Computer Fundamentals and Programming in C

SECOND EDITION

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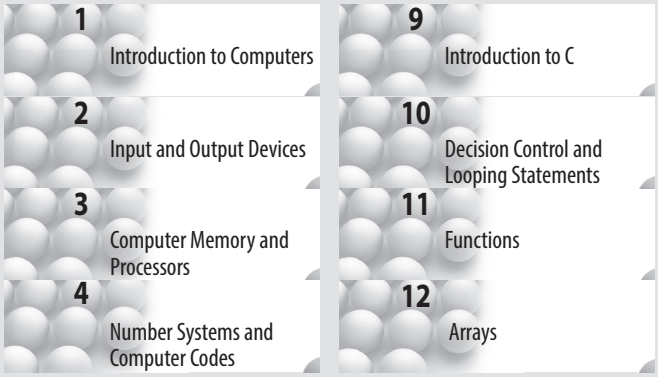
Features of



Comprehensive Coverage

Chapters provide a comprehensive coverage of topics ranging from basics of computer hardware and software to the basics of C programming

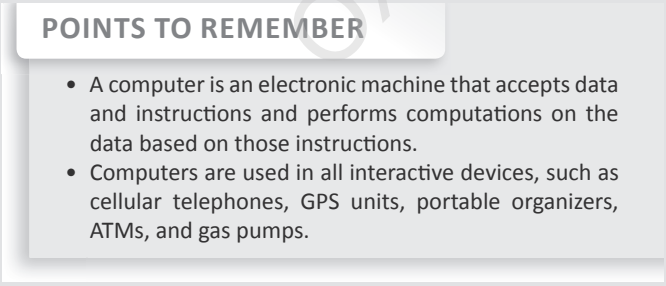
Note

Keys such as Shift, Ctrl, and Alt are called *modifier keys* because they are used to modify the normal function of a key. For example, Shift + character (lowercase) makes the computer display the character in upper case.

Notes and Programming Tips

Notes highlight important terms and concepts, and programming tips educate the readers about common programming errors and how to avoid them

Programming Tip:
Strings cannot be manipulated with arithmetic or other operators available in C boundaries.


POINTS TO REMEMBER

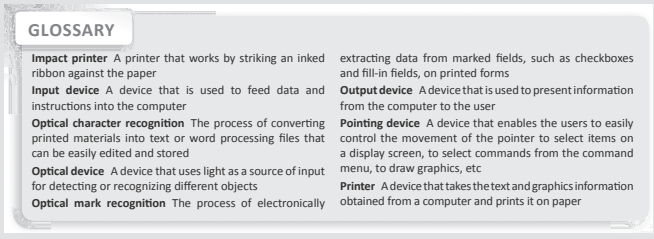
- A computer is an electronic machine that accepts data and instructions and performs computations on the data based on those instructions.
- Computers are used in all interactive devices, such as cellular telephones, GPS units, portable organizers, ATMs, and gas pumps.

Points to Remember

Summary points at the end of each chapter help readers to revise all the important concepts explained in the chapter

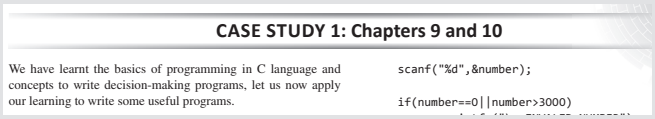
Glossary

Includes a list of key terms along with their definitions for a quick recapitulation of important terms learned in all chapters


GLOSSARY

Impact printer A printer that works by striking an inked ribbon against the paper
Input device A device that is used to feed data and instructions into the computer
Optical character recognition The process of converting printed materials into text or word processing files that can be easily edited and stored
Optical device A device that uses light as a source of input for detecting or recognizing different objects
Optical mark recognition The process of electronically extracting data from marked fields, such as checkboxes and fill-in fields, on printed forms
Output device A device that is used to present information from the computer to the user
Pointing device A device that enables the users to easily control the movement of the pointer to select items on a display screen, to select commands from the command menu, to draw graphics, etc
Printer A device that takes the text and graphics information obtained from a computer and prints it on paper

the Book

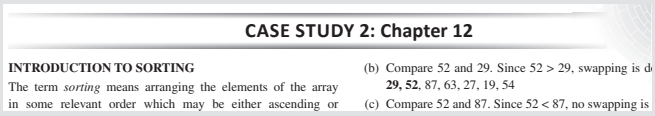


CASE STUDY 1: Chapters 9 and 10

We have learnt the basics of programming in C language and concepts to write decision-making programs, let us now apply our learning to write some useful programs.

```
scanf("%d",&number);

if(number==0||number>3000)
```



CASE STUDY 2: Chapter 12

INTRODUCTION TO SORTING

The term *sorting* means arranging the elements of the array in some relevant order which may be either ascending or

(b) Compare 52 and 29. Since 52 > 29, swapping is d
29, 52, 87, 63, 27, 19, 54
(c) Compare 52 and 87. Since 52 < 87, no swapping is

Case Studies

Select chapters on C include case studies that show how C can be used to create programs demonstrating real-life applications

Programming Examples

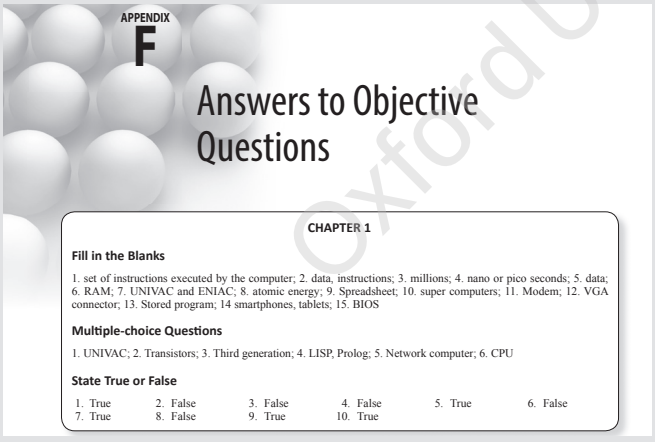
About 250 C programs are included, which demonstrate the applicability of the concepts learned

2. Write a program to print Hello World, using pointers.

```
#include <stdio.h>
int main()
{
  char *ch = "Hello World";
  printf("%s", ch);
  return 0;
}
```

Output

```
Hello World
```



APPENDIX F

Answers to Objective Questions

CHAPTER 1

Fill in the Blanks

1. set of instructions executed by the computer; 2. data, instructions; 3. millions; 4. nano or pico seconds; 5. data; 6. RAM; 7. UNIVAC and ENIAC; 8. atomic energy; 9. Spreadsheet; 10. super computers; 11. Modem; 12. VGA connector; 13. Stored program; 14 smartphones, tablets; 15. BIOS

Multiple-choice Questions

1. UNIVAC; 2. Transistors; 3. Third generation; 4. LISP, Prolog; 5. Network computer; 6. CPU

State True or False

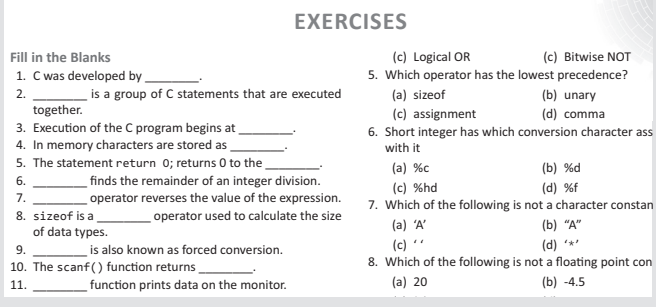
1. True	2. False	3. False	4. False	5. True	6. False
7. True	8. False	9. True	10. True		

Objective Questions

Includes comprehensive exercises at the end of each chapter to facilitate revision—Answers to these questions are provided in Appendix F at the end of the book

Exercises

Includes plenty of program code-related programs at the end of relevant chapters, which require the readers to find the output of a given code, the functionality of a given loop, or errors in a given program code



EXERCISES

Fill in the Blanks

1. C was developed by _____.
2. _____ is a group of C statements that are executed together.
3. Execution of the C program begins at _____.
4. In memory characters are stored as _____.
5. The statement `return 0;` returns 0 to the _____.
6. _____ finds the remainder of an integer division.
7. _____ operator reverses the value of the expression.
8. `sizeof` is a _____ operator used to calculate the size of data types.
9. _____ is also known as forced conversion.
10. The `scanf()` function returns _____.
11. _____ function prints data on the monitor.

(c) Logical OR (c) Bitwise NOT

5. Which operator has the lowest precedence?
(a) sizeof (b) unary
(c) assignment (d) comma
6. Short integer has which conversion character ass with it
(a) %c (b) %d
(c) %hd (d) %f
7. Which of the following is not a character constan
(a) 'A' (b) "A"
(c) ' ' (d) '*'
8. Which of the following is not a floating point con
(a) 20 (b) -4.5

Preface to the Second Edition

Information technology (IT) is the buzzword in the 21st century. It has revolutionized the way we think and irreversibly changed our everyday existence. Computers form the backbone of information technology affecting all aspects of our lives. They are not only used for general computing but also for performing tasks such as booking railway and airline tickets, designing a building, training a player, and practicing landing of an airplane. The use of computers has become so widespread that almost all electrical and electronic devices such as washing machines and air conditioners have a small embedded computer within them. Even the smartphones are connected to the Internet.

Learning computers is no longer meant only for students pursuing a career in engineering and technology, but is also mandatory for students of other professions such as journalism, nursing, archaeology, and construction and management. Therefore, a basic knowledge of computers helps one to be more productive and self-sufficient.

Moreover, C is considered to be the mother of all modern-day computer languages. Almost all popular cross-platform programming languages and scripting languages, such as C++, Java, Python, Objective-C, Perl, Ruby, PHP, Lua, and Bash, are implemented in C and borrow syntaxes and functions heavily from C. In the programming language popularity website, C tops the list followed by C++ and Java.

Thus, knowledge of C provides a solid foundation to learn advanced programming skills such as object-oriented programming, event-driven programming, multi-thread programming, real-time programming, embedded programming, network programming, parallel programming, other programming languages, and new and emerging computing paradigms such as grid-computing and cloud computing.

ABOUT THE BOOK

This second edition of *Computer Fundamentals and Programming in C* has been designed as a textbook for the undergraduate students of engineering, computer science, and computer applications. The objective of this book is to introduce the readers to the elements of computing, computer hardware and software, and C programming.

PEDAGOGICAL FEATURES

The following are the salient features of the book:

Comprehensive coverage Provides comprehensive coverage of important topics ranging from the basics of computers to C programming and important data structures

Case studies Includes case studies at the end of select chapters on C, which provide practical orientation to the concepts discussed in the respective chapters.

Complete program codes Contains plenty of program codes that are thoroughly tested and compiled to support the text

Practical orientation Provides numerous solved examples and chapter-end exercises in the form of objective-type questions, review exercises, and programming problems that enable the students to check their understanding of the concepts

Glossary Includes a list of key terms at the end of each chapter that facilitates revision of important topics learned

Tips and Notes Includes programming tips that educate readers about common programming errors and how to avoid them and notes that highlight important terms and concepts in between the text as sidebars for a quick recapitulation.

