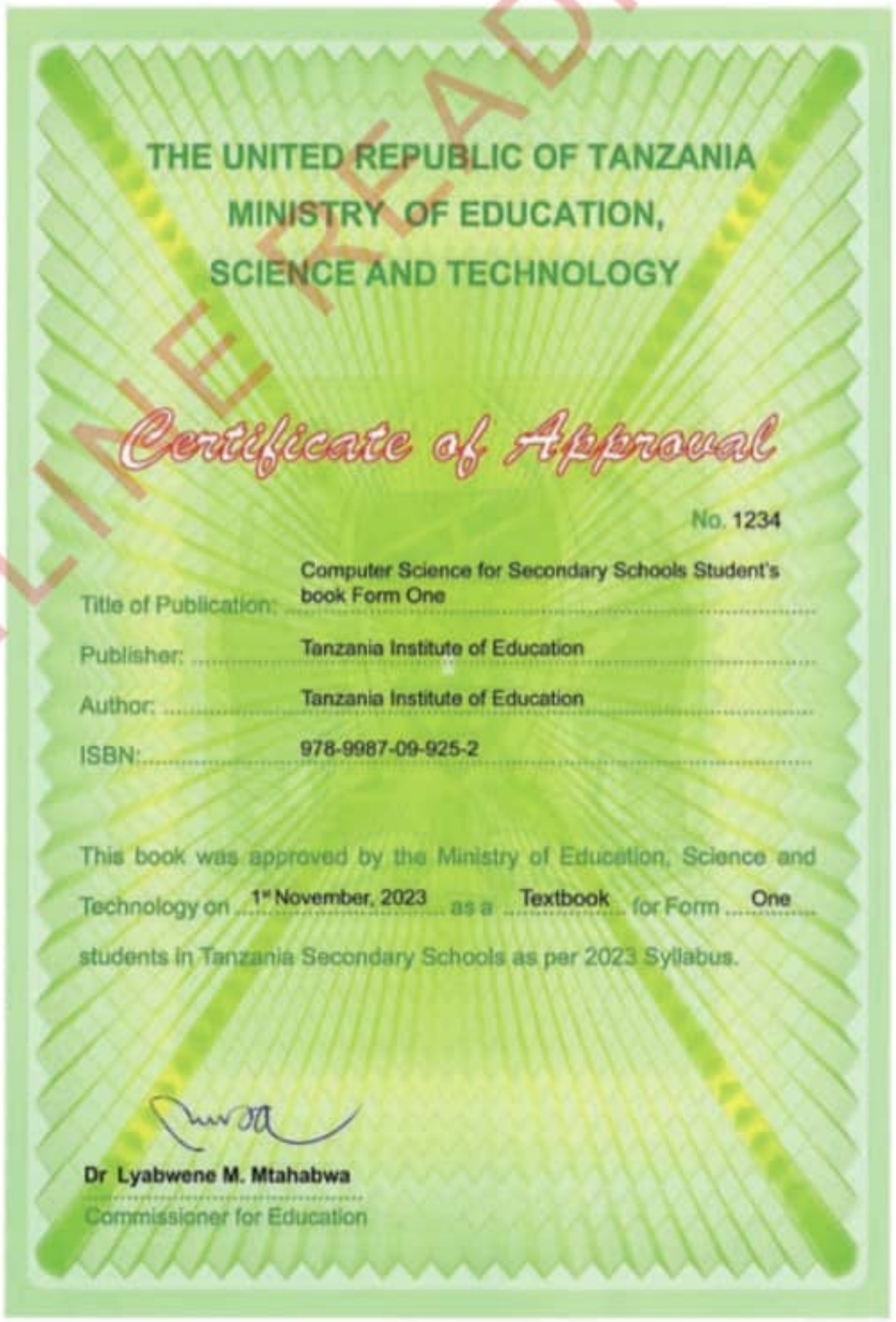
Computer Science

for Secondary Schools

Student's Book

Form One



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Acronyms and abbreviations

ABC	Atanasoff-Berry Computer
ADAS	Advanced Driver Assistance Systems
AI	Artificial Intelligence
ALU	Arithmetic Logical Unit
AR	Augmented Reality
AS	Autonomous Systems
ATM	Automated Teller Machine
BIOS	Basic Input/Output System
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CD	Compact Disk
CGI	Computer-Generated Imagery
CMOS	Complementary Metal-Oxide Semiconductor
COBOL	Common Business-Oriented Language
CPU	Central Processing Unit
CRM	Customer Relationship Management
CT	Computed Tomography
CPU	Central Processing Unit
CU	Control Unit
DA	Digital Agriculture
DAWs	Digital Audio Workstations
DVD	Digital Versatile Disk
ECG	Electrocardiogram
EFD	Electronic Fiscal Device
ENIAC	Electronic Numeric Integrator and Calculator
EPOM	Erasable Programable Read Only Memory
ESD	Electrostatic Discharge
GPS	Global Positioning System
GUI	Graphical User Interface
HCI	Human-Computer Interaction
HDD	Hard Disk Drive
HDMI	High-Definition Multimedia Interface
HPC	High-Performance Computing
HTTPS	Hypertext Transfer Protocol Secure
IBM	International Business Machines
ICT	Information and Communication Technology

IoT	Internet of Things
IS	Information System
ISA	Industry Standard Architecture
IT	Information Technology
ITS	Intelligent Transportation System
LAN	Local Area Network
LARC	Livermore Advanced Research Computer
MFA	Multi-Factor Authentication
ML	Machine Learning
MRI	Magnetic Resonance Imaging
MU	Mzumbe University
NWP	Numerical Weather Prediction
NLP	Natural Language Processing
OS	Operating System
PC	Personal Computer
PIN	Personal Identification Number
PCI	Peripheral Component Interconnect
PDA	Personal Digital Assistant
POS	Point-Of-Sale
PROM	Programable Read Only Memory
PSU	Power Supply Unit
RAM	Random Access memory
SQA	School Quality Assurance
SSD	Solid State Disk
SUA	Sokoine University of Agriculture
SSL/TLS	Secure Socket Layers/ Transport Layer Security
TIE	Tanzania Institute of Education
UAVs	Unmanned Aerial Vehicles
UDOM	University of Dodoma
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
VLSI	Very Large-Scale Integration
VMS	Virtual Memory System
VoIP	Voice Over Internet Protocol
VR	Virtual Reality
WAN	Wide Area Network
Webcam	Web Camera
Wi -Fi	Wireless Fidelity
www	World Wide Web

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Dr Aneth A. Komba
Director General
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Preface

This textbook, *Computer Science for Secondary Schools*, is written specifically for Form One students in the United Republic of Tanzania. The book is prepared in accordance with the 2023 Computer Science Syllabus for Ordinary Secondary Education, Form 1–IV, issued by the Ministry of Education Science and Technology.

The book consists of eight (8) chapters, namely, Introduction to Computer Science, Computer systems, Computer hardware, Computer software, Computer systems handling and care, Computer system maintenance, Computer systems troubleshooting, and Problem solving. In addition to the contents, each chapter contains activities, scenarios, illustrations, and exercises. You are encouraged to do all the activities, projects, and attempt all questions in the exercises. You are also required to prepare a portfolio for keeping records of the entire lessons. Doing that, you will enhance your understanding and development of the intended competencies for this level.

Additional learning resources are available in the TIE e-learning at *https://ol.tie.go.tz* or *ol.tie.go.tz*

Tanzania Institute of Education

Chapter One

Introduction to Computer Science

Introduction

The world is undergoing great changes in science and technology, and the use of computers has taken a large part of human life. For example, Artificial Intelligence (AI), is used in many areas of our daily lives to increase productivity and efficiency. AI is one of the fastest-developing fields in Computer Science, which is transforming the world. In this chapter, you will learn about Computer Science, its branches, relevance, applications, and fields related to Computer Science. The competencies developed will enable you to recognise the significance and application of Computer Science in everyday life.

Think

Living in a world without Computer Science

Concept of Computer Science

Read scenario 1.1 and then answer the questions that follow.

Scenario 1.1: *Autonomous systems*

Surprising things are happening today. Doors are automatically opened. The doors sense the presence of a person and get opened. A similar situation may be observed in tap water, where you don't need to touch the tap; it just senses your hand and pours up water. Technology is advancing very fast to the point that we have airplanes, trains and vehicles that do not need human drivers.

Questions

1. What kind of technology do you think is behind these autonomous actions?
2. Have you ever come across any autonomous system? Describe it.

Meaning of Computer Science

The field of Computer Science is helping us make things better and faster. We are moving from doing things manually to doing things automatically. Behind all these automations is the use of advanced computer systems. Those computer systems are developed using principles of Computer Science.

Computer Science is the study of how computers work. It is about learning the rules and how things are done in the computer world. It involves learning how to build a computer set instead of just using it. Generally, Computer Science is about building and understanding the computer.

Imagine that you want to cook a cake. You need to follow a recipe, which is a set of instructions that tell you what ingredient to use and what steps to take. The computer also follows a logical set of instructions known as an algorithm to solve a problem. A computer algorithm is similar to a recipe. It is a set of instructions that tells a computer what steps to take to solve a problem or perform a task.

In the world of computers, algorithms are used to solve problems and make things happen. For example, let us say you are playing a game of card on a computer. The computer needs to know how to move the card to win the game. That is where algorithms come in. They tell the computer how to move the pieces to win. So, Computer Science is concerned with learning how to build and understand these algorithms.

Activity 1.1

Use the library or reliable online sources to read articles, books, and other publications on the history, concepts, and developments in Computer Science. Gain insights into the foundational principles and explore how Computer Science has evolved over time. Document the findings in a portfolio.

Questions

1. In your exploration, what factors influenced the development of Computer Science?
2. Does this influence affect your everyday life? Explain briefly.

Branches of Computer Science

Computer Science is divided into many branches. Each branch focuses on different aspects of computers such as how to build and program a computer. Another aspect might be about how to make a computer understand human language. A few branches of Computer Science are:

(i) **Artificial Intelligence (AI):** This branch of Computer Science deals with making machines intelligent so that they can think and solve problems like humans.

