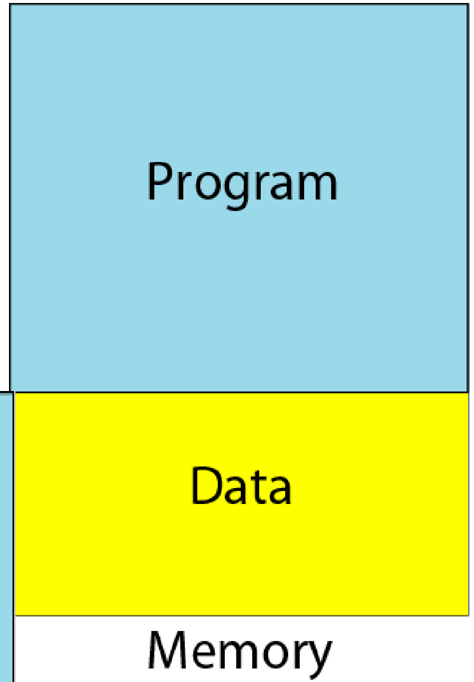
Data Organization

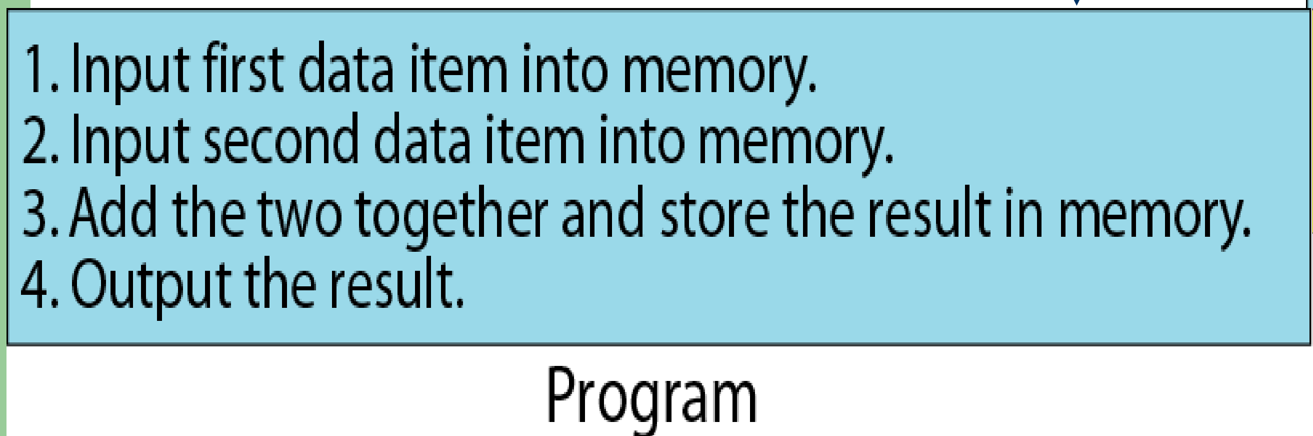
- Although data should be stored only in one form (a binary pattern) inside a computer,
  data outside a computer can take many forms.

- Data come in different forms:
  - Numbers
  - Text
  - Images
  - Audio
  - Video

Requirements of von Neumann model

1. The programs must be *stored in memory*. (Fig. 1.6)
2. The programs must be *a sequence of instructions*. (Fig. 1.7)





Algorithms

- A programmer should
  - first solve the problem in <u>a step-by-step manner</u> and then
  - try to find the <u>appropriate sequence of instructions</u> that solves the problem.

- *<u>The step-by-step solution</u>* is called an algorithm.

Operating Systems

- An operating system originally worked as a manager to facilitate access of the computer components for a program.

1-4 History

Before 1950

- Mechanical machines (before 1930)
- Early electronic computers (1930-1950)

- ***ENIAC*** (Electronic Numerical Integrator and Calculator)
  first general-purpose, totally electronic computer
  University of Pennsylvania, ***1946***

1950

- The preceding computers used memory only for storing data.

- EDVAC
  the first computer based on von Neumann's idea,
  University of Pennsylvania,1950

Computer generations (1950-present)

- First generation (1950-1959)
  vacuum tubes
- Second generation (1959-1965)
  transistors,
  High-level languages(FORTRAN, COBOL)
- Third generation (1965-1975)
  IC(Integrated Circuit),
  Minicomputer, software industry was born
- Fourth generation (1975-1985)
  VLSI,
  microcomputer
- Fifth generation (1985-)
  laptop and palmtop computer

Microcomputer

- Microcomputers are designed to be used by individuals, whether in the form of PCs, workstations or notebook computers.
- A microcomputer contains
  - a CPU on a microchip (the microprocessor),
  - a memory system (typically ROM and RAM),
  - a bus system and
  - I/O ports,
- typically housed in a motherboard.

1-5 Social and Ethical Issues

Social issues

- **Dependency**
  - Some people think that computers have created a kind of dependency, which makes people’s lives more difficult.
- **Social Justice**
  - Using computers at home is a luxury benefit that not all people can afford.
- **Digital Divide**
  - The concept divides society into two groups: those who are electronically connected to the rest of society and those who are not.

Ethical issues

- **Privacy**
  - Much needs to be done to make this type of communication private.
- **Copyright**
  - The Internet has created opportunities to share ideas, but has also brought with it a further ethical issue: electronic copyright.
- **Computer Crime**
  - Computers and information technology have created new types of crime.

1-6 Computer Science as a Discipline

Computer Science as a Discipline

- We can divide computer science into two broad categories: systems areas and applications areas.
- This book is a breadth-first approach to all these areas.