NEW TO THIS EDITION

The following are the most notable additions in this:

- Introduces a chapter on *Boolean Algebra and Logic Gates*, which discusses the basic concepts underlying digital computing systems
- Many new sections have been added in this edition. The details are as follows:

Chapter 1 To provide readers a perspective of how computers evolved over the last century, this chapter presents a **section** on history of computers, which gives a timeline of the developments in computing technology. The **section** on applications of computers covers new applications.

Chapter 3 The **section** on secondary storage devices includes latest devices such as Blu-ray disks and external hard disks. The chapter now also provides section on processor architecture, which focuses on the different components of a processor, and types of processors.

Chapter 4 This chapter includes **new examples** to demonstrate the addition and subtraction of hexadecimal and octal numbers. In addition, the chapter covers codes such as Unicode and 8421 and 2421 BCD codes. The **sections** on logic gates and universal gates have been moved to Chapter 5.

Chapter 5 This is a **new chapter**, which focuses on logic gates that form the basic building blocks of a digital circuit, and discuses Boolean algebra, which is used to express the output of any circuit implemented using logic gates.

Chapter 6 This **chapter** strengthens discussion on operating systems by briefly explaining the command interpretation module of an operating system and CLI vs GUI interface. It discusses the features of Windows 8 and Windows 10 along with mobile operating systems. In addition, it includes a **section** outlining the differences between customized and public domain software.

Chapter 7 To familiarize readers with how applications communicate over a network, this **chapter** provides a brief overview of two reference models—OSI model and TCP/IP model. In addition, it discusses Internet-related concepts such as IP address, URL, and domain name system (DNS).

Chapter 8 In order to make the text more coherent, this chapter has been restructured to focus on the program designing tools that aid in the development of efficient programs. The **section** on programming languages has been shifted to chapter 6.

Chapter 9 This **chapter** includes an annexure, which shows the steps to compile and execute C programs on both Unix/Linux and Ubuntu platforms.

Chapter 12 This **chapter** adds a program showing the array representation of sparse matrices. Similarly, it includes a program to find whether a matrix is symmetric or not.

Chapter 14 It includes a program to illustrate the dangling pointer problem.

Chapter 15 It presents three different ways to find the size of a structure. All these different methods have been exemplified through program codes.

CONTENT AND COVERAGE

The book is divided into two parts spanning 18 chapters and five appendices.

Part I: Computers in Fundamentals

Chapter 1, *Introduction to Computers*, provides an introduction to computers. The chapter explains the generations, classifications, applications, and the basic organization of a computer system.

Chapter 2, *Input and Output Devices*, presents a detailed description of the different types of input and output devices.

Chapter 3, *Computer Memory and Processors*, explains the significance of memory hierarchy and discusses the different types of primary and secondary memory that are widely used to store data. It also discusses the basic processor architecture (including RISC and CISC) and the instruction set.

Chapter 4, *Number Systems and Computer Codes*, discusses binary, octal, and hexadecimal number systems. The chapter enables the reader to perform arithmetic operations on different number systems. Important codes such as ASCII, EBCDIC, Excess 3, Gray code, and Unicode are also discussed in the chapter.

Chapter 5, *Boolean Algebra and Logic Gates*, introduces the concepts of digital computing systems such as Boolean algebra, Boolean functions, Boolean expressions, and logic gates.

Chapter 6, *Computer Software*, provides a thorough overview of computer software. It discusses different types of system software and application software packages that are widely used.

Chapter 7, *Computer Networks and the Internet*, talks about different types of computer networks, wired and wireless media, network devices and topologies, area networks, and data transmission mode. It also discusses the Internet, TCP/IP protocol, and different services provided by the Internet.

Chapter 8, *Designing Efficient Programs*, details the different steps in software development process, which are performed for creating efficient and maintainable programs. It also explains the different tools, which are used to obtain solution(s) of a given problem at hand.

Part II: Programming in C

Chapter 9, *Introduction to C*, discusses the building blocks of the C programming language. It includes descriptions on identifiers, constants, variables, and operators supported by the language.

Annexure 1 shows the steps to write, compile, and execute a C program in Unix/Linux and Ubuntu environments.

Chapter 10, *Decision Control and Looping Statements*, deals with special types of statements such as decision control, iterative, break, control, and jump.

Case Study 1 includes two programs which harness the concepts learnt in Chapters 9 and 10.

Chapter 11, *Functions*, deals with declaring, defining, and calling functions. It also discusses the storage classes as well as variable scope in C. The chapter ends with the concept of recursion and a discussion of the Tower of Hanoi problem.

Annexure 2 discusses how to create user-defined header files.

Chapter 12, *Arrays*, provides a detailed explanation of arrays that includes one-dimensional, two-dimensional, and multi-dimensional arrays. Towards the end of the chapter, the operations that can be performed on such arrays are also explained.

Case Study 2 provides an introduction to sorting and various sorting techniques such as bubble sort, insertion sort, and selection sort.

Chapter 13, *Strings*, discusses the concept of strings, which are better known as character arrays. The chapter not only focuses on reading and writing strings but also explains various operations that can be used to manipulate them.

Chapter 14, *Pointers*, presents a detailed overview of pointers, pointer variables, and pointer arithmetic. The chapter also relates the use of pointers with arrays, strings, and functions. This helps readers to understand how pointers can be used to write better and efficient programs.

Annexure 3 explains the process of deciphering pointer declarations.

Case Study 3 includes a program which demonstrates how pointers can be used to access and manipulate strings.

Chapter 15, *Structure, Union, and Enumerated Data Type*, introduces user-defined data types— structures and unions. It includes the use of structures and unions with pointers, arrays, and functions so that the inter-connectivity between the programming techniques can be well understood.

Annexure 4 provides an explanation about bit fields and slack bytes.

Chapter 16, *Files*, discusses how data can be stored in files. The chapter deals with opening, processing, and closing of files through a C program. These files are handled in text mode as well as binary mode for better clarity of the concepts.

Chapter 17, *Preprocessor Directives*, deals with preprocessor directives. It includes small program codes that illustrate the use of different directives in a C program.

Chapter 18, *Introduction to Data Structures*, provides an introduction to different data structures such as linked lists, stacks, queues, trees, and graphs.

Appendix A, *Bitwise Operations*, discusses bit-level programming and some of the bitwise operators.

Appendix B, *ANSI C Library Functions*, lists some of the ANSI C library functions and their descriptions.

Appendix C, *Advanced Type Qualifiers and Inline Functions in C*, introduces some advanced type qualifiers as well as inline functions.

Appendix D, *Interview Questions with Solutions*, includes about 100 frequently asked interview questions along with their solutions.

Appendix E, *Linux: A Short Guide* discusses the basics of Linux kernel and shell and describes the most commonly used Linux commands.

Appendix F, *Answers to Objective Questions*, provides answers to objective questions.

ACKNOWLEDGEMENTS

I would like to gratefully acknowledge the feedback and suggestions provided by various faculty members for the improvement of the book. I am obliged to the editorial team at Oxford University Press India for all their support towards revising this book. Suggestions for improving the presentation and contents can be sent to the publishers through their website www.india.oup.com or to me at reemathareja@gmail.com.

Reema Thareja

Preface to the First Edition

Computers are so widely used in our day-to-day lives that imagining a life without them has become almost impossible. They are not only used by professionals but also by children for interactively learning lessons, playing games, and doing their homework. Applications of the computer and its users are increasing by the day.

Learning computer fundamentals is a stepping stone to having an insight into how these machines work. Once the reader is aware of the basic terminology that is commonly used in computer science, he/she can then go on to develop useful computer programs that may help solve a user's problems.

Since computers cannot understand human languages, special programming languages are designed for this purpose. C is one such programming language. Being the most popular programming language, it is used in several different software platforms such as system software and application software. A few other programming languages such as C++ and JAVA are also based on C. Hence, mastering the C language is a prerequisite for learning such languages.

ABOUT THE BOOK

Computer Fundamentals and Programming in C is aimed at serving as a textbook for undergraduate level courses in computer science and engineering and postgraduate level courses of computer applications. The objective of this book is to introduce the students to the fundamentals of computers and the concepts of the C programming language and enable them to apply these concepts for solving real-world problems. The book has been designed keeping in mind the requirements of a basic first-level course on computer fundamentals and programming, which is offered as a common subject in all engineering disciplines. It comprehensively covers the fundamental concepts of computers, including topics such as introduction to computers, number system, input/output devices, computer memory, computer software, the Internet, and introduction to algorithms and programming languages. Programming is a skill best developed by rigorous practice. Keeping this in mind, the book provides a number of examples and exercises that would help the reader learn how to design efficient, workable programs. Various programming examples that have been thoroughly implemented and tested have been included in the book.

To further enhance the understanding of the subject, there are numerous chapter-end exercises provided in the form of objective type questions, review questions, and programming problems.

The book is also useful as a reference and resource to computer professionals.

ACKNOWLEDGEMENTS

The writing of this textbook was a mammoth task for which a lot of help was required from many people. Fortunately, I have had the fine support of my family, friends, and fellow members of the teaching staff at the Institute of Information Technology and Management, Delhi.

My special thanks would always go to my father Shri Janak Raj Thareja, my mother Smt. Usha Thareja, my brother Pallav, and sisters Kimi and Rashi who were a source of inspiration and divine blessings for me. I am especially thankful to my son Goransh who has been very patient and cooperative in letting me realize my dreams. My sincere thanks go to my uncle, Mr B.L. Theraja, for his inspiration and guidance in writing this book.

Finally, I would like to acknowledge the technical assistance provided to me by Ed. Udit Chopra, who helped me in designing and testing the numerous program codes provided in the book.

Last but not least, my acknowledgements will remain incomplete if I do not thank the editorial team at Oxford University Press, India, for supporting me wholeheartedly during the publication of my books over the past few years.

Reema Thareja

Brief Contents

Detailed Contents

1 Introduction to Computers

TAKEAWAYS

- Characteristics of computers
- Digital computers
- Stored program concept
- Generations of computers
- Types of computers
- Applications of computers
- Basic organization of a computer

1.1 COMPUTER

A computer, in simple terms, can be defined as an electronic device that is designed to accept data, perform the required mathematical and logical operations at high speed, and output the result.

We all have seen computers in our homes, schools, and colleges. In fact, in today's scenario, we find computers in most aspects of our daily lives. For some of us, it is hard to even imagine a world without them.

In the past, computers were extremely large in size and often required an entire room for installation. These computers consumed enormous amounts of power and were too expensive to be used for commercial applications. Therefore, they were used only for limited tasks, such as computing trajectories for astronomical or military applications. However, with technological advancements, the size of computers became smaller and their energy requirements reduced immensely. This opened the way for adoption of computers for commercial purposes.

These days, computers have become so prevalent in the market that all interactive devices such as cellular phones, global positioning system (GPS) units, portable organizers, automated teller machines (ATMs), and gas pumps, work with computers.

1.2 CHARACTERISTICS OF COMPUTERS

We have seen that a computer is an electronic device that performs a function based on a given set of instructions known as a *program*. A computer accepts data, processes it, and produces information. Here, data refers to some raw fact or figure, and information implies the processed data. For example, if 12-12-92 is the date of birth of a student, then it is data (a raw fact/figure). However, when we process this data (subtract it from the present-date) and say that the age of the student is 23 years, then the outcome is information.