(ii) **Data Science:** This branch involves obtaining insights and knowledge from large datasets through statistical analysis and machine learning techniques.

(iii) **Software Engineering:** This branch focuses on how to design, develop, test, and maintain software systems.

(iv) **Computer Networking:** This part of Computer Science is about ensuring computers can communicate with each other and share information.

(v) **Cyber Security:** Focuses on protecting computer systems and networks from security breaches, damages, attacks, and unauthorised access.

(vi) **Computer Architecture:** This branch of Computer Science deals with designing and organising the parts of a computer to make it work.

(vii) **Quantum Computing:** This branch of Computer Science focuses on using the rules of quantum theory to make computers work better and faster.

Activity 1.2

Use the library or reliable online sources to explore other branches of Computer Science apart from those mentioned in this chapter. Write the summary and document the findings in a portfolio.

Questions

1. Did you find other branches? If yes, what differentiates them from the one you learnt in this section?
2. Which branch do you think is more relevant to you and should be your primary focus in your career? Why?

Importance of Computer Science

Computer Science plays an essential role in the modern world. The importance of Computer Science is as follows:

(i) It helps to create all the software we use on our computers and devices.

(ii) It contributes to technological innovation, which improves and speeds up processes that allow constant change.

(iii) It helps to make everything work better and faster, from learning in school to buying things in a store.

(iv) It helps us in develop systems that connect and share information across different devices and platforms. For example, you can message to your friend on your phone or computer.

(v) It helps us use lots of information to make decisions and make things better.

(vi) It helps in designing systems that keep our information safe and private. So, we can use the internet and our devices without worrying about bad people trying to get our information.

(vii) It helps us make robots that can do things on their own, like driving cars or picking up things in a factory.

(viii) It helps in creating entertainment, such as video games, movies, and music.

(ix) It helps us solve big problems in science and engineering. For example, figuring out how to grow food, predicting the weather, finding new medicine, and making things lighter and more durable.

Activity 1.3

Use reliable online sources to search a video showing how robots are used in car manufacturing.

Questions

1. Describe how Computer Science is involved in the car manufacturing process.
2. What would happen if the robot was not used to perform such a task?

Exercise 1.1

1. What are the key concepts and ideas that form the foundation of Computer Science? Describe these concepts.
2. Which field of Computer Science has caught your interest? Explain why.
3. Consider a potential profession in which you are interested. How do you believe Computer Science skills would be useful in achieving this?
4. In your own words, explain the importance of Computer Science.

Computer Science helps us make things that help us learn, get healthy, grow food, and do business. Also, Computer Science helps us keep our money safe, protect us, create entertainment, and tell us how the weather will be. Computer Science can be

applied in different areas such as education, medicine, agricultures, business, defence, manufacturing industries, entertainment, communication and transportation

Education

Computer Science helps teachers teach better, and students learn better. It helps us learn new things and do things faster. For example, Compute Science enables us to design and implement digital learning platforms that allow students to access online tutoring and interactive content. These platforms help students to be engaged with multimedia elements like videos, simulations, and interactive quizzes. It also helps students attend virtual classes, access online classes, and participate in collaborative projects regardless of their geographical location.

Other platforms can analyse students' progress and learning patterns, enabling the delivery of personalised learning materials and tailored feedback to meet individual needs. Such a platform can also help learners learn at their own pace. Figure 1.1 shows a student using a computer to learn.

Figure 1.1: *Student using a computer to learn*

Medicine

Nowadays, most hospitals are using computer systems to improve health services. Computer systems are used in the process of diagnosing diseases, providing treatment to patients, and maintaining proper medical records of patients. Also, medical researchers use computer systems as a tool for discovering drugs and finding the causes of diseases. Additionally, patients can remotely receive services via computer systems, when a doctor and patients are not physically in contact. This situation is called telemedicine. Figure 1.2 shows a doctor using a computer to examine a patient.

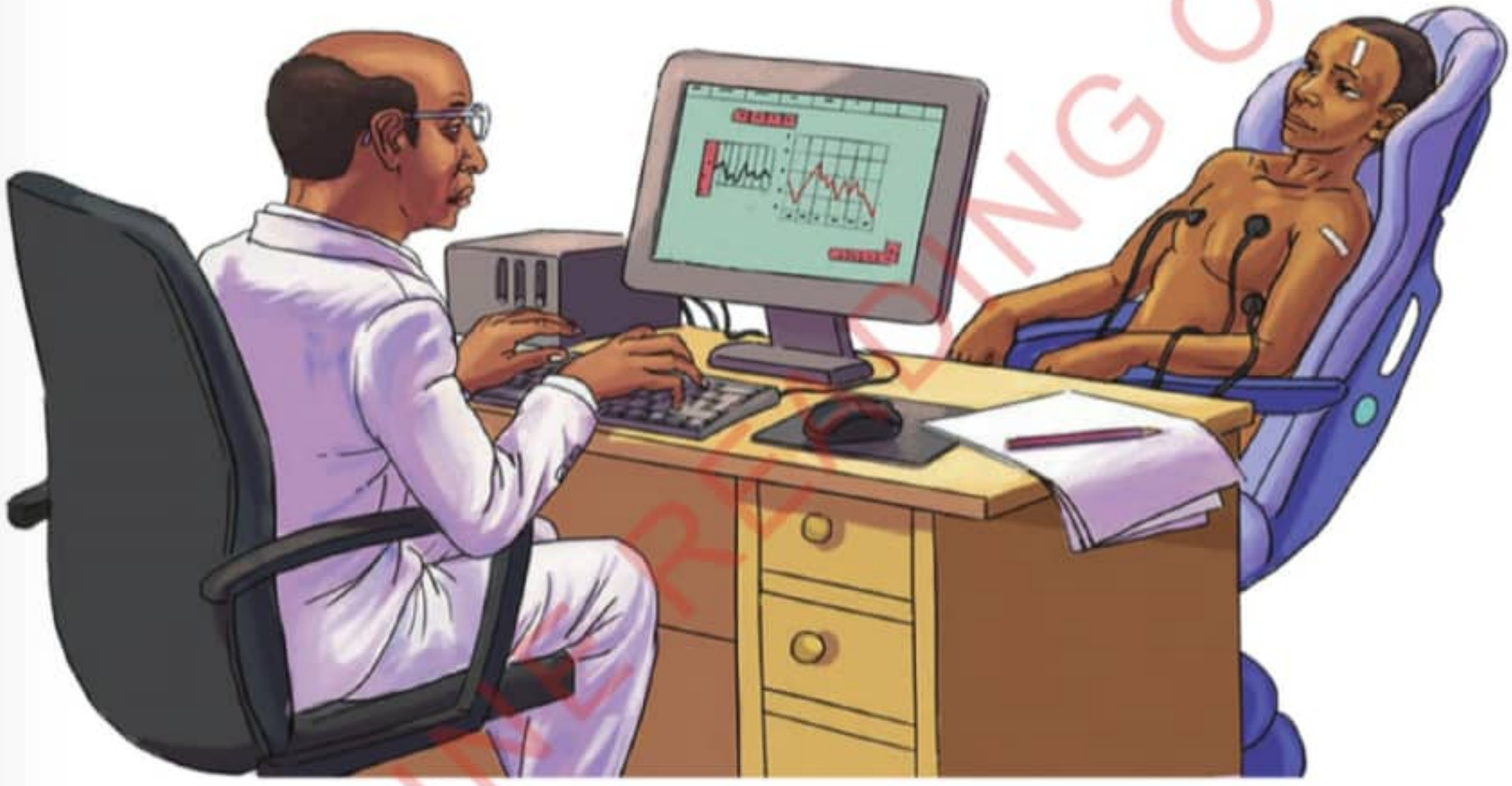


Figure 1.2: *Doctor using a computer to examine a patient*

Agriculture

Computer Science continues to drive innovations in agriculture. Computer Science has emerged as an asset in modern agriculture. It is often referred to as Digital Agriculture (DA). DA helps transform the agricultural industry by enhancing various aspects of farming, particularly food production. The key aspects of Computer Science in today's digital agriculture are precision and smart farming.

Precision farming

Computer Science enables the use of sensors, Global Position System (GPS) technology, and data analytics to monitor and manage crops more accurately. Farmers can collect real-time data on soil conditions, weather patterns, and crop health. The collected data allows us to optimise irrigation, fertilisation, and fumigation. That optimisation results in increased yields and resource efficiency. Precision farming aims to make every operation accurate, optimised and

controlled. Figure 1.3 shows a computer-controlled drone fumigating infected crops, focusing only on infected areas.

Figure 1.3: *Computer-controlled drone fumigating crops*

Smart farming

Computer Science improves farming systems and operations by using data and information. The following are some of the technologies used in smart farming:

Automated machinery and robotics

Computer-controlled machinery and autonomous robots are used in planting, harvesting, and processing crops. The use of automated machinery and robotics reduce the need for manual labour, thus increasing yield.

Farm management software

Computer Science has led to the development of farm management software. That software helps farmers to plan, track, and optimise various farming activities. Those activities include inventory management, budgeting, and crop rotation.

Remote monitoring

With the use of internet of things (IoT) devices, farmers can remotely monitor their farms. Farmers can receive real-time updates on critical parameters, such as soil moisture levels, weather, and crop health. That information may be received via smartphones and computers.

Plant breeding and genomics

Computer algorithms are used to analyse genetic data to enhance crop breeding

programs. That analysis helps in developing plants that have desirable traits. Desirable traits include resistance to diseases, improved yield, and better nutritional content.

Supply chain management

Computer scientists create software that optimises the supply chain. The software created enables better coordination between farmers, processors, distributors, and retailers, resulting in improved efficiency and reduced food waste.

Business

Computer Science facilitates the development of systems that have changed how business is done. These systems continue to drive growth, efficiency, and success across various business sectors. Computer Science helps to develop computer systems that facilitate businesses to:

(i) Collect, store, and understand lots of information, which helps them make better decisions.

(ii) Sell things online, reach more people, and make more money. This type of business is known as e-business.

(iii) Market products and services online to reach a global audience. This is known as digital marketing and advertising.

(iv) Keep track of all their customers and understand what those customers want so they can give them what they need. It is known as customer relationship management.

(v) Helps businesses assess risk, detect fraud, and make decisions.

(vi) Develop tools that help to generate reports and visualisations.

Banking

Computer Science enables the development of systems that facilities online banking. Customers can access their accounts, transfer funds, and pay bills using digital devices with no need to carry cash. Online banking has facilitated the use of various digital transactions, such as credit cards, debit cards, and mobile banking. Online banking has minimised theft and robbery incidents, saved time, and reduced transaction costs. Examples of mobile banking services include M-Pesa, HaloPesa, Airtel Money, T-Pesa, and Tigo Pesa. These services have made the transfer of money between people and banks easier and more convenient.

Other facilities powered by computer systems are the Automated Teller Machines (ATMs). ATMS allows cash to be withdrawn and deposited. Figure 1.4 shows a person withdrawing money from an ATM.

Figure 1.4: *Person withdrawing money from an ATM*

Defence

Computers are used in defence to organise and carry out military operations. Computer systems are used to gather and analyse data, such as the location of an enemy or target. Once the target has been identified and located, computer algorithms are used to determine how the missile will be launched in its direction.

Also, computer systems help soldiers in conducting military operations in challenging or hazardous circumstances. For instance, the military uses unmanned aerial vehicles known as drones. Those drones can travel long distances to attack the enemy. There is no human driver in those drones. Instead, soldiers use computer systems to command drones from the ground. As a result, the risks of soldiers losing their lives when an enemy strikes the drone are avoided. Figure 1.5 shows a soldier using a computer to plan how a missile flies.

Figure 1.5: *Soldier planning the trajectory of a missile*

Manufacturing industries

Computer Science plays an important role in modern manufacturing industries. Some key applications of Computer Science in manufacturing industries are:

Automation and robotics

Computer Science enables the development and implementation of advanced automation systems and robotics. Robots can perform repetitive tasks with precision, speed, and consistency, leading to increased productivity and reduced human errors. Robots can perform complicated and dangerous tasks like assembling cars, welding, and painting in a consistent manner. For example, robots

can perform paint perfectly in car manufacturing without wasting paint or skipping parts. Figure 1.6 shows a robot panting a car.

Figure 1.6: *Robot painting a car*

Simulation and modelling

Computer simulations are used to model manufacturing processes. The use of models allows companies to test different scenarios without physical implementation. This reduces experimentation costs and helps identify optimal production strategies. Some simulation and modelling software include Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM). CAD software is used extensively in the manufacturing industry to create detailed product designs and models. The CAM software assists in converting CAD designs into machine-readable instructions. CAD optimises manufacturing processes, such as three-dimension (3D) printing, leading to improved accuracy and reduced production time.

Meteorology

Computer Science has revolutionised the field of meteorology, including weather forecasting. Weather forecasts have become more accurate, timely, and accessible to the public. Computer Science applications in meteorology have significantly improved our ability to understand and predict weather patterns. These innovations have led to more accurate and reliable weather predictions. Weather prediction benefits various sectors, including agriculture, transportation, disaster preparedness, and public safety.

Weather forecasting

Computers and other scientists use mathematical models to simulate atmospheric conditions and predict weather patterns. These models process vast amounts of meteorological data collected from satellites, radars, and weather stations to generate short-term and long-term forecasts. Using computer science techniques to present weather maps, charts, and animations helps the public understand weather information. Figure 1.7 shows weather forecasting using computers.

Figure 1.7: *Weather forecasting using computers*

Climate modelling

Computer models are used to simulate long-term climate patterns and changes. Climate modelling helps scientists understand climate trends and project future climate scenarios. Also, climate modelling helps to assess the potential impact of climate change on weather patterns.

Entertainment

Computer Science has significantly transformed the entertainment industry. It has revolutionised content creation, distribution, and engagement. Computer Science has enabled digital content creation in various forms, such as Computer-Generated Imagery (CGI), multimedia, and Virtual reality (VR) experiences. These technologies enhance storytelling and visual appeal in movies, television (TV) shows, and video games. In addition, computer software allows for sophisticated video and audio editing, making it easier to produce high-quality content in film, music, and television production. Editing tools enable professionals to enhance visuals, add special effects, and improve sound quality. Figure 1.8 shows a music composer using a computer and a mixer to produce music.

Figure 1.8: *Music composer using a computer and a mixer to produce music*

Communication

Computer Science plays a fundamental and transformative role in communication. It revolutionises how we connect, shares information, and collaborate globally. Applications of Computer Science have had a profound impact on various aspects of communication. For example, the development of the Internet and computer networks has enabled efficient data transmission. Efficient data transmission allows people to communicate through emails, instant messaging, video conferencing, and social media platforms. An example of a computer network is shown in Figure 1.9.

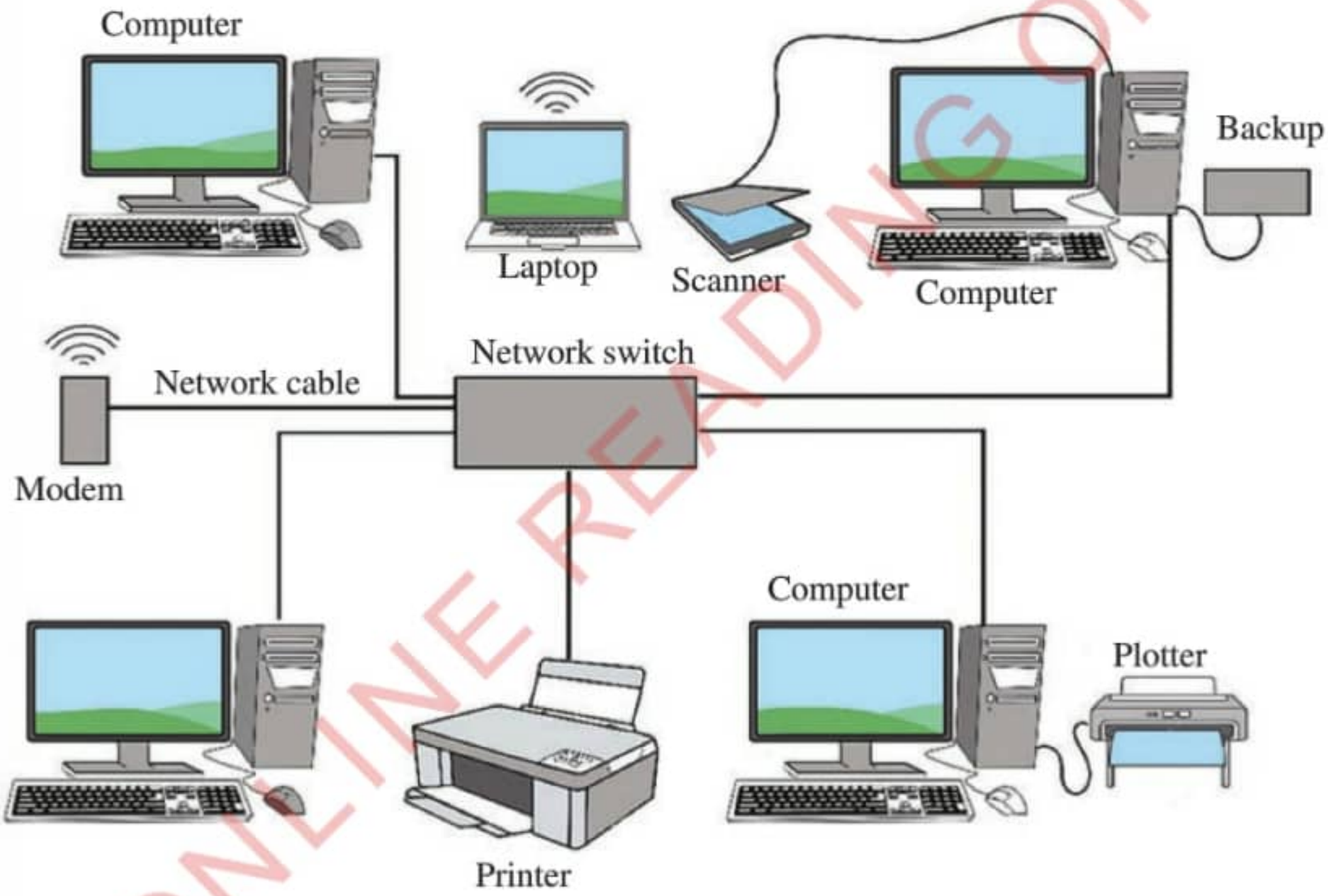


Figure 1.9: *Example of a computer network*

Also, computer systems have empowered video conferencing and transforming remote communication. This enables real-time audio and video conversations, bridging geographical distances. Computer scientists develop devices like smartphones and tablets to enable timely personal communication.

Computer Science also gives us tools that are very useful for translating languages and creating the most Natural Language Processing (NLP) technologies. This innovation is very important for making it possible to communicate easily across languages.

Transportation

Computer Science has significantly impacted the transportation industry. It has transformed how we move people and goods efficiently, safely,

and sustainably. Some of the areas where Computer Science is useful in transportation include:

Ride hailing

You may be familiar with the conventional taxi service, which you can hire a taxi to transport you to your destination. To achieve that, you must meet the driver in person and decide on a route and the amount to be paid. Nowadays, the game has changed because you can hire a driver online. The hiring of a driver online is famously termed as "requesting". The driver will come to your real location to pick you up and take you to your destination after you request a ride. That form of transportation service is known as ride-hailing.

Ride-hailing services are typically provided by individuals who use their vehicles. Computer algorithms built into the digital platform enable the connection between passengers and drivers. Those algorithms match passengers and drivers based on many variables, such as pickup and destination points. The algorithms, for instance, offer passengers the choice of drivers who are closer rather than those who are farther away. Additionally, a driver is guided by algorithms as they navigate to the pickup and destination locations.