These days, computers have become a crucial part of our everyday lives, and we need computers just like we need televisions, telephones, or other electronic devices at home. Computers are basically meant to solve problems quickly and accurately. The important characteristics of a computer (refer to Figure 1.1) are discussed in the following text.

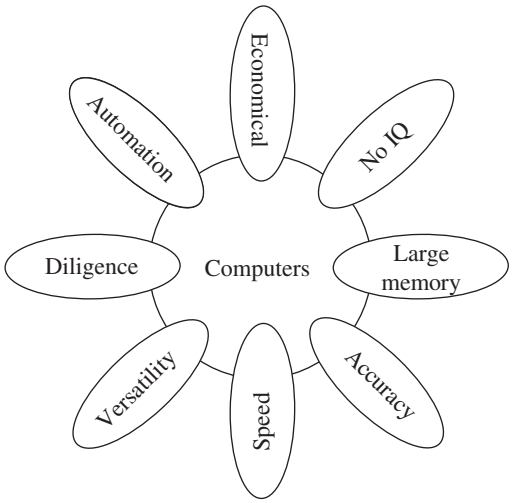


Figure 1.1 Characteristics of computers

Speed Computers can perform millions of operations per second, which means that data that may otherwise take many hours to process is output as information in the blink of an eye. The speed of computers is usually given in nanoseconds and picoseconds, where 1 nanosecond = 1×10^{-9} seconds and 1 picosecond = 1×10^{-12} seconds.

Accuracy A computer is a very fast, reliable, and robust electronic device. It always gives accurate results, provided the correct data and set of instructions are input to it. Hence, in the event of an error, it is the user who has

fed the incorrect data/program is responsible. This clearly means that the output generated by a computer depends on the given instructions and input data. If the input data is wrong, then the output will also be erroneous. In computer terminology, this is known as *garbage-in, garbage-out (GIGO)*.

Automation Besides being very fast and accurate, computers are automatable devices that can perform a task without any user intervention. The user just needs to assign the task to the computer, after which it automatically controls different devices attached to it and executes the program instructions.

Diligence Unlike humans, computers never get tired of a repetitive task. It can continually work for hours without creating errors. Even if a large number of executions need to be executed, each and every execution requires the same duration, and is executed with the same accuracy.

Versatile Versatility is the quality of being flexible. Today, computers are used in our daily life in different fields. For example, they are used as personal computers (PCs) for home use, for business-oriented tasks, weather forecasting, space exploration, teaching, railways, banking, medicine, and so on, indicating that computers can perform different tasks simultaneously. On the PC that you use at home, you may play a game, compose and send e-mails, listen to music, etc. Therefore, computers are versatile devices as they can perform multiple tasks of different nature at the same time.

Memory Similar to humans, computers also have memory. Just the way we cannot store everything in our memory and need secondary media, such as a notebook, to record certain important things, computers also have internal or primary memory (storage space) as well as external or secondary memory. While the internal memory of computers is very expensive and limited in size, the secondary storage is cheaper and of bigger capacity.

The computer stores a large amount of data and programs in the secondary storage space. The stored data and programs can be retrieved and used whenever required. Secondary memory is the key for data storage. Some examples of secondary devices include floppy disks, optical disks (CDs and DVDs), hard disk drives (HDDs), and pen drives.

When data and programs have to be used, they are copied from the secondary memory into the internal memory, often known as random access memory (RAM). The concept of computer memory is discussed in detail in Chapter 3.

No IQ Although the trend today is to make computers intelligent by inducing artificial intelligence (AI) in them, they still do not have any decision-making abilities of their own. They need guidance to perform various tasks.

Economical Today, computers are considered as short-term investments for achieving long-term gains. Using computers also reduces manpower requirements and leads to an elegant and efficient way of performing various tasks. Hence, computers save time, energy, and money. When compared to other systems, computers can do more work in lesser time. For example, using the conventional postal system to send an important document takes at least two to three days, whereas the same information when sent using the Internet (e-mail) will be delivered instantaneously.

1.3 STORED PROGRAM CONCEPT

All digital computers are based on the principle of stored program concept,which was introduced by Sir John von Neumann in the late 1940s. The following are the key characteristic features of this concept:

- Before any data is processed, instructions are read into memory.
- Instructions are stored in the computer's memory for execution.
- Instructions are stored in binary form (using binary numbers—only 0s and 1s).
- Processing starts with the first instruction in the program, which is copied into a control unit circuit. The control unit executes the instructions.
- Instructions written by the users are performed sequentially until there is a break in the current flow.
- Input/Output and processing operations are performed simultaneously. While data is being read/written, the central processing unit (CPU) executes another program in the memory that is ready for execution.

Note

A stored program architecture is a fundamental computer architecture wherein the computer executes the instructions that are stored in its memory.

John W. Mauchly, an American physicist, and J. Presper Eckert, an American engineer, further contributed to the stored program concept to make digital computers much more flexible and powerful. As a result, engineers in England built the first stored-program computer, Manchester Mark I, in the year 1949. They were shortly followed by the Americans who designed EDVAC in the very same year.

Today, a CPU chip can handle billions of instructions per second. It executes instructions provided both the data and instructions are valid. In case either one of them or both are not valid, the computer stops the processing of instructions.

1.3.1 Types of Stored Program Computers

A computer with a Von Neumann architecture stores data and instructions in the same memory. There is a serial machine in which data and instructions are selected one

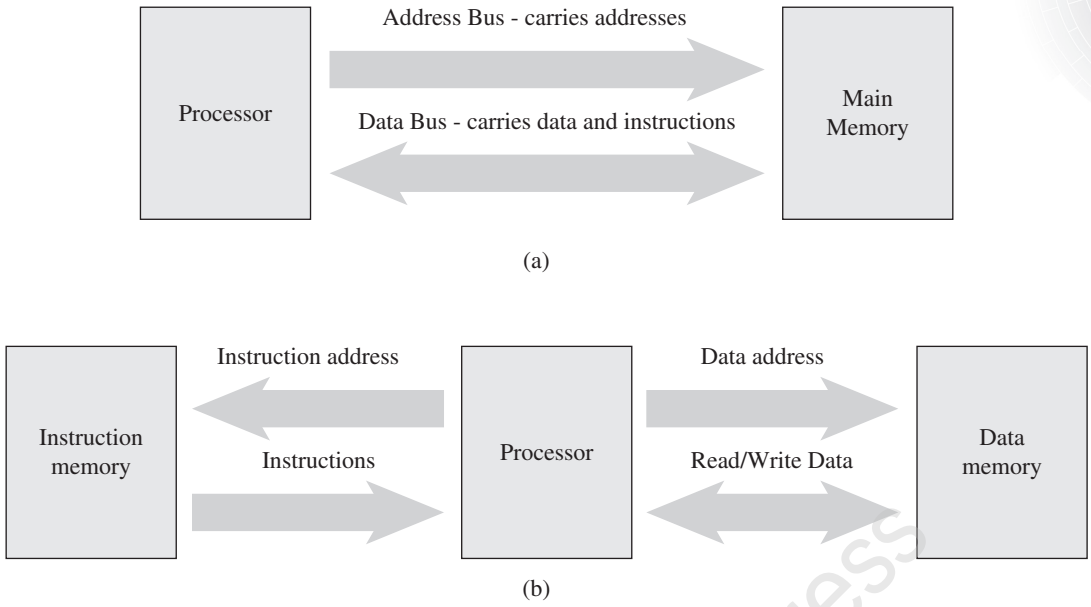


Figure 1.2 Von Neumann architecture (a) Shared memory for instructions and data (b) Separate memories for instructions and data

at a time. Data and instructions are transferred to and from memory through a shared data bus. Since there is a single bus to carry data and instructions, process execution becomes slower.

Later Harvard University proposed a stored program concept in which there was a separate memory to store data and instructions. Instructions are selected serially from the instruction memory and executed in the processor. When an instruction needs data, it is selected from the data memory. Since there are separate memories, execution becomes faster.

1.4 HISTORY OF COMPUTERS

Early computers were designed not for entertainment but for solving number-crunching problems. These computers were punch-card based computers that took up entire rooms. Today, our smartphones have much more computing power than that was available in those early computers.

In this section, we will read about history of computers way back from the invention of abacus and take a look at the remarkable achievements in computing technology till the current time.

Timeline of Developments

300 BC: The *abacus* was an early aid for mathematical computations and was designed to aid human's memory while performing calculations. A skilled abacus operator can add and subtract with the same speed as that of a person performing the same calculation using a hand calculator. The invention of abacus is often wrongly attributed to China. It was used by the Babylonians even in 300 BC and is still in use today (in the Far East).

1822: English mathematician Charles Babbage designed a steam-driven calculating machine that could compute tables of numbers. Though the project failed as he could not complete the construction of the engine, it laid the foundation for the first computer.

1890: Herman Hollerith, an American inventor, designed a punched card system to calculate the 1880 census. The system completed the task in three years saving the US government $5 million. Later Herman established a company that we today know as IBM.

1936: British mathematician Alan Turing introduced a universal machine called the Turing machine capable of computing anything that is computable. The central concept of the modern computer is based on this machine.

1941: John Vincent Atanasoff, a Bulgarian-American physicist, and his graduate student, Clifford Berry, at Iowa State College designed Atanasoff–Berry computer (ABC) that could solve 29 equations simultaneously. It was the first time a computer could store information in its main memory.

1943–1944: John W. Mauchly and J. Presper Eckert built the Electronic Numerical Integrator and Calculator (ENIAC), which is considered as the grandfather of digital computers. It filled a 20 × 40 feet room and had 18,000 vacuum tubes.

1946: Mauchly and Presper designed the UNIVAC, which was the first commercial computer for business and government applications.

1947: William Shockley, John Bardeen, and Walter Brattain of Bell Laboratories invented the transistor. Soon vacuum tubes in computers were replaced by transistors.

1953: Grace Hopper developed the first computer language COBOL.

1954: The FORTRAN programming language was developed.

1958: Jack Kilby of Texas Instruments and Robert Noyce at Fairchild Semiconductor Corporation separately invented integrated circuit, which is commonly known as the computer chip.

1964: Douglas Engelbart developed a prototype of the modern computer, with a mouse and a graphical user interface (GUI). This was a remarkable achievement as it shifted computers from a specialized machine for scientists and mathematicians to general public.

1969: Unix operating system was developed at Bell Labs. It was written in the C programming language and was designed to be portable across multiple platforms. Soon it became the operating system of choice among mainframes at large companies and government entities.

1970: DRAM chip was introduced by Intel.

1971: Alan Shugart with his team in IBM invented the floppy disk which allowed data to be shared among computers.

1973: Robert Metcalfe, a research member at Xerox, developed Ethernet for connecting multiple computers and other hardware.

1974–1977: Personal computers started becoming popular.

1975: Paul Allen and Bill Gates started writing software for the Altair 8800 using the new BASIC language. On April 4, they both formed their own software company, Microsoft.

1976: Steve Jobs and Steve Wozniak started Apple Computers and developed Apple I, the first computer with a single-circuit board.

1977: Apple II was launched that offered colour graphics and incorporated an audio cassette drive for storage.

1978: WordStar, a word processor application, was released by MicroPro International.

1979: VisiCalc, the first computerized spreadsheet program for personal computers, was unveiled.

1981: The first IBM personal computer was introduced that used Microsoft's MS-DOS operating system. The term PC was popularized.

1983: The first laptop was introduced. Moreover, Apple introduced Lisa as the first personal computer with a GUI with drop-down menus and icons.

1985: Microsoft announced Windows as a new operating system.

1986: Compaq introduced Deskpro 386 in the market, which was a 32-bit architecture machine that provides speed comparable to mainframes.

1990: Tim Berners-Lee invented World Wide Web with HTML as its publishing language.

1993: The Pentium microprocessor introduced the use of graphics and music on PCs.

1994: PC games became popular.

1996: Sergey Brin and Larry Page developed the Google search engine at Stanford University.

1999: The term Wi-Fi was introduced when users started connecting to the Internet without wires.

2001: Apple introduced Mac OS X operating system, which had protected memory architecture and pre-emptive multi-tasking, among other benefits. To stay competitive, Microsoft launched Windows XP.

2003: The first 64-bit processor, AMD's Athlon 64, was brought into the consumer market.

2004: Mozilla released Firefox 1.0 and in the same year Facebook, a social networking site, was launched.

2005: YouTube, a video sharing service, was launched. In the same year, Google acquired Android, a Linux-based mobile phone operating system.

2006: Apple introduced MacBook Pro, its first Intel-based, dual-core mobile computer.

2007: Apple released iPhone, which brought many computer functions in the smartphone.

2009: Microsoft launched Windows 7 in which users could pin applications to the taskbar.

2010: Apple launched iPad, which revived the tablet computer segment.

2011: Google introduced Chromebook, a laptop that runs on the Google Chrome operating system.

2015: Apple released the Apple Watch. In the same year, Microsoft launched Windows 10.

After reading these interesting developments in computing technology, let us also understand the evolution of computers through different generations.

First Generation (1942–1955)

Hardware Technology First generation computers were manufactured using thousands of vacuum tubes (see Figure 1.3); a vacuum tube is a device made of fragile glass.

Memory Electromagnetic relay was used as primary memory and punched cards were used to store data and instructions.

Software Technology Programming was done in machine or assembly language.

Used for Scientific applications

Examples ENIAC, EDVAC, EDSAC, UNIVAC I, IBM 701

Highlights

- They were the fastest calculating device of those times
- Computers were too bulky and required a complete room for storage
- Highly unreliable as vacuum tubes emitted a large amount of heat and burnt frequently
- Required air-conditioned rooms for installation
- Costly
- Difficult to use
- Required constant maintenance because vacuum tubes used filaments that had limited life time. Therefore, these computers were prone to frequent hardware failures

Figure 1.3 Vacuum tube

Source: Vladyslav Danilin/Shutterstock

Second Generation (1955–1964)

Hardware Technology Second generation computers were manufactured using transistors (see Figure 1.4). Transistors were reliable, powerful, cheaper, smaller, and cooler than vacuum tubes.

Memory Magnetic core memory was used as primary memory; magnetic tapes and magnetic disks were used to store data and instructions. These computers had faster and larger memory than the first generation computers.

Software Technology Programming was done in high level programming languages. Batch operating system was used.

Used for Scientific and commercial applications

Examples Honeywell 400, IBM 7030, CDC 1604, UNIVAC LARC

Highlights

- Faster, smaller, cheaper, reliable, and easier to use than the first generation computers
- They consumed 1/10th the power consumed by first generation computers
- Bulky in size and required a complete room for its installation
- Dissipated less heat than first generation computers but still required air-conditioned rooms
- Costly
- Difficult to use

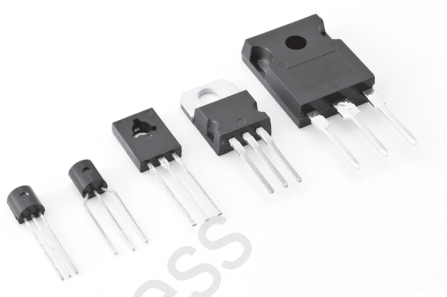


Figure 1.4 Transistors

Source: yurazaga/Shutterstock

Third Generation (1964–1975)

Hardware Technology Third generation computers were manufactured using integrated chips (ICs) (shown in Figure 1.5). ICs consist of several components such as transistors, capacitors, and resistors on a single chip to avoid wired interconnections between components. These computers used *SSI and MSI technology*. Minicomputers came into existence.

Note

Initially, ICs contained 10–20 components. This technology was called Small Scale Integration (SSI). Later, it was enhanced to contain about 100 components. This was called MSI (Medium Scale Integration).

Memory Larger magnetic core memory was used as primary memory; larger capacity magnetic tapes and magnetic disks were used to store data and instructions.

Software Technology Programming was done in high level programming languages such as FORTRAN, COBOL, Pascal, and BASIC. Time sharing operating system was used. Software was separated from the hardware. This allowed users to invest only in the software they need.

Used for Scientific, commercial, and interactive online applications

Examples IBM 360/370, PDP-8, PADP-11, CDC6600

Highlights

- Faster, smaller, cheaper, reliable, and easier to use than the second generation computers
- They consumed less power than second generation computers

- Bulky in size and required a complete room for installation
- Dissipated less heat than second generation computers but still required air-conditioned rooms
- Costly
- Easier to use and upgrade

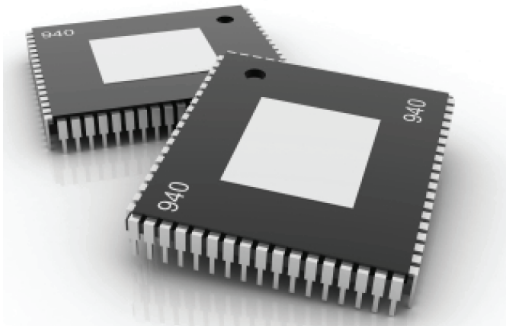


Figure 1.5 Integrated circuits

Source: cooldesign/FreeDigitalPhotos.net

Fourth Generation (1975–1989)

Hardware Technology Fourth generation computers were manufactured using ICs with LSI (Large Scale Integrated) and later with VLSI technology (Very Large Scale Integration). Microcomputers came into existence. Use of personal computers became widespread. High speed computer networks in the form of LANs, WANs, and MANs started growing. Besides mainframes, supercomputers were also used

Note

LSI circuits contained 30,000 components on a single chip and VLSI technology had about one million electronic components on a single chip.

Memory Semiconductor memory was used as primary memory, large capacity magnetic disks were used as built-in secondary memory. Magnetic tapes and floppy disks were used as portable storage devices.

Software Technology Programming was done in high level programming language such as C and C++. Graphical User Interface (GUI) based operating system (e.g. Windows) was introduced. It had icons and menus among other features to allow computers to be used as a general purpose machine by all users. UNIX was also introduced as an open source operating system. Apple Mac OS and MS DOS were also released during this period. All these operating systems had multi-processing and multi-programming capabilities.

Used for Scientific, commercial, interactive online, and network applications

Examples IBM PC, Apple II, TRS-80, VAX 9000, CRAY-1, CRAY-2, CRAY-X/MP

Highlights Faster, smaller, cheaper, powerful, reliable, and easier to use than the previous generation computers

Figure 1.6 VLSI chip

Fifth Generation (1989–Present)

Hardware Technology Fifth generation computers are manufactured using ICs with ULSI (Ultra Large Scale Integrated) technology. The use of Internet became widespread and very powerful mainframes, desktops, portable laptops, and smartphones are being used commonly. Supercomputers use parallel processing techniques.

Note

ULSI circuits contain about 10 million electronic components on a single chip.

Memory Semiconductor memory is used as primary memory; large capacity magnetic disks are used as built-in secondary memory. Magnetic tapes and floppy disks were used as portable storage devices, which have now been replaced by optical disks and USB flash drives.

Software Technology Programming is done in high-level programming languages such as Java, Python, and C#. Graphical User Interface (GUI)-based operating systems such as Windows, Unix, Linux, Ubuntu, and Apple Mac are being used. These operating systems are more powerful and user friendly than the ones available in the previous generations.

Used for Scientific, commercial, interactive online, multimedia (graphics, audio, video), and network applications

Examples IBM notebooks, Pentium PCs, SUM workstations, IBM SP/2, Param supercomputer

Highlights

- Faster, smaller, cheaper, powerful, reliable, and easier to use than the previous generation computers
- Speed of microprocessors and the size of memory are growing rapidly

- High-end features available on mainframe computers in the fourth generation are now available on the microprocessors
- They consume less power than computers of prior generations
- Air-conditioned rooms required for mainframes and supercomputers but not for microprocessors

Figure 1.7 ULSI chip

1.5 CLASSIFICATION OF COMPUTERS

Computers can be broadly classified into four categories based on their speed, amount of data that they can process, and price (refer to Figure 1.8). These categories are as follows:

- Supercomputers
- Mainframe computers
- Minicomputers
- Microcomputers

1.5.1 Supercomputers

Among the four categories, the supercomputer is the fastest, most powerful, and most expensive computer. Supercomputers were first developed in the 1980s to process large amounts of data and to solve complex scientific problems. Supercomputers use parallel processing technology and can perform more than one trillion calculations in a second.

A single supercomputer can support thousands of users at the same time. Such computers are mainly used for weather forecasting, nuclear energy research, aircraft design, automotive design, online banking, controlling industrial units, etc. Some examples of supercomputers are CRAY-1, CRAY-2, Control Data CYBER 205, and ETA A-10.

1.5.2 Mainframe Computers

Mainframe computers are large-scale computers (but smaller than supercomputers). These are very expensive and need a very large clean room with air conditioning, thereby making them very costly to deploy. As with supercomputers, mainframes can also support multiple processors. For example, the IBM S/390 mainframe can support 50,000 users at the same time. Users can access mainframes by either using terminals or via PCs. The two types of terminals that can be used with mainframe systems are as follows:

Dumb Terminals

Dumb terminals consist of only a monitor and a keyboard (or mouse). They do not have their own CPU and memory and use the mainframe system's CPU and storage devices.

Intelligent Terminals

In contrast to dumb terminals, intelligent terminals have their own processor and thus can perform some processing operations. However, just like the dumb terminals, they do not have their own storage space. Usually, PCs are used as intelligent terminals to facilitate data access and other services from the mainframe system.

Mainframe computers are typically used as servers on the World Wide Web. They are also used in organizations such as banks, airline companies, and universities, where a large number of users frequently access the data stored in their databases. IBM is the major manufacturer of mainframe computers. Some examples of mainframe computers include IBM S/390, Control Data CYBER 176, and Amdahl 580.

1.5.3 Minicomputers

As the name suggests, minicomputers are smaller, cheaper, and slower than mainframes. They are called minicomputers because they were the smallest computer of their times. Also known as *midrange computers*, the capabilities of minicomputers fall between mainframe and personal computers.