Uber and Bolt are examples of digital platforms that offer ride-hailing in cities in Tanzania. Figure 1.10 shows a passenger requesting a ride-hailing on the Uber platform.

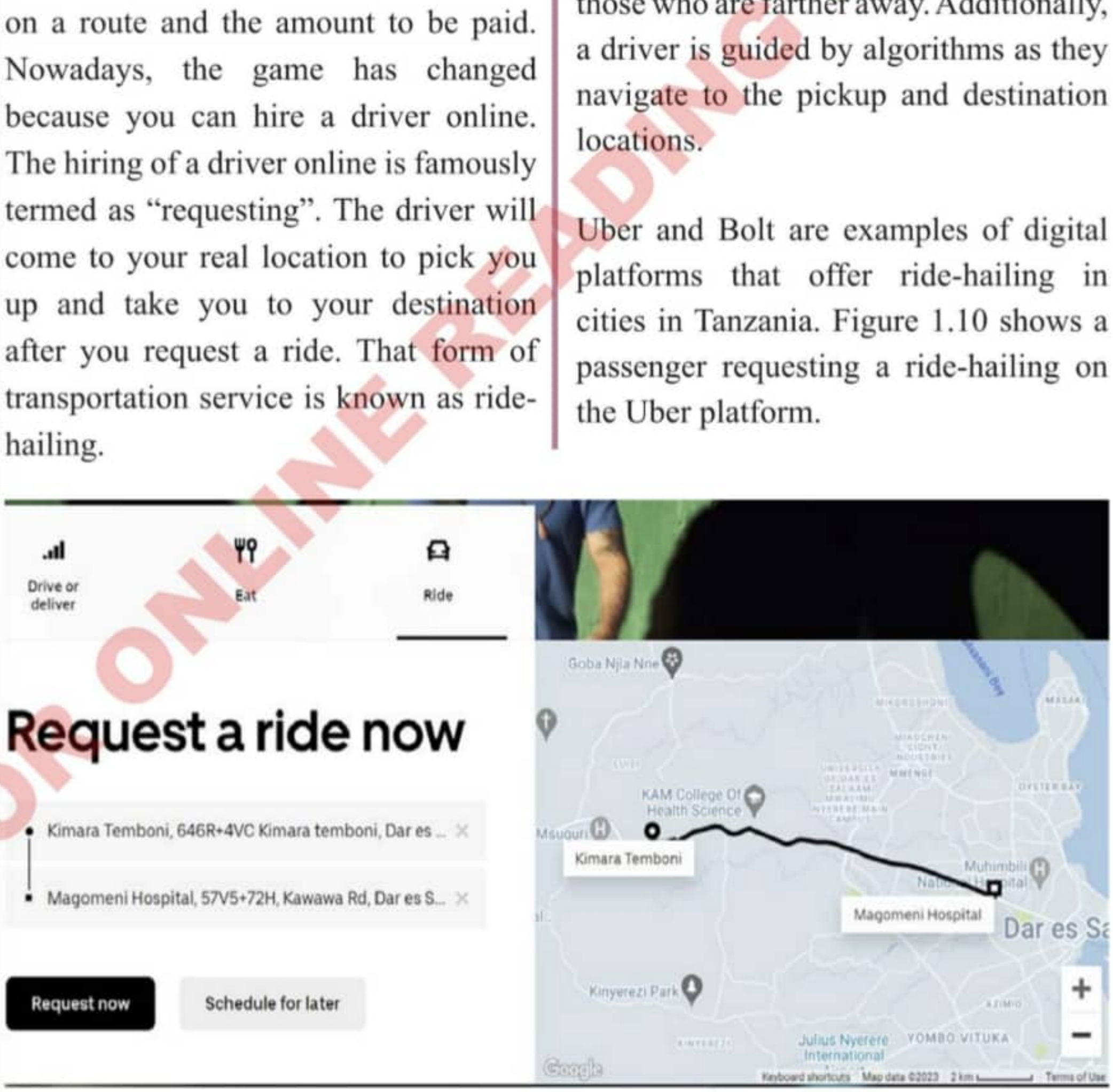


Figure 1.10: *Requesting a ride-hailing on the Uber platform*

Global Position System

Global Position System (GPS) is a computer system that enables accurate location-based services. It is a navigation and vehicle tracking application system for logistics and fleet management. Figure 1.11 shows the application of GPS in car navigation.

Figure 1.11: *Application of GPS in a car navigation*

E-ticketing and contactless payments

E-ticketing is a computer system that facilitates contactless payment methods in public transport. That technology streamlines the payment process and improves the overall passenger experience. This practice is known as online booking because the computer needs to be connected to the network. This approach saves customers from moving long distances and facing challenges in booking. Figure 1.12 shows a customer service agent for an airline at the airport.

Figure 1.12: *Customer service agent for an airline at the airport.*

Traffic safety and accident prevention

Computer scientists have developed Advanced Driver Assistance Systems (ADAS) that enhance traffic safety. These systems include features like collision avoidance, lane departure warnings, and adaptive cruise control. They reduce the tragic incidence of driving.

Activity 1.4

Write a summary of your thoughts and perspectives on how Computer Science impacts society. Document your summary in a portfolio.

Questions

1. Do you think there is any field in which principles of Computer Science cannot be applied? Explain briefly.
2. Does your school use any tools that were made using Computer Science? Briefly explain.

Exercise 1.2

1. Write a short essay on how Computer Science has reformed operations and efficiency in education and agriculture. Provide specific examples to support your answer.
2. Computer Science is only applicable to the technology sector. Discuss.

There are different fields related to Computer Science. They include Information Technology (IT), Information and Communication Technology (ICT), Information Systems (IS), and Computer Engineering. They are all interconnected fields within the broader domain of technology under the umbrella of Computer Science. They have overlapping areas and complementary roles in various aspects of computing.

Information Technology

IT refers to the practical application of computer systems, software, networks, and other technologies to manage and process information. It involves using technology to store, retrieve, transmit, and protect data for various purposes within an organisation or business.

Information and Communication Technology

ICT is a broader term encompassing the use of various technologies, including computer system, software, networking, telecommunications, and other digital tools, to manage, process and transfer information. It is more application-oriented and deals with the practical use of technology for communication and information management.

Information Systems

This field focuses on the strategic use of information technology to support and improve organisational processes, decision-making, and business operations. It involves intergating of technology, people, and processes to manage and utilise information effectively.

Computer Engineering

Computer Engineering is a branch of engineering that focuses on designing, developing, and implementing of computer hardware, software and systems. It involves a combination of electrical engineering and Computer Science principles to build and integrate hardware and software components.

Exercise 1.3

1. Describe the relationship between Computer Science and IT and how they complement each other in the modern technology landscape.
2. Explain other fields related to Computer Science apart from those mentioned in this chapter.
3. Elaborate on the collaboration between Computer Engineering and Computer Science in creating of computing systems.
4. Do you think it is important to learn the fields related to Computer Science? Briefly explain.

Project 1.1

To accomplish your project the following steps maybe used:

Step 1: Use books, articles, websites, or videos to explore a specific element of Computer Science that interests you.

Step 2: Create posters that visually represent the aspect of Computer Science you have choosen. Use illustrations, diagrams, and simple explanations to convey your chosen topic.

Step 3: Present your aspect by making your poster colourful and engaging to capture attention.

Step 4: Present your posters to other students in the class. Explain your chosen topic and why you find it interesting.

Chapter Summary

Computer Science holds significant importance in the modern world due to its significant impact on society, economy, and technology. It has driven technological advancements, enabled digital transformation across industries, and opened vast job opportunities. The field fosters innovation and research, equips individuals with problem- solving skills, and plays a vital role in education and other sectors. Moreover, it has revolutionised communications and connectivity, strengthened cyber security, and enhanced entertainment and creativity. Embracing Computer Science is essential for progress, innovation, and thriving in the digitally driven era.

Revision exercise 1

1. Explain the role of Computer Science in developing practical solutions to enhance transportation systems.
2. Explain the significance of Computer Science various in industries.
3. There has been a revolution in entertainment due to advances in Computer Science. With examples, explain how Computer Science plays a role in this revolution.
4. Discuss how Computer Science improves teaching and learning and give examples of software or platforms that support education delivery.

Chapter Two

Computer systems

Introduction

The computer is one of the most revolutionary and powerful tools ever developed in the history of the modern world. It plays significant roles in different aspects of our daily lives. In this chapter, you will be introduced to the concept of computer systems, computer generations, and the significance of computers in performing different tasks. The competencies developed will enable you to articulate the potential of computer systems and their use.

Think

Impact of a world without computer systems

Concept of computer systems

Read scenario 2.1 then answer the questions that follow.

Scenario 2.1: *Checkout and payment*

The world is proceeding to paperless and cashless transactions. For example, Kole, who is the general manager of BENICO company always requests and makes all payments online. Kole checks his company's bank balance using a mobile phone. She enters her delivery address and payment details. The computer systems take steps to ensure the safety of the transaction by encrypting sensitive data during transmission and protecting BENICO's company information.

Questions

1. How does the payment system recognise Kole?
2. What is the role of encryption during transactions?
3. What information must be encrypted?

Meaning of computer systems

Modern life is determined by the ability to process large amounts of data quickly and accurately. Nowadays, computers perform complex tasks, solve problems, and connect with the world. Such abilities were not easy a few decades ago. These abilities are enabled by advancements in the field of Computer Science and related technology. A computer is an electronic device that processes data and transforms it into information that is useful to people. A computer, regardless of its size, type, or purpose, is controlled by a set of instructions that tell the machine what to do. Therefore, a computer system is a complex arrangement of hardware, software, user, and data that work together to perform various tasks and processes.

Components of computer systems

The fundamental components of computer systems include hardware, software, and users. Understanding the components of computer systems is essential for realising how computer systems function.