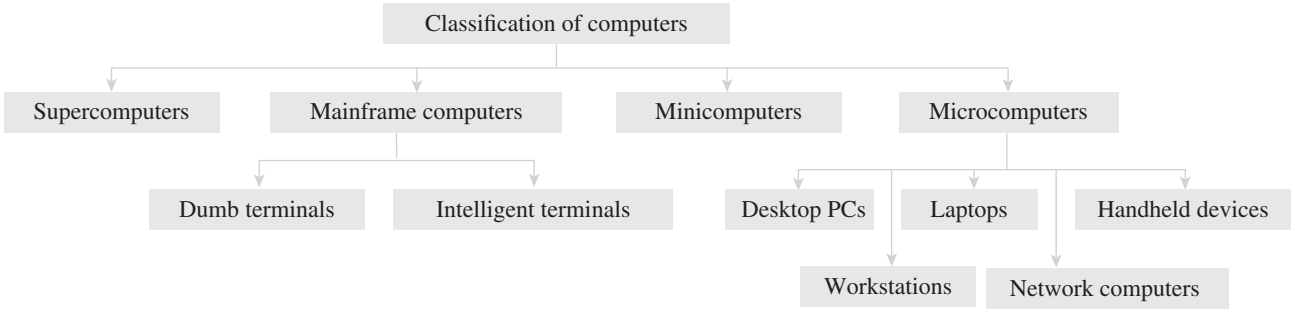


Figure 1.8 Classification of computers

Minicomputers are widely used in business, education, hospitals, government organizations, etc. While some minicomputers can be used only by a single user, others are specifically designed to handle multiple users simultaneously. Usually, single-user minicomputers are used for performing complex design tasks.

As with mainframes, minicomputers can also be used as servers in a networked environment, and hundreds of PCs can be connected to it.

The first minicomputer was introduced by Digital Equipment Corporation (DEC) in the mid-1960s. Other manufacturers of minicomputers include IBM Corporation (AS/400 computers), Data General Corporation, and Prime Computer.

1.5.4 Microcomputers

Microcomputers, commonly known as PCs, are very small and cheap. The first microcomputer was designed by IBM in 1981 and was named IBM-PC. Later on, many computer hardware companies copied this design and termed their microcomputers as *PC-compatible,* which refers to any PC that is based on the original IBM PC design.

Another type of popular PC is designed by Apple. PCs designed by IBM and other PC-compatible computers have a different architecture from that of Apple computers. Moreover, PCs and PC-compatible computers commonly use the Windows operating system, while Apple computers use the Macintosh operating system (MacOS). PCs can be classified into the following categories:

Desktop PCs

A desktop PC is the most popular model of PCs. The system unit of the desktop PC can be placed flat on a desk or table. It is widely used in homes and offices.

Laptops

Laptops (Figure 1.9) are small microcomputers that can easily fit inside a briefcase. They are very handy and can easily be carried from one place to another. They may also be placed on the user's lap (thus the name). Hence, laptops are very useful, especially when going on long journeys. Laptops operate on a battery and do not always have to be plugged in like desktop computers.

Figure 1.9 Laptop

Source: You can more/Shutterstock

The memory and storage capacity of a laptop is almost equivalent to that of a desktop computer. As with desktop computers, laptops also have hard disk drives, USB drives, etc. For input, laptops have a built-in keyboard and a trackball/touchpad, which is used as a pointing device (as a mouse is used for a desktop PC).

Today, laptops have the same features and processing speed as the most powerful PCs. However, a drawback is that laptops are generally more expensive than desktop computers. These computers are very popular among business travellers.

Workstations

Workstations are single-user computers that have the same features as PCs, but their processing speed matches that of a minicomputer or mainframe computer. Workstation computers have advanced processors, more RAM and storage capacity than PCs. Therefore, they are more expensive and powerful than a normal desktop computer.

Although workstation computers are widely used as powerful single-user computers by scientists, engineers, architects, and graphic designers, they can also be used as servers in a networked environment.

Network Computers

Network computers have less processing power, memory, and storage than a desktop computer. These are specially designed to be used as terminals in a networked environment. For example, some network computers are specifically designed to access data stored on a network (including the Internet and intranet).

Some network computers do not have any storage space and merely rely on the network's server for data storage and processing tasks. The concept of network computers had become popular in the mid-1990s when several variations of computers such as Windows terminals, NetPCs, and diskless workstations were widely used.

Network computers that are specifically designed to access only the Internet or intranet are often known as Internet PCs or Internet boxes. Some network computers used in homes do not even have a monitor. Such computers may be connected to a television, which serves as the output device. The most common example of a home-based network computer is Web TV, which enables the user to connect a television to the Internet. The Web TV is equipped with a special set-top box that is used to connect to the Internet. The set-top box also provides controls to enable the user to navigate the Internet, send and receive e-mails, and to perform other tasks on the network while watching television. The other reason for the popularity of network computers is that they are cheaper to purchase and maintain than PCs.

Handheld Computers

The mid-1990s witnessed a range of small personal computing devices that are commonly known as handheld computers, or mobile computers. These computers are called handheld computers because they can fit in one hand, while users can use the other hand to operate them. Handheld computers are very small in size, and hence they have small-sized screens and keyboards. These computers are preferred by business travellers and mobile employees whose jobs require them to move from place to place.

Some examples of handheld computers are as follows:

- Smartphones
- Tablet PCs

Smartphones These days, cellular phones are web-enabled telephones. Such phones are also known as smartphones because, in addition to basic phone capabilities, they also facilitate the users to access the Internet and send e-mails, edit Word documents, generate an Excel sheet, create a presentation, and lots more.

Smartphones run an advanced mobile operating system that enables it to run various applications. The four major mobile operating systems are iOS, Android, BlackBerryOS, and Windows Mobile. Smartphones also have a CPU, more storage space, more memory, and a larger screen than a regular cell phone.

In a nutshell, smartphone refers to a multi-functional mobile phone handset that packs in varied functionalities from a camera to a web browser to a high-density display.

Tablet PCs A tablet PC (see Figure 1.10) is a computing device that is smaller than a laptop, but bigger than a smartphone. Features such as user-friendly interface, portability, and touch screen have made them very popular in the last few years. These days, a wide range of high-performance tablets are available in the market. While all of them look similar from outside, they may differ in features such as operating system, speed of data connectivity, camera specifications, size of the screen, processing power, battery life, and storage capability.

Some operating systems that are used in tablets are Android Jellybean (an open-source operating system built by Google), Windows 8, and iOS (developed by Apple). Each operating system has its own advantages and disadvantages and a proprietary app store, from which users can download applications, extending the tablet's functionality. These apps range from games to specialized word processors and even instruments.

While users can easily type directly on the surface of a tablet, some users prefer a wireless or bluetooth-connected keyboard. These days, tablets also offer an optional docking station with keyboards that transforms the tablet into a full-featured netbook.

Uses The following are the uses of Tablet PCs:

- View presentations
- Videoconferencing
- Reading e-books, e-newspaper
- Watching movies
- Playing games
- Sharing pictures, video, songs, documents, etc.
- Browsing the Internet
- Keeping in touch with friends and family on popular social networks, sending emails
- Business people use them to perform tasks such as editing a document, exchanging documents, taking notes, and giving presentations
- Tablets are best used in crowded places such as airports and coffee shops, where size and portability become more important.

Note

Tablets may replace laptops if users don't have to perform heavy processing tasks and do not require a CD or DVD player

Figure 1.10 Tablet

Source: bloomua/Shutterstock/OUP Picture Bank

1.6 APPLICATIONS OF COMPUTERS

When the first computers were developed, they were used only in the fields of mathematics and science. In fact, the first effective utilization of computers was for decoding messages in military applications. Later on, computers were used in real-time control systems, like for landing on the moon. However, with the advancement of technology, the cost of computers and their maintenance declined. This opened the way for computers to be extensively used in the business and commercial sector for information processing. Today, computers are widely used in fields such as engineering, health care, banking, education, etc. Let us discuss how computers are being effectively utilized to perform important tasks.

Word processing Word processing software enables users to read and write documents. Users can also add images, tables, and graphs for illustrating a concept. The software automatically corrects spelling mistakes and includes copy–paste features (which is very useful where the same text has to be repeated several times).

Internet The Internet is a network of networks that connects computers all over the world. It gives the user access to an enormous amount of information, much more than available in any library. Using e-mail, the user can communicate in seconds with a person who is located thousands of miles away. Chat software enables users to chat with another person in real-time (irrespective of the physical location of that person). Video conferencing tools are becoming popular for conducting meetings with people who are unable to be present at a particular place.

Digital video or audio composition Computers make audio or video composition and editing very simple. This has drastically reduced the cost of equipment to compose music or make a film. Graphics engineers use computers for developing short or full-length films and creating 3-D models and special effects in science fiction and action movies.

Desktop publishing Desktop publishing software enables us to create page layouts for entire books.

After discussing how computers are used in today's scenario, let us now have a look at the different areas where computers are being widely utilized.

e-Business

e-Business or electronic business is the process of conducting business via the Internet. This may include buying and selling of goods and services using computers and the Internet. Use of email and videoconferencing technology has revolutionized the way business is being conducted these days.

While an e-mail is a service that delivers messages from a sender to one or more receivers via computer, voice mail systems capture, store, and transmit spoken messages. Videoconferencing, which is an advanced form of teleconferencing, provides a complete simulation of a normal meeting environment in which all concerned parties can see, hear, and present material, just as if they were in the same room. These meetings not only speed up business process but also save the cost of travel and cost of the time wasted during travel.

Note

Both the terms—e-Commerce and e-Business—are often used interchangeably.

Companies today use e-commerce applications for marketing, transaction, processing, and product and customer services processing. For example, the website of a company can perform activities such as interactive marketing, ordering, payment, and customer support process.

e-commerce used to perform transactions between business partners or customers has several applications such as home banking, electronic shopping, buying stocks, finding a job, conducting an auction, marketing and advertising products or services, and providing customer service. The following are techniques in which e-commerce helps users to conduct business transactions.

Business-to-consumer or B2C In this form of electronic commerce, business companies deploy their websites on the Internet to sell their products and services to the customers. On their websites, they provide features such as catalogues, interactive order processing system, secure electronic payment system, and online customer support.

Business-to-business or B2B This type of electronic commerce involves business transactions performed between business partners (customers are not involved). For example, companies use computers and networks (in the form of extranets) to order raw materials from their suppliers. Companies can also use extranets to supply their products to their dealers.

Consumer-to-consumer or C2C This type of electronic commerce enables customers to carry business transactions among themselves. For example, on auction websites, a customer sells his/her product which is purchased by another customer.

Electronic banking Electronic banking, also known as cyberbanking or online banking, supports various banking activities conducted from home, a business, or on the road instead of a physical bank location.

Bioinformatics

Bioinformatics is the application of computer technology to manage large amount of biological information. Computers are used to collect, store, analyse, and integrate biological and genetic information to facilitate gene-based drug discovery and development. The need for analysis has become even more important with enormous amount of genomic information available publicly from the Human Genome Project.

Bioinformatics is an interdisciplinary field of molecular biology, computer science, statistics, and mathematics. It involves analyses of genomic information to understand human diseases and thus discover new drugs to treat those diseases.

We know that DNA is made up of smaller pieces of molecules and the sequence of molecules along a string of DNA contains all information about an organism. This information can be used to grow new organisms. For example, scientists are using this information to grow better variety of crops, to generate a genome that will enable cows to yield more milk, so and so forth.

Therefore, bioinformatics helps scientists to store the DNA information in huge databases, retrieve it as and when required, and analyse it to grow and develop new organisms.

Scientists also use bioinformatics to identify diseases and discover drugs for them. This is done by writing

special programs that compare the sequence of molecules in DNA of a healthy person with that of the patient's. These analyses help them to identify what is missing in a patient and to determine drugs that can make the molecules in DNA of the patient look similar to that of a healthy person. For example, one of the drugs to treat AIDS was designed using bioinformatics techniques.

Health care

Last few years have seen a massive growth of computers and smartphone users. Like in our daily lives, computers have also become a necessary device in the health care industry. The following are areas in which computers are extensively used in the health care industry.

Storing records To begin with, computers are first and foremost used to store the medical records of patients. Earlier, patient records were kept on paper, with separate records dealing with different medical issues from separate healthcare organizations. With time, the number of prescriptions, medical reports, etc., grow in volume making it difficult to maintain and analyse. Use of computers to store patient records has been a game-changer in terms of improving the efficiency and accuracy of the entire process.

Now, the entire medical history of patients is easily accessible. Since the records are electronically stored, they can be easily shared between different doctors (in same or different healthcare organizations) who are treating the same patient. Besides saving paper and enhancing efficiency, use of computers also saves patients' money by reducing duplication of tests and procedures.

Surgical procedures Computers are used for certain surgical procedures. They enable the surgeon to use computer to control and move surgical instruments in the patient's body for a variety of surgical procedures. In such surgeries, a small incision is made, and then a small surgical tool with an attached camera is placed inside the patient's body. This reduces the risk of complications from a larger surgical wound, and minimizes damage done to the patient's body. In such a scenario, computers are not only used to drive the tools but also used to relay images from inside the patient's body out to the doctors.

Computers also help to determine the cause of an affliction or illness. For example, computers can combine ultrasonography and imaging in fields like cardiology to check the functionality of the heart. In case of a serious ailment, the causes can be detected in less time and treatment can be started at the earliest thereby saving a number of lives.

Today, tablets and computers are being used in surgical consultations and videoconferencing between doctors.

Better diagnosis and treatment Computers help physicians make better diagnoses and recommend treatments. Moreover, computers can be used to compare expected results with actual results in order to help physicians make better decisions.

Doctors sitting in hospitals can monitor their patients sitting in their homes by using computer-based systems. As soon as warning signs of serious illnesses are spotted, they alert the concerned doctor quickly.

Geographic Information System and Remote Sensing

A geographic information system (GIS) is a computer-based tool for mapping and analysing earth's features. It integrates database operations and statistical analysis to be used with maps. GIS manages location-based information and provides tools for display and analysis of statistics such as population count, types of vegetation, and economic development opportunities. Such type of information helps to predict outcomes and plan strategies.

Remote sensing is the science of taking measurements of the earth using sensors on airplanes or satellites. These sensors collect data in the form of images, which are then analysed to derive useful information.

The key feature of remote sensing is that it acquires information about an object without making physical contact with it. Remote sensing is a sub-field of geography, which can be applied in the following areas to collect data of dangerous or inaccessible areas for the following:

- Monitoring deforestation in areas like the Amazon Basin
- Studying features of glaciers in Arctic and Antarctic regions
- Analysing the depth of coastal and ocean areas
- Studying land usage in agriculture
- Examining the health of indigenous plants and crops
- Determining the prospect for minerals
- Locating and measuring intensity of earthquakes (after they had occurred) by comparing the relative intensity and precise timings of seismograms collected from different locations

Meteorology

Meteorology is the study of the atmosphere. This branch of science observes variables of Earth's atmosphere such as temperature, air pressure, water vapour, and the gradients and interactions of each variable, and how they change over time. Meteorology has applications in many diverse fields such as the military, energy production, transport, agriculture, and construction. Some of the applications include the following:

Weather forecasting It includes application of science and technology to predict the state of the atmosphere (temperature, precipitation, etc.) for a future time and a given location. Weather forecasting is done by collecting quantitative data about the current state of the atmosphere and analysing the atmospheric processes to project how the atmosphere will evolve.

Weather forecasts are especially made to generate warnings regarding heavy rainfall, snowfall, etc. They are also important to agriculturists and also to commodity traders within stock markets. Temperature forecasts are used by utility companies to estimate demand over coming days.

Aviation meteorology Aviation meteorology studies the impact of weather on air traffic management. It helps cabin crews to understand the implications of weather on their flight plan as well as their aircraft.

Agricultural meteorology Agricultural meteorology deals with the study of effects of weather and climate on plant distribution, crop yield, water-use efficiency, plant and animal development.

Nuclear meteorology Nuclear meteorology studies the distribution of radioactive aerosols and gases in the atmosphere.

Maritime meteorology Maritime meteorology is the study of air and wave forecasts for ships operating at sea.

Multimedia and Animation

Multimedia and animation that combines still images, moving images, text, and sound in meaningful ways is one of most powerful aspects of computer technology. We all have seen cartoon movies, which are nothing but an example of computer animation.

Note

Displaying a number of still images within a fraction of a second gives an animation effect. For example, displaying at least 30 still images in a second gives an effect of a moving image.

Using animation software, we can reproduce real-world phenomena such as fire, smoke, fluids, movement of chemicals through the air and ground, and the respiratory system to name a few. Animation is an easy and effective way to show complex interactions or events. Thus, it is an excellent tool for educating an audience.

A dynamic multimedia presentation (created using tools like MS PowerPoint) can make the message not only easily understood but also effective. Multimedia presentation helps corporate people to share information or their ideas and graphically present information in a more understandable and persuasive manner. Multimedia presentations can be recorded and played or displayed dynamically depending on user's inputs. Multimedia and animation is used to create computer games. A laser show is also an example of a multimedia application.

Multimedia and animation is used to add special effects in movies. In education, multimedia is used to prepare training courses. Students find learning complex computer algorithms and data structures by reading only a textual explanation. However, they find it interesting to learn through interacting with an animation of the algorithm

Note

Edutainment is the combination of education with entertainment.

Legal System

Computers are used by lawyers to shorten the time required to conduct legal precedent and case research. Lawyers use computers to look through millions of individual cases and find whether similar or parallel cases have been approved, denied, criticized, or overruled in the past. This enables the lawyers to formulate strategies based on past case decisions. Moreover, computers are also used to keep track of appointments and prepare legal documents and briefs in time for filling cases.

Retail Business

Computers are used in retail shops to enter orders, calculate costs, and print receipts. They are also used to keep an inventory of the products available and their complete description.

Sports

In sports, computers are used to compile statistics, identify weak players and strong players by analysing statistics, sell tickets, create training programs and diets for athletes, and suggest game plan strategies based on the competitor's past performance. Computers are also used to generate most of the graphic art displays flashed on scoreboards.

Television networks use computers in the control room to display action replays and insert commercial breaks as per schedule.

In addition, there are simulation software packages available that help a sportsperson to practice his or her skills as well as identify flaws in the technique.

Travel and Tourism

Computers are used to prepare tickets, monitor the train's or airplane's route, and guide the plane to a safe landing. They are also used to research about hotels in an area, reserve rooms, or to rent a car.

Simulation

Supercomputers that can process enormous amount of data are widely used in simulation tests. Simulation of automobile crashes or airplane emergency landings is done to identify potential weaknesses in designs without risking human lives. Supercomputers also enable engineers to design aircraft models and simulate the effects that winds and other environmental forces have on those designs.

Astronauts are trained using computer-simulated problems that could be encountered during launch, in space, or upon return to earth.

Astronomy

Spacecrafts are usually monitored using computers that not only keep a continuous record of the voyage and of the speed, direction, fuel, and temperature, but also suggest corrective action if the vehicle makes a mistake. The remote stations on the earth compare all these quantities with the desired values, and in case these values need to be modified to enhance the performance of the spacecraft, signals are immediately sent that set in motion the mechanics to rectify the situation. With the help of computers, all this is done within a fraction of a second.

Education

A computer is a powerful teaching aid and can act as another teacher in the classroom. Teachers use computers to develop instructional material. Teachers may use pictures, graphs, and graphical presentations to easily illustrate an otherwise difficult concept. Moreover, teachers at all levels can use computers to administer assignments and keep track of grades. Students can also give exams online and get instant results.

Industry and Engineering

Computers are found in all kinds of industries, such as thermal power plants, oil refineries, and chemical industries, for process control, computer-aided designing (CAD), and computer-aided manufacturing (CAM).

Computerized process control (with or without human intervention) is used to enhance efficiency in applications such as production of various chemical products, oil refining, paper manufacture, and rolling and cutting steel to customer requirements.

In CAD, computers and graphics-oriented software are integrated for automating the design and drafting process. It helps an engineer to design a 3D machine part, analyse its characteristics, and then subject it to simulated stresses. In case a part fails the stress test, its specifications can be modified on the computer and retested. The final design specifications are released for production only when the engineer is satisfied that the part meets strength and other quality considerations.

The CAM phase begins when the CAD phase is complete. In this phase, the metal or other materials are manufactured while complying with their specifications. For this computer controlled manufacturing, tools are used to produce high quality products.

Robotics

Robots are computer-controlled machines mainly used in the manufacturing process in extreme conditions where humans cannot work. For example, in high temperature, high pressure conditions or in processes that demand very high levels of accuracy. The main distinguishing feature between a robot and other automated machines is that a robot can be programmed to carry out a complex task and then reprogrammed to carry out another complex tasks.

Decision Support Systems

Computers help managers to analyse their organization's data to understand the present scenario of their business, view the trends in the market, and predict the future of their products. Managers also use decision support systems to analyse market research data, to size up the competition, and to plan effective strategies for penetrating their markets.

Expert Systems

Expert systems are used to automate the decision-making process in a specific area, such as analysing the credit histories for loan approval and diagnosing a patient's condition for prescribing an appropriate treatment. Expert systems analyse the available data in depth to recommend a course of action. A medical expert system might provide the most likely diagnosis of patient's condition.

To create an expert system, an extensive amount of human expertise in a specific area is collected and stored in a database, also known as a knowledge base. A software called an interface engine analyses the data available in the knowledge base and selects the most appropriate response.

Adding more to it, in today's scenario, computers are used to find jobs on the Internet, read news and articles online, find your batchmates, send and receive greetings pertaining to different occasions, etc.

1.7 BASIC ORGANIZATION OF A COMPUTER

A computer is an electronic device that performs five major operations:

- Accepting data or instructions (input)
- Storing data
- Processing data
- Displaying results (output)
- Controlling and coordinating all operations inside a computer

In this section, we will discuss all these functions and see how one unit of a computer interacts with another to perform these operations. Refer to Figure 1.11, which shows the interaction between the different units of a computer system.