Hardware: These are physical components of a computer system that can be seen and touched. They are used for performing various tasks, including entering and displaying data and processing the data. Examples include mouse, keyboard, RAM, and monitor. More details of computer hardware will be covered in Chapter Three. Figure 2.1 shows different hardware that form a simple computer system.

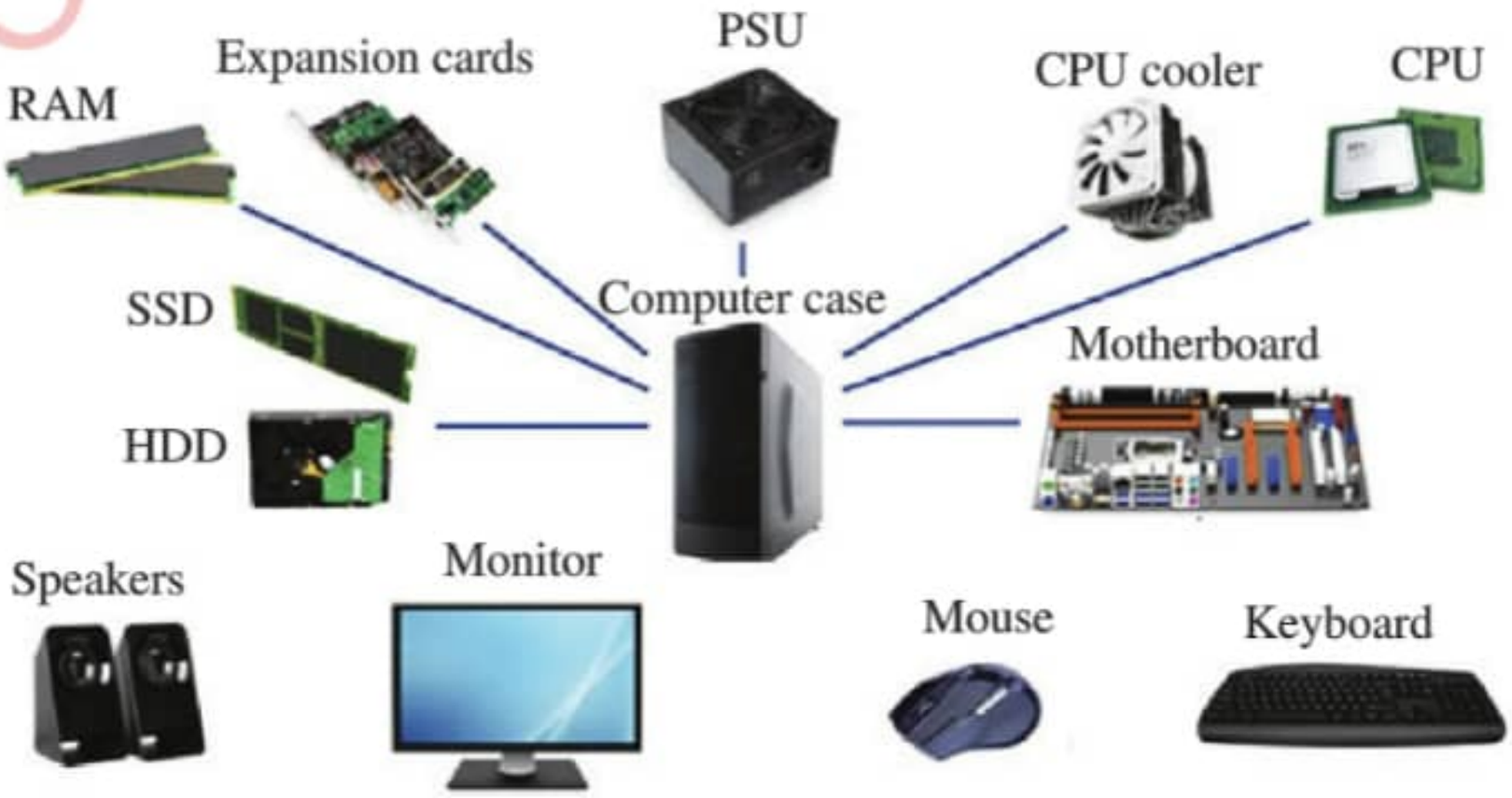


Figure 2.1: *Different hardware that forms a simple computer system*

Note: In Figure 2.1, lines indicate those components found inside a computer case.

Computer case or system unit

A computer system unit, sometimes called a system unit or computer case, is the enclosure that houses the main internal components of a computer. Its primary role is to protect and arrange these internal components and connect them to external components which are usually known as peripherals.

(a) Internal components

(i) *Motherboard:* This serves as the primary circuit board that establishes connections and enables communication among all the other computer components.

(ii) *Central Processing Unit (CPU):* Sometimes called the "brain" or CPU, this component handles most computations and carries out instructions within the computer.

(iii) *Memory:* This includes Random Access Memory (RAM) and Read-Only Memory (ROM). RAM is used for temporary storage of data and instructions that the CPU needs to access quickly, while ROM contains permanent instructions that cannot be modified.

(iv) *Storage Devices:* These devices, such as hard disk drives (HDDs) or solid-state drives (SSDs), are used for long-term storage of data and programs.

(v) *Power Supply Unit (PSU):* The PSU provides electrical power to the computer system and its components.

(vi) *Expansion Slots:* These slots enable the addition of extra components, like graphics cards, sound cards, or network cards.

(vii) *Cooling System:* The system unit often includes fans or other cooling mechanisms to prevent overheating of the components.

(viii) *Ports and Connectors:* These are used to connect external devices, such as monitors, keyboards, mice, and USB devices, to the computer.

(b) External components

External components or parts of a computer system unit are typically those elements that are not housed within the computer case (tower). These components are often peripherals or accessories that connect to the computer to enhance its functionality or provide interaction with the user. The details of computer hardware will be covered in Chapter Three.

Software: These are instructions that govern the operation of a computer

system. Software tells the computer what to do. Some software are designed to control the computer itself, for example by managing its resources. Other software are meant for the end user to perform their day-to-day activities, such as creating documents, searching for information, or editing music. The details of computer software will be covered in Chapter Four.

Data: These are the raw facts entered in to a computer system that is used to make decisions, solve problems, or gain insights. For example, the name of a student, subjects, and corresponding marks is a single point of data. It might not have any meaning by itself. However, when computed into total and average, that data gives information such as the student's progress. That information can be used to make some conclusions or develop insights about the student.

Users: Refer to individuals who interact with and utilise the computer and its resources to perform various tasks and achieve specific objectives.

Exercise 2.1

1. What if computers did not exist in today's world?
2. Baraka is a student at Kantalamba Secondary School. While in the school's computer laboratory, he enjoys playing games on his computer. Neema is the technician in charge of the computer lab. Describe their roles in terms of computer systems.

Computer generation refers to the ongoing evolution and development of computers and computing technology over several generations. Each generation represents a significant leap in terms of hardware, software, and overall computing abilities. These advancements have shaped the way we live, work, and interact with technology.

The different computer generations are:

(a) First Generation:
   (i) These are computers that were developed between the 1940s – 1950s.
   (ii) They were characterised by vacuum tubes as the primary electronic components.
   (iii) Computers were large, expensive, and consumed a lot of power.
   (iv) Examples include the ENIAC and UNIVAC computers.
   (v) They had limited computational capabilities and were used primarily for scientific and military applications.
   (vi) They were using machine-level language programming.

(b) Second Generation:

(i) They were developed between 1950s -1960s.

(ii) They used transistors instead of vacuum tubes.

(iii) They had smaller sizes compared to the first-generation computers.

(iv) They had less power consumption.

(v) Magnetic core memory was introduced, improving data storage.

(vi) They used assembly languages, and high-level programming languages like Fortran and COBOL emerged.

(vii) They had batch processing capability and the concept of operating systems began to develop.

(c) Third Generation:

(i) They were developed between 1960s-1970s.

(ii) They used Integrated Circuits (ICs).

(iii) They became smaller in size compared to the second generation.

(iv) Introduction of the IBM System/360 series and early mainframes.

(v) They had increased processing power.

(vi) They used high-level programming languages like BASIC and Pascal.

(vii) Multiprogramming and time-sharing operating systems allowed multiple users to interact with a single computer simultaneously.

(d) Fourth Generation:

(i) They were developed between 1970s-1980s.

(ii) They used Very Large-Scale Integration (VLSI) technology that enabled the creation of microprocessors.

(iii) Personal computers (PCs) like the IBM PC and Apple II were introduced.

(iv) They had Graphical User Interfaces (GUIs), and the mouse was invented.

(v) High-level languages such as C, C++, and Java gained popularity.

(vi) Networking and the internet began to take shape.

(e) Fifth Generation:

(i) They were developed between1980s-Present:

(ii) They continnued to deploy advancements in microprocessor design, storage, and networking.

(iii) PCs became more affordable and widespread.

(iv) There was the rise of mobile computing, with laptops, smartphones, and tablets.

(v) The World Wide Web (WWW) revolutionised information access and communication.

(vi) Artificial Intelligence (AI) and machine learning gained prominence.

(vii) Cloud computing and virtualisation changed how data and software are stored and managed.

(f) Future Generations:

(i) Quantum computing holds the promise of exponential processing power.

(ii) Neuromorphic computing mimics human brain architecture for AI applications.

(iii) Continued advancements in nanotechnology may lead to even smaller and more powerful computing devices.

(iv) Increased emphasis on sustainability and energy efficiency in computing.

Note: Details of programming languages will be covered in book two.

Activity 2.1

Use a library or reliable online sources to explore the early development of computers. Document your exploration using the word processor of your choice in a portfolio. Share your findings with fellow students using any presentation software.

Question

Do you think those early developments contributed to modern computers? Explain.

Activity 2.2

Use the library or reliable online sources to learn more about computer generations.

Question

What did you learn that was not discussed in this chapter?

Exercise 2.2

1. Is there any link between one computer generation and the next one? Explain.
2. What drove the transition from one generation of computers to the next?
3. Do you think computer generations have reached their end and we won't have another generation? Explain.

Modern computers can be classified using different criteria. This section uses four main criteria to classify computers.

Classification based on performance

Based on this criterion, computers are classified into personal computers, workstation computers, minicomputers, mainframe computers, and supercomputers.

Personal Computers

Personal Computers (PCs) are small computers designed for personal use. Their small sizes, capabilities, and affordable prices make them useful and comfortable for personal use. Some software applications that are installed on PCs include, word processing, spreadsheets, databases, web browsers, and e-mail clients. Personal computers may be connected to a network using either a cable or a wireless connection. A personal computer may be a desktop or a laptop as shown in Figure 2.2 (a) and (b), respectively.

(a) Desktop *(b)Laptop*

Figure 2.2: *Examples of personal computers*

Workstation computers

Workstation computers are desktop computers that are more powerful than normal PCs in terms of processing power. Workstation computers have very good graphics capabilities and large display screens (monitors). These computers are mainly used by engineers and scientists for demanding tasks that require high processing power and high-quality images. For example, Computer-Aided Design (CAD), used in engineering designs, and Computer Aid Manufacturing (CAM), used to automate manufacturing processes, constitute tasks that need high processing power. Figure 2.3 shows an example of an engineering workstation computer with multiple monitors.

Figure 2.3: *Engineering workstation computer with multiple monitors*

Minicomputers

Minicomputers are designed to support multiple users at a time. These computers have large storage capacities and operate at a higher speed. Minicomputers are used in systems that involve many users (multi-user systems) in which multiple users work on the same computer simultaneously, and large volumes of data are processed. Minicomputers can also be used as servers in local area networks (LANs). Figure 2.4 shows examples of minicomputers.

Figure 2.4: *Examples of Minicomputers*

Mainframe computers

Mainframe computers are very powerful computer. They also have a very large storage capacity, and they can handle the workloads of many users. The mainframe is the workhorse of the business world. It is the heart of a network of computers or terminals that allows hundreds of people to work a simultaneously on the same data. Mainframe computers are commonly used to control large networks in business companies such as Google, Yahoo, and Microsoft Network (MSN). Such companies

have millions of users using computers concurrently. Figure 2.5 shows a mainframe computer.

Figure 2.5: *Mainframe computer*

Supercomputers

Supercomputers are the most powerful and most expensive computers. They are used for jobs requiring massive computational power, like weather forecasting and engineering design. Supercomputers have higher processing speeds than all other computers. These computers use multiprocessing techniques to do their job. The main difference between supercomputers and mainframes is that supercomputers channel all their power into executing a few programs as fast as possible. In contrast, mainframes use their power to execute multiple programs concurrently. Like mainframe computers, the high processing power of supercomputers and the need for cooling systems means they require more electricity to operate. Figure 2.6 shows an example of a supercomputer.

Figure 2.6: *Example of a supercomputer*

Classification based portability

Computers can be classified according to this criterion as desktops, laptops, notebooks, palmtops, and tablet computers.

Desktop computers

A desktop computer (see Figure 2.2 (a)) is a personal computer intended for regular use at a single location on a desk or table due to its size and power requirements. It is designed to fit conveniently on top of a typical office desk. In businesses and increasingly at home, desktop computers can be interconnected and can share resources such as printers. To share the resources, they must be connected to a Local Area Network (LAN), Wide Area Network (WAN) and the Internet. The connection is through cables or a wireless network, also known as Wireless Fidelity (Wi-Fi).

Laptop computers

A laptop is a portable personal computer suitable for mobile use as seen Figure 2.2 (b). Laptops are commonly used for various purposes, such as work, education, and other personal tasks. A laptop is made up of components like those of the desktop computer, namely the display, speakers, keyboard, and mouse combined into a single device. Most modern-day laptops also have built-in web cameras (webcam) and pre-installed microphones to facilitate video conferencing and audio virtual meetings.

Notebooks

Notebooks computers are small compared to laptop computers. Besides the size and portability, the main difference between a notebook computer and a laptop, is the display screen. Notebook computers use various techniques, known as flat panel technologies, to produce a lightweight and non-bulky display screen. The quality of notebook display screens varies considerably. Figure 2.7 shows notebook computers.

Figure 2.7: *Notebook PCs*

Palmtops

Palmtops are small computers that literally fit in your palm. Compared to full-size computers, palmtops are severely limited in functionality. However, they are practical for certain functions, such as phone books and calendars. They are commonly known as Personal Digital Assistants (PDAs). Because of their small size, most palmtop computers do not include disk drives. Palmtops have small keyboards or specialised keypads tailored to specific industries. Palmtops use pens and keyboards to input data. Figure 2.8 shows different palmtops.

Figure 2.8: *Palmtops*

Due to the advancement of mobile technologies, the palmtop is being replaced with smartphones, which are even smaller. Smartphones are more advanced in terms of processing power, storage capacity, and multitasking. They are more convenient for personal and business use. Figure 2.9 shows different smartphones.

Figure 2.9: *Smartphones*

Tablets

A tablet is a mobile computer with a touchscreen display. Tablets are equipped with various sensors such as accelerometers, cameras and microphones, allowing one to use finger or stylus gestures instead of a mouse and keyboard. Some tablets contain physical buttons which control basic features such as volume and power. Besides, some tablets have ports for charging. An on-screen pop-up virtual keyboard is usually used for typing. Figure 2.10 shows different examples of tablet computers.

Figure 2.10: *Tablet computers*

Classification based signal

Computers can be classified into three categories: analog, digital, and hybrid, depending on the signal they use.

Analog computers

An analog computer stores data in the continuous form of physical quantities and performs computations with the help of measurements. It can be a mechanical analog or an electronic analog computer. These computers are used in hospitals, music studios, and aircraft for controlling equipment. The audio mixer is an example of an analog computer. Figure 2.11 shows an audio mixer.

Figure 2.11: *Audio mixer*

Digital computers

Digital computers are the most common class of computers used today. They perform computational and logical operations with discrete quantities represented as numbers in digital form. When the data supplied is in text or numeric format, it is first converted to digital form using the digits 0 and 1 before processing. Nowadays, when the word computer is used, we mostly refer to digital computers. Personal computers like desktop computer and laptop in Figure 2.2 (a) and (b), respectively, are some examples of digital computers.

Hybrid computers

Desirable features of analog and digital computers can be combined to create a hybrid computer. This computer performs arithmetic operations and measures different phenomena. The output can be in the form of either numbers or specific units of measurement. An example of a hybrid computer is the electrocardiogram (ECG). The ECG device records electrical changes in a patient's heart as shown in Figure 2.12. The measurements of the heart from this device are converted into digital form and the digital device checks for abnormalities.

Figure 2.12: *Electrocardiogram machine*

Another example is a modem. The modem converts digital signals into analog signals. It then carries these signals along a telephone line. The other modem at the receiving end changes them back to digital signals. Figure 2.13 shows an example of a universal modem.

Figure 2.13: *Universal modem*

Classification based on purpose

Computers can be classified based on the purpose of use, whether general or specific.

General-purpose computers

These are computers (such as PC) designed to perform various functions and operations because they can store and execute different programs in their internal storage. Most computers in use today are general-purpose computers; they are built for processing various jobs. Computers can be used to accomplish different tasks. These include writing and editing documents playing music, watching movies, and doing scientific computations.

Special-purpose computers

Special-purpose computers are designed for specific tasks and their job is to solve a particular problem. These computers are also known as dedicated computers because they are assigned to perform a single task repeatedly. Examples of special-purpose computers include Electronic Fiscal Devices (EFDs) which are used in tax collection. Other examples include computers designed to control washing machines, elevators, aircraft, satellites, traffic light systems, navigational systems, oil exploration systems, and automobiles. Figure 2.14 shows an example of a washing machine controlled by a special-purpose computer.

Figure 2.14: *Example of a washing machine controlled by a special-purpose computer*

Activity 2.3

Explore the school or home settings to find out about available computer.

Questions

1. Can you list the characteristics of the computers found in your environment and classify them?
2. Which computer type do you like most and why?

General characteristics of computers

The following are some characteristics of a computer.

Versatility

Computers are versatile in nature. They can perform different types of tasks with the same accuracy and efficiency. For example, you can use a computer to prepare a letter and at the same time play music, print a document, or follow an online class. All activities will be performed with the same accuracy and efficiency.

Speed

Computers can process data very fast, at the rate of millions of instructions per second. Some calculations that seem impossible to complete in a short time are performed in a few seconds by a computer. For example, calculations that require analysis of a large amount of data, such as salary slips of thousands of employees and processing of examination results. Other tasks such as weather forecasting related to temperature, pressure, and humidity at various places, can be done relatively faster.

Accuracy

The computer provides a high degree of accuracy. For example, the computer can accurately give the result of the division of any two numbers up to 10 decimal places.

Diligence

When used for a longer period, the computer does not get tired or fatigued. It can perform long and complex calculations with the same speed and accuracy from the start till the end.

Storage capability

Large volumes of data and information can be stored in the computer and retrieved whenever required. A limited amount of data can be stored temporarily in the primary memory. Secondary storage devices like flash disks and compact disks can permanently store a large amount of data.

Exercise 2.3

1. Compare and contrast the different classifications of computers and discuss the advantages and disadvantages of each type.
2. Give an instance of a task that necessitates the use of a supercomputer.
3. Give three reasons why a mobile phone is regarded as a computer.
4. Explain why we need different types of computers in today's world.

Chapter Summary

A computer system is a complex interconnected network of hardware and software components designed to process and store information. A complete computer system includes hardware and software. Hardware consists of electronic devices, the parts you can touch. Software, also known as programs, consists of organised sets of instructions for controlling the computer, the parts you cannot touch.