Input This is the process of entering data and instructions (also known as *programs*) into the computer system. The

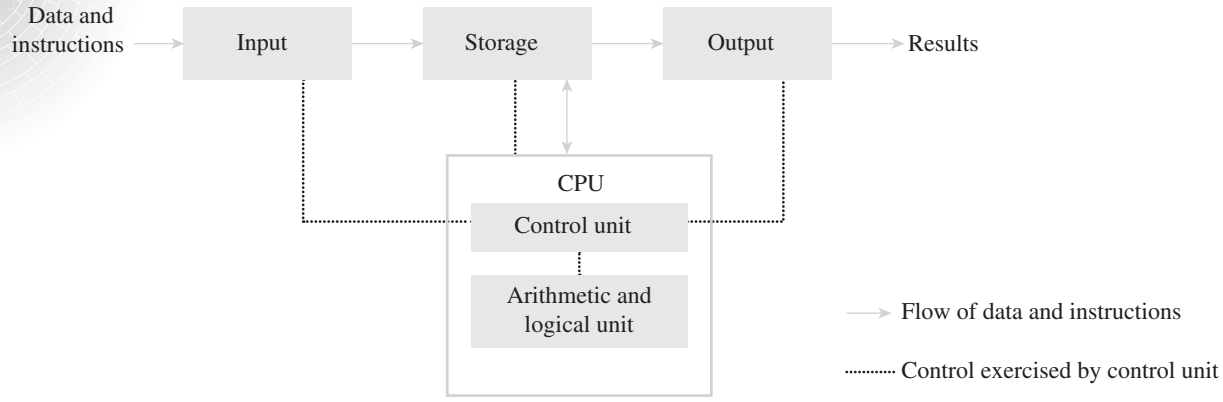


Figure 1.11 Block diagram of a computer

data and instructions can be entered by using different input devices such as keyboard, mouse, scanner, and trackball. Note that computers understand binary language, which consists of only two symbols (0 and 1), so it is the responsibility of the input devices to convert the input data into binary codes.

Storage Storage is the process of saving data and instructions permanently in the computer so that they can be used for processing. The computer storage space not only stores the data and programs that operate on that data but also stores the intermediate results and the final results of processing.

A computer has two types of storage areas:

Primary storage Primary storage, also known as the *main memory*, is the storage area that is directly accessible by the CPU at very high speeds. It is used to store the data and parts of programs, the intermediate results of processing, and the recently generated results of jobs that are currently being worked on by the computer. Primary storage space is very expensive and therefore limited in capacity. Another drawback of main memory is that it is volatile in nature; that is, as soon as the computer is switched off, the information stored gets erased. Hence, it cannot be used as a permanent storage of useful data and programs for future use. An example of primary storage is random access memory (RAM).

Secondary storage Also known as auxiliary memory, this memory is just the opposite of primary memory. It overcomes all the drawbacks of the primary storage area. It is cheaper, non-volatile, and used to permanently store data and programs of those jobs that are not being currently executed by the CPU. Secondary memory supplements the limited storage capacity of the primary memory. An example is the magnetic disk used to store data, such as C and D drives, for future use.

Output Output is the process of giving the result of data processing to the outside world (external to the computer system). The results are given through output devices such as monitor, and printer. Since the computer accepts data only in binary form and the result of processing is also in binary form, the result cannot be directly given to the user. The output devices, therefore, convert the results available in binary codes into a human-readable language before displaying it to the user.

Control The control unit (CU) is the central nervous system of the entire computer system. It manages and controls all the components of the computer system. It is the CU that decides the manner in which instructions will be executed and operations performed. It takes care of the step-by-step processing of all operations that are performed in the computer.

Note that the CPU is a combination of the arithmetic logic unit (ALU) and the CU. The CPU is better known as the brain of the computer system because the entire processing of data is done in the ALU, and the CU activates and monitors the operations of other units (such as input, output, and storage) of the computer system.

Processing The process of performing operations on the data as per the instructions specified by the user (program) is called *processing*. Data and instructions are taken from the primary memory and transferred to the ALU, which performs all sorts of calculations. The intermediate results of processing may be stored in the main memory, as they might be required again. When the processing completes, the final result is then transferred to the main memory. Hence, the data may move from main memory to the ALU multiple times before the processing is over.

Note

ALU, CU, and CPU are the key functional units of a computer system.

1.8 LAB SESSION—INSIDE THE COMPUTER

As a part of this chapter, the instructor must show the parts of the computer to the students, as illustrated in Figure 1.12.

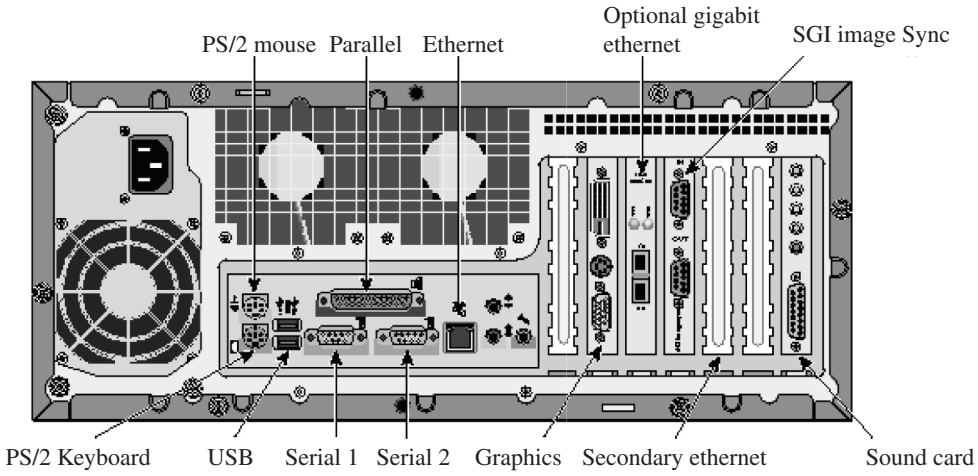


Figure 1.12 Computer case and its parts

The following are some of the major parts of the computer:

CPU The CPU is the brain of the computer. It performs all calculations and controls the devices connected to the computer system. The faster the CPU, the quicker programs can process the instructions.

RAM A fast CPU is of no use if the computer does not have sufficient RAM. As discussed earlier, RAM is the computer's memory which stores information used by applications that are currently being executed by the CPU. More memory means more applications can be executed at the same time without degrading the system's performance.

Hard disk drive (HDD) The HDD of the computer is the secondary memory of the computer system where information is stored permanently. All types of data, documents, and programs are stored on the hard disk. The larger the hard disk, the more the amount of data that can be stored on the drive. Though the size of the HDD does not affect the speed of execution of the program, it does affect the speed at which the user can access his/her files.

Video card The video card is a board that plugs into the motherboard of the computer and generates images for display. Many video cards these days have their own RAM and processor to enhance the speed of the graphics display. Many computers come with an in-built video chip. In such a computer, a separate video card is used only if the computer has to be used for high-end multimedia work or to play video games.

Sound card As with video cards, sound cards are expansion boards that are used to enable a computer to manipulate sound. For example, sound cards allow the users to plug in speakers and a microphone. Some sound cards also provide the jacks for hooking your computer up to a common stereo. These days, many computers come with a built-in sound chip, which makes it unnecessary to buy a separate card unless a higher quality of sound is needed.

Modem A modem (modulator–demodulator) is a device that enables the computer to use a telephone line to communicate and connect to the Internet.

Network card A network card is used to connect the computer either to other computers or to the Internet (in case you are using a fast Internet connection such as cable or DSL).

Fans There are one or more fans inside the computer to keep the air moving and the computer cool.

Cables There are multiple wires inside the computer that are flat, ribbon-like cables. They are used to provide power and communication to the various parts inside the computer.

1.9 MOTHERBOARD

The motherboard, also known as the mainboard or the parent board (refer Figure 1.13), is the primary component of a computer. It is used to connect all the components of the computer. The motherboard is a printed circuit that has connectors for expansion cards, memory modules, the processor, etc.

1.9.1 Characteristics of a Motherboard

A motherboard can be classified depending on the following characteristics:

- Form factor
- Chipset
- Type of processor socket used
- Input–Output connectors

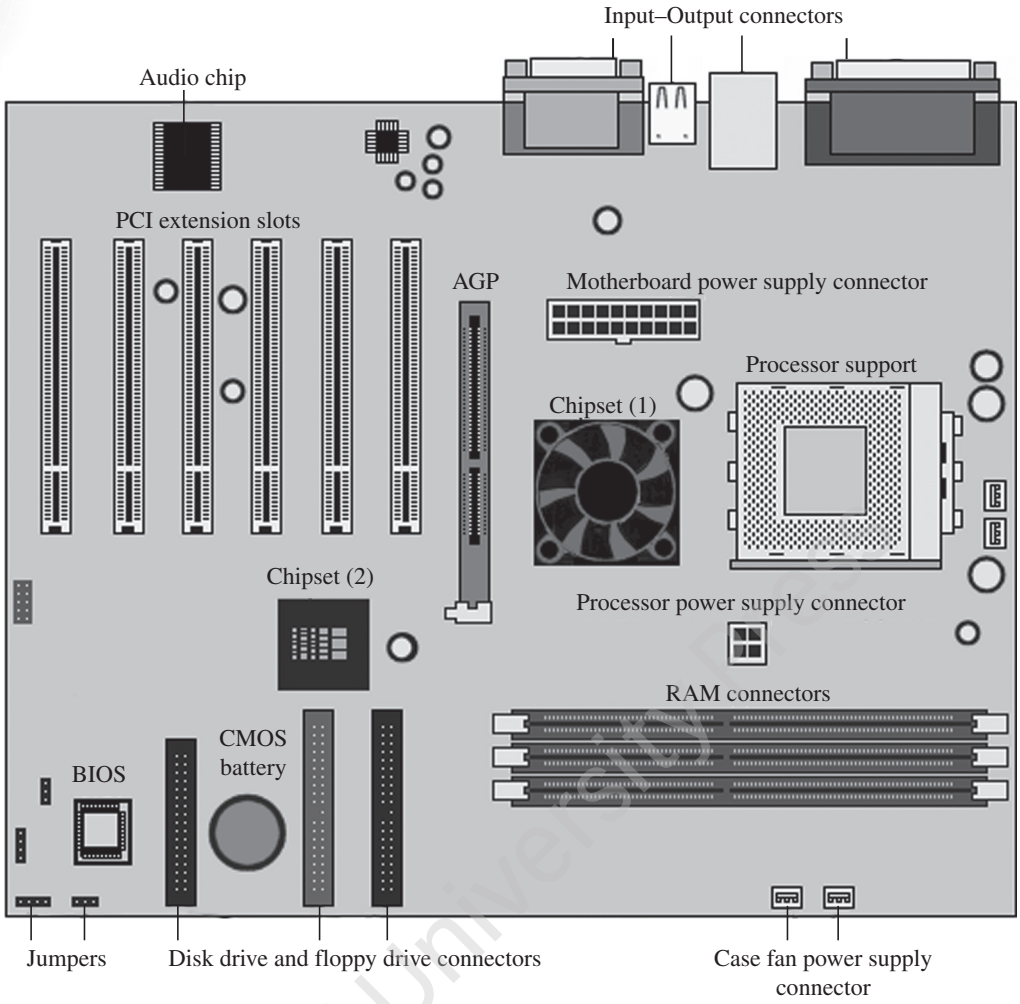


Figure 1.13 Computer's motherboard

Form factor Form factor refers to the motherboard's geometry, dimensions, arrangement, and electrical requirements. The industry has defined a few standards for the form factors, so that they can be used in different brands of cases.