Supercomputers are the most powerful computers in terms of processing. Mainframe computers handle massive amounts of input, output, and storage for multiple users. Minicomputers are smaller than mainframes but larger than personal computers. They often support multiple users. Workstations are powerful single-user computers that are used by engineers, scientists, and graphic artists. Desktop computers are the most common type of personal computer. Notebook computers and laptops are used by people who need portable computing power outside the office or away from home. Handheld personal computers are the smallest computing devices. They lack the power of a desktop or notebook PC, but they offer specialised features for users who need only limited functions and small sizes.

Revision exercise 2

A: Multiple choice

1. Which of the following best describes the first-generation computers?
   (a) Featured graphical user interfaces.
   (b) Used vacuum tubes for processing.
   (c) Utilised integrated circuits.
   (d) Used transistor technology.
2. Which computer generation introduced the concept of personal computers (PCs) and graphical user interfaces (GUIs)?
   (a) Second Generation
   (b) Third Generation
   (c) Fourth Generation
   (d) Fifth Generation
3. Which of the following is not a class of computers?
   (a) Supercomputers
   (b) Ultra-compact
   (c) Mainframes
   (d) Microcomputers
4. Among the options provided, which classification of computers is specifically intended for demanding computational tasks and scientific simulations?
   (a) Microcomputers
   (b) Mainframes
   (c) Minicomputers
   (d) Supercomputers

5. Laptops and desktops are examples of which classification of computers?
   (a) Supercomputers
   (b) Minicomputers
   (c) Microcomputers
   (d) Mainframes

B: Matching items

6. Match the following computer generations with its associated technology:

Computer generation	Technology
(a) Second generation computers	(i) Very Large-Scale Integration
(b) Fifth generation computers	(ii) Vacuum tube technology
(c) Fourth generation computers	(iii) Transistor technology
(d) First generation computers	(iv) Microprocessor design technology
(e) Third generation computers	(v) Integrated circuits technology

7. Match the following classifications of computers with their descriptions:

Classification	Description
(a) Personal computers	(i) Designed for complex simulations and scientific calculations.
(b) Mainframes	(ii) Compact and portable computers for individual use
(c) Supercomputers	(iii) Large, powerful machines for organisation-wide data processing
(d) Minicomputers	(iv) Mid-sized computers are often used in universities and research institutions

8. Match the following area of work with suitable type of computer.

Area of work	Suitable type of computer
(a) Hospital labour ward	(i) Hybrid computers
(b) School offices	(ii) General purpose computer
(c) Laundry	(iii) Special purpose computer
(d) Newsroom	(iv) Laptop computers
(e) Steel industries	(v) Tablets
(f) Meteorological station	

C: Short answer

9. Why the first-generation computers were large, over-heating, and power inefficient?
10. Write a brief reflection on the relevance and significance of classifying computers and discuss how understanding these classifications can be helpful in various technology-related decisions.
11. Imagine a school with a tight budget planning to buy computers for its computer laboratory. As an advisor, recommend suitable computers they should buy and give reasons to explain your selection.
12. Create a timeline that shows how computers evolved over different generations. Use at least four generations and mark important advancements or key points for each one.
13. Explain why the development of microprocessors was a major development in computer technology.
14. Assess the importance of transitioning from vacuum tubes to transistors in computer development. Give two reasons why transistors were deemed superior to vacuum tubes.

Chapter Three

Computer hardware

Introduction

In todays world, computers are essential, and a lot of people use them daily. These computers operate relying on the interaction of various hardware components working together. Possessing a basic understanding of computers is essential for navigating the modern world and avoiding being left behind. In this chapter, you will learn the concept of computer hardware, input, storage, processing, and output devices. The competencies developed will enable you to use computer hardware for different purposes.

Think

Use of computer hardware

Concept of computer hardware

Meaning of computer hardware

Computer hardware is the collection of all the tangible parts of a computer that can be seen and touched. They work together to enable the functioning of a computer. These parts are classified into input, processing, storage, and output devices. Input devices include mice and keyboards. Processing devices refer to the central processing unit (CPU). Output devices include the monitors and printers. Storage devices include hard disk drives and DVDs. Figure 3.1 shows a block diagram of a typical computer system.

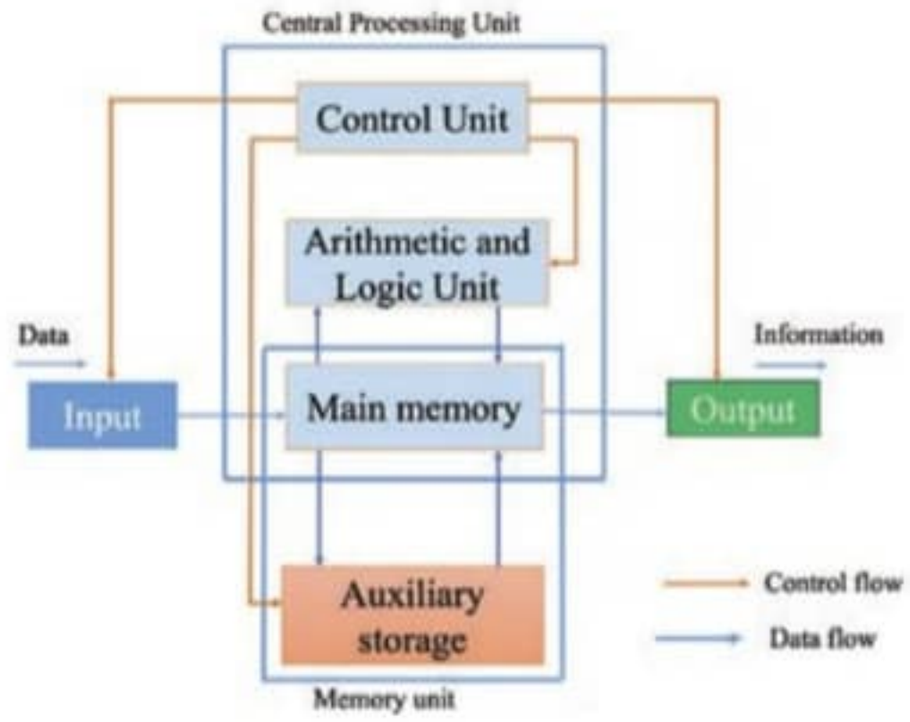


Figure 3.1: *Block diagram of a computer system*

Types of computer hardware

Computer hardware is categorised based on its operations, namely input, processing, storage, and output. Hardware components are usually called devices, hence the terms input, processing, storage, and output devices.

These are devices that control signals that initiate the process of a computer system. These devices convert the input data into a digital form that is understandable to the computer. These devices are used to enter raw data (input) into the computer to be processed into information. Some examples of input devices include keyboards, mice, scanners, joysticks, digital cameras, microphones, light pens, and touch screens.

Keyboards

A computer keyboard is an input device used to enter data into the computer system by pressing buttons or keys. It contains keys for individual letters, numbers, and special characters, as well as keys for specific functions and punctuation marks. The keyboard is connected to the computer system using either a cable or a wireless connection. Laptops have in-built keyboards, while other mobile devices like tablets and smartphones use virtual keyboards. Figure 3.2 shows an example of a standard keyboard and its layout.

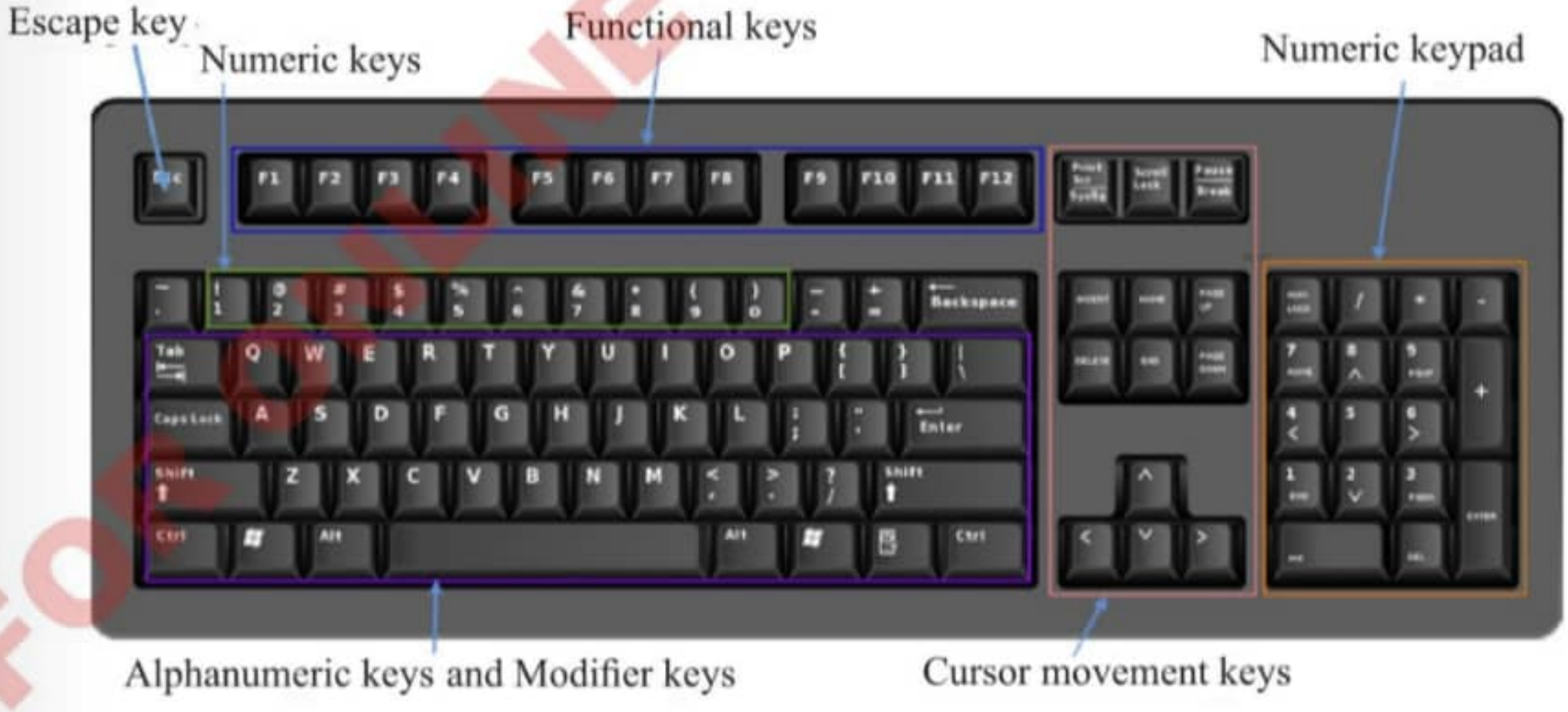


Figure 3.2: *Standard physical keyboard and its layout*

The keys for the keyboard are grouped as follows:

Alphanumeric keys

This part of the keyboard is for typing letters on the computer. The letters are arranged in three rows but not in the ascending order of the English letters. In some computers,

the first row consists of the letters Q, W, E, R, T, and Y, such a keyboard is known as a QWERTY (pronounced as KWER-tree). Usually, the spacebar is included in alphanumeric keys.