Integrated components Some of the motherboard's components are integrated into its printed circuitry. These include the following:

- The chipset is a circuit that controls the majority of the computer's resources such as the bus interface with the processor, cache memory, RAM, and expansion cards.
- CMOS clock and battery
- BIOS
- System bus and expansion bus

In addition to these, the latest motherboards also have a number of onboard multimedia and networking devices (which can be disabled), such as integrated network card, integrated graphics card, integrated sound card, and upgraded hard drive controllers.

Chipset The chipset is an electronic circuit that basically coordinates data transfers between the different components of the computer (such as the processor and memory). In order to enhance the computer's upgradeability, one must choose a motherboard that has the latest chipset integrated in it. Some chipsets may include a graphics or audio chip, which makes it unnecessary to install a separate graphics card or sound card. However, in case you need very high quality of audio and visual capabilities, then you must disable the graphics/audio chip in the BIOS setup and install high-quality expansion cards in the appropriate slots.

CMOS clock and battery The real-time clock (or RTC) is a circuit that is used to synchronize the computer's signals. When the computer is switched off, the power supply stops providing electricity to the motherboard. You must have observed that when we turn on the system, it always displays the correct time. This is because an electronic circuit, called the complementary metal-oxide semiconductor (CMOS) chip, saves some system information, such as the time, date, and other essential system settings.

The CMOS chip is powered by a battery located on the motherboard. Information on the hardware installed in the computer (such as the number of tracks or sectors on each

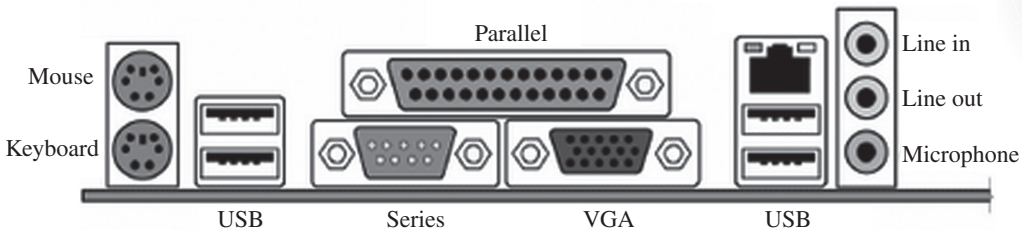


Figure 1.14 I/O connectors

hard drive) is stored in the CMOS chip. Since the CMOS chip is quite slow, some systems prefer to copy the CMOS chip's content into the RAM, which is a comparatively faster storage. This process of copying data into RAM is better known as *memory shadow*.

Have you noticed that, at times, the system time gets reset automatically, or the clock runs late? This indicates that you need to change the battery.

BIOS The basic input/output system (BIOS) is an interface between the operating system and the motherboard. The BIOS is stored in the read-only memory (ROM), which cannot be rewritten. The BIOS uses data stored in the CMOS chip to know about the system's hardware configuration.

To configure the BIOS, the user can use an interface known as *BIOS setup*, which can be accessed when the computer is booting. To enter BIOS setup, the user must press the DEL key. F1 and F2 keys can also be used.

Processor socket The processor (also called the *microprocessor*) is the brain of the computer. The processor is characterized by its speed or frequency, which is the rate at which it executes instructions. For example, an 800-MHz processor can perform 800 million operations per second.

The slot on the motherboard into which the processor is inserted is called the *processor socket* or *slot*. Irrespective of whether you use a slot or a socket, you must gently insert the processor, so that none of its pins are bent (it has hundreds of them). Usually, a concept called *zero insertion force* (ZIF) is used. The ZIF sockets allow the processor to be inserted very gently and easily.

When the computer is on, the processor is working and it releases heat, which must be dissipated to keep the circuits from melting. Therefore, the processor is generally mounted on a cooler that is made of metal (such as copper or aluminum), which conducts heat well. In addition to the cooler, there is also a fan to improve air circulation around it and to improve the heat transfer. The fan vents hot air from the case and lets fresh air come in from outside.

RAM connectors RAM is the primary storage area that stores data while the computer is running. However, its contents are erased when the computer is turned off or restarted. While the hard disk can store data permanently, we still need RAM because it is extremely fast when compared to mass storage devices such as hard drives. Therefore, the fast processor accesses data from RAM and not from the hard disk. The data is transferred from the hard disk to the RAM, from where it is used by the processor. RAM is available in the form of modules that plug into motherboard connectors.

Expansion slots Expansion slots are compartments into which expansion cards can be inserted. Such cards render new features or enhance the computer's performance. For example, the AGP slot (also known as Accelerated Graphic Port) is a fast port used for graphics cards.

I/O connectors The motherboard has a number of input–output sockets (Figure 1.14) on its rear panel, some of which include:

- A serial port to connect some old peripherals
- A parallel port to connect old printers
- USB ports to connect more recent peripherals such as mouse and pen drive.
- RJ45 connector (also known as LAN or Ethernet port) to connect the computer to a network. It corresponds to a network card integrated into the motherboard.
- Video graphics array (VGA) connector to connect a monitor. This connector interfaces with the built-in graphics card.
- Audio plugs that include the *line in*, *line out*, and *microphone* to connect sound speakers, hi-fi system, or microphone. This connector interfaces with the built-in sound card.

POINTS TO REMEMBER

- A computer is an electronic machine that accepts data and instructions and performs computations on the data based on those instructions.
- Computers are used in all interactive devices, such as cellular telephones, GPS units, portable organizers, ATMs, and gas pumps.
- Modern-day computers are based on the principle of the stored program concept, which was introduced by Sir John von Neumann in the late 1940s.
- The speed of the computer is usually given in nanoseconds and picoseconds.

- The term *computer generation* refers to the different advancements of new computer technology. With each new generation of computers, the circuitry has become smaller and more advanced than that in its previous generation.
- First-generation computers used a very large number of vacuum tubes for circuitry and magnetic drums for memory.
- Second-generation computers were manufactured using transistors rather than vacuum tubes.
- The development of the integrated circuit was the hallmark of the third generation of computers.
- The microprocessor started the fourth generation of computers, with thousands of integrated circuits built on to a single silicon chip.
- Fifth-generation computers are manufactured using integrated chips (ICs) built with ultra-large scale integration (ULSI) technology.
- The CPU is a combination of the ALU and the CU. The CPU is known as the brain of the computer system.
- The CU is the central nervous system of the entire computer system. It manages and controls all the components of the computer system.
- The motherboard, also known as the mainboard or the parent board, is the primary component of a computer.

GLOSSARY

Computer A computer is an electronic machine that takes instructions and performs computations based on those instructions.

Expert systems Expert systems are custom-written computer programs that are 'expert' in a particular problem area, and embody a human expert's knowledge, experience, and problem-solving strategies. They are being used in many areas such as medicine, chemistry, geology, meteorology, and computer systems.

Garbage-in, garbage-out If input data is wrong, then the output will also be erroneous.

GUI A GUI is a type of user interface that enables users to interact with programs in more ways than typing. A GUI offers graphical icons and visual indicators to display the information and actions available to a user. The actions are performed by direct manipulation of the graphical elements.

Input The process of entering data and instructions into the computer system.

Integrated circuit Also called a chip or microchip, an IC is a semiconductor wafer on which thousands or millions of tiny resistors, capacitors, and transistors are fabricated. It can be used as an amplifier, oscillator, timer, counter, computer memory, or microprocessor.

Internet It is a network of networks that connects computers all over the world.

Memory shadow The process of copying data from CMOS into RAM.

Program A set of instructions executed by the computer.

Robotics Computers programmed to look, listen, and react to other sensory stimuli.

Semiconductor devices Semiconductor devices are electronic components that make use of the electronic properties of semiconductor materials (such as silicon and germanium). The conductivity of such devices can be controlled by introducing an electric field, by exposure to light, and even pressure and heat, thereby making such devices excellent sensors.

Storage The process of saving data and instructions permanently in the computer so that it can be used for processing.

Stylus A stylus is an electronic pen that looks like a small ballpoint pen.

Transistor A transistor is a semiconductor device that is used to amplify and switch electronic signals. Although some transistors are packaged individually, others are usually found embedded in ICs.

Vacuum tube A vacuum tube is a device used to amplify electronic signals.

EXERCISES

Fill in the Blanks

1. A program is the _____.
2. Computers operate on _____ based on _____.
3. Computers can perform _____ calculations in a second.
4. The speed of computers is expressed in _____ or _____.
5. Raw facts or figures are called _____.
6. _____ is an example of primary memory.

7. _____ and _____ are examples of first-generation computing devices.
8. Second-generation computers were first developed for the _____ industry.
9. _____ packages allow easy manipulation and analysis of data organized in rows and columns.
10. CRAY-1, CRAY-2, Control Data CYBER 205, and ETA A-10 are _____.
11. _____ enables the computer to use a telephone line to communicate and connect to the Internet.
12. _____ connector is used to connect a monitor.
13. _____ concept was introduced by Sir John von Neumann in the late 1940s.
14. Android Jellybean, Windows, and iOS are all examples of popular operating systems used in _____ and _____.
15. _____ is an interface between the operating system and the motherboard.

Multiple-choice Questions

1. Which was the first commercial computer delivered to a business client?
   (a) UNIVAC (b) ENIAC
   (c) EDSAC (d) None of these
2. Which technology was used to manufacture second-generation computers?
   (a) Vacuum tubes (b) Transistors
   (c) ICs (d) None of these
3. Time sharing operating systems were used in which generation of computers?
   (a) First (b) Second
   (c) Third (d) Fourth
4. Choose the computer languages that are specially designed for the fifth generation of computers.
   (a) ALGOL (b) SNOBOL
   (c) LISP (d) Prolog
5. Web TV is an example of
   (a) supercomputer (b) minicomputer
   (c) network Computer (d) laptop
6. The brain of the computer is the
   (a) control unit (b) ALU
   (c) CPU (d) All of these

State True or False

1. Computers work on the GIGO concept.
2. 1 nanosecond = 1×10^{-12} seconds.
3. Floppy disks and hard disks are examples of primary memory.
4. First-generation computers used a very large number of transistors.
5. First-generation computers could be programmed only in binary language.
6. ALGOL is used in the third generation of computers.
7. Fifth-generation computers are based on AI.
8. Network computers have more processing power, memory, and storage than a desktop computer.
9. RAM stores the data and parts of program, the intermediate results of processing, and the recently generated results of jobs that are currently being worked on by the computer.
10. A serial port is used to connect old printers.

Review Questions

1. Define a computer.
2. Differentiate between data and information.
3. Differentiate between primary memory and secondary memory.
4. Write a short note on the characteristics of a computer.
5. Computers work on the garbage-in, garbage-out concept. Comment.
6. Explain the evolution of computers. Further, state how computers in one generation are better than their predecessors.
7. Broadly classify computers based on their speed, the amount of data that they can hold, and price.
8. Discuss the variants of microcomputers that are widely used today.
9. Explain the areas in which computers are being applied to carry out routine and highly-specialized tasks.

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