Modifiers keys

These are keys that modify the input of other keys. Modifier keys include the Shift key, Control (**Ctrl**) keys, and the Alternate (**Alt**) key.

(i) *The Shift key:* This is the modifier key on the keyboard that performs different functions. For example, pressing and holding the shift key while pressing a letter a key would generate a corresponding capital letter. The shift key is commonly located on both the left and right-hand sides of the keyboard for typing efficiency.

(ii) *Control (Ctrl) keys:* These keys are found on standard computer keyboards on the bottom left and right of the keyboard. It is mostly used in combination with other keys to perform some functions or commands. For example, Ctrl + Alt + Del on a Windows computer opens the task manager application that gives an option to terminate a process, active programs, or reboot the computer.

(iii) *The alternate (Alt) key:* Like the Shift keys, the Alt keys are modifier keys that are used to change (alternate) the function of other pressed keys. For example, the key combination Alt + Tab, that is, pressing and holding the Alt key and then pressing the Tab key, enables to switch between open windows.

Function keys

The keys, **F1** through **F12** (**see Figure 3.2**), are called function keys. They may have various uses, depending on the installed operating system. A computer program that is currently opened may also change how each of these keys operates. A piece of software may use function keys independently or combine function keys with other keys, such as the **Alt** or **Ctrl** keys. For example, when you press **Alt + F4** in Microsoft Windows, the active window closes.

The cursor-movement keys

A cursor is a movable indicator that displays the location on a computer screen where text will be entered when a user types on the keyboard. The cursor movement keys are used to move the cursor around, and they include the **Home, End, Enter, Page up, Page down, and the arrow** keys.

(i) *The Home key:* This key, when pressed it returns the cursor at the beginning of a line. However, when combined with **Ctrl,** it moves the cursor to the beginning of the document.

(ii) *The End key*: This key takes the cursor to the end of the line. However, when combined with **Ctrl**, it moves the cursor to the end of the document.

(iii) *The Enter key:* Moves the cursor to a new line.

(iv) *Page up (Pgup) key:* Move the cursor to the previous page in a document.

(v) *Page down (Pgdn) key:* Move the cursor to the next page in a document.

(vi) *Arrow keys:* Move the cursor to the left, up, right, and down.

Special keys

These keys perform special functions. Examples are **Tab, Caps Lock, Num lock, Esc, Num keys, Home, End, and Enter**.

(i) *The Tab key:* Moves the cursor several spaces at once.

(ii) *The Caps lock key:* A key that enables or disables all letters from being typed in uppercase. For example, if you want to type "see me" when this key is enabled, the keyboard types "**SEE ME**", and when it is disabled, the keyboard types "see me". For some keyboards, on the right corner of this key, there is a status light that turns on when the caps lock key is enabled and turns off when disabled.

(iii) *The Num lock key:* The key that is on the top-left corner of the keyboard's numeric keypad. It is used to enable and disable the numeric keypad.

(iv) *Escape (Esc) key:* The escape key's function depends on your program or operating system. It is usually used to cancel or interrupt the current operation.

(v) *Start key:* It is mostly used to open the window start-up menu on a Windows computer.

How the computer accepts input from the keyboard

When you press a key on the keyboard, it physically goes down, completing an electrical circuit. This generates a unique electrical signal corresponding to the specific key pressed. Inside the keyboard, there is a keyboard controller that processes the electrical signals. It acts as an interface between the keyboard and the computer.

Once the keyboard controller identifies the key that was pressed, it translates the key's number (unique identifier). The keyboard controller then sends the translated signal to the computer through a wired or wireless connection. The signal is sent as a series of binary digits (0s and 1s), which the computer can interpret.

When the translated signal reaches the computer, it is stored in an area of main memory known as the keyboard buffer.

Then, the operating system's keyboard driver takes over. It interprets the binary signal and converts it into characters or commands that applications can understand.

Finally, the application that is in use, such as a text editor or web browser, receives the input interpreted by the operating system. Depending on the application, the input may be used to type a text, trigger specific commands, or perform other functions.

This process allows you to interact with the computer, type text, navigate through applications, play games, and perform various tasks using the keyboard as an input device. Figure 3.3 summarises the way the keyboard receives and processes input.

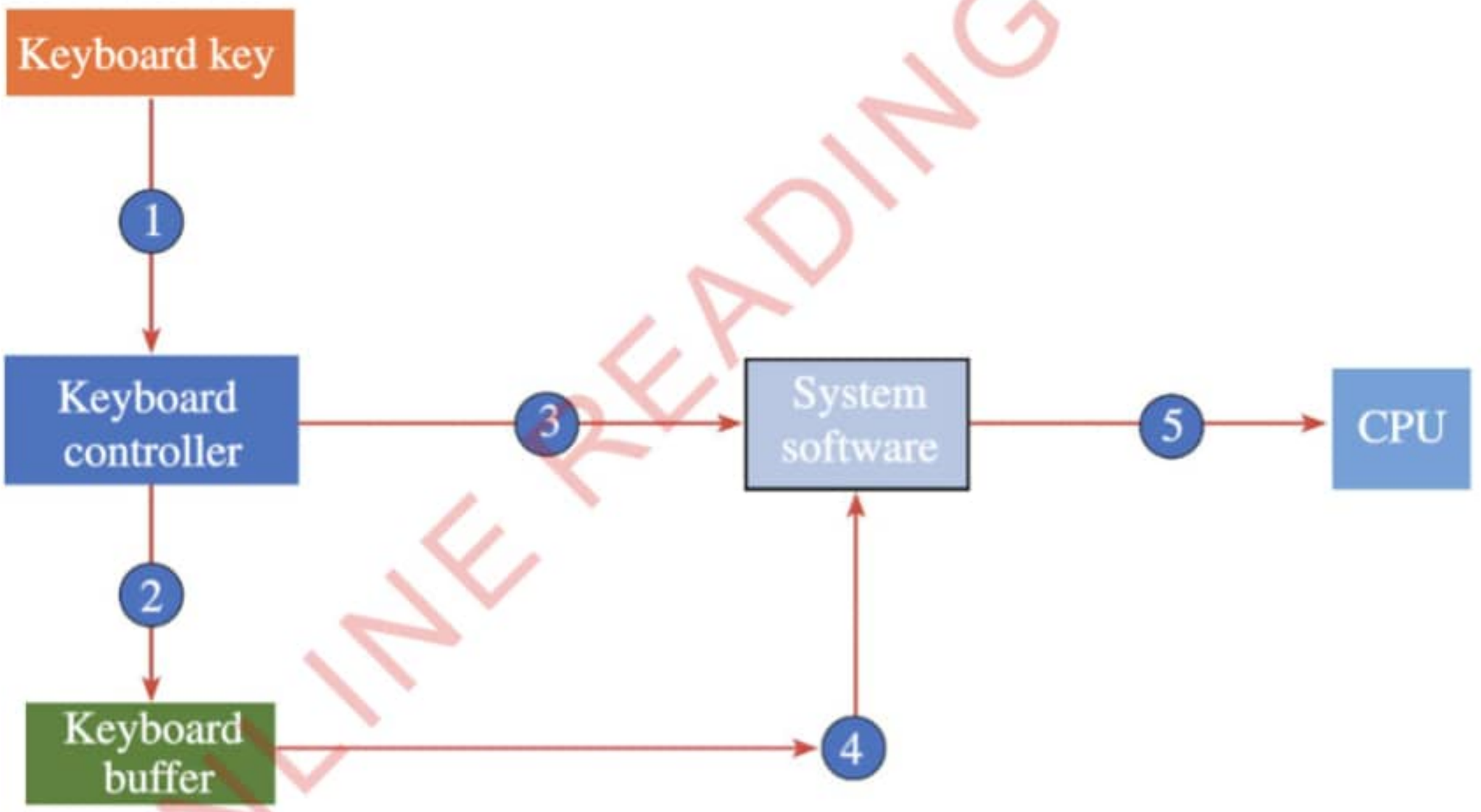


Figure 3.3: *Steps of keyboard operation*

Key

1. A key pressed on a keyboard
2. The keyboard controller sends the translated code to the keyboard buffer.
3. The keyboard controller sends interrupt requests to the system software.
4. The system's software responds to the interrupt request by reading the translated code from the keyboard buffer.
5. The system software passes the translated code to the CPU.

Activity 3.1

Use the information in this section to practice using different keyboard keys, such as alphanumeric, modifier, and special keys. Find online tutorial

that will help you to use different keyboard keys.

Question

Did you find any challenges in practising the use of different keys on the keyboard?

Mice

A computer mouse is an input device that controls cursor movement in a Graphical User Interface (GUI). It can be moved and used to select text, icons for files and folders, and menu items. For desktop computers, the mouse is placed on a flat surface, such as a mouse pad or a desk. Figure 3.4 shows examples of mice.

(a) *Wired mouse* (b) *Wireless mouse*

Figure 3.4: *Computer mice*

Scanners

A scanner is a device that is used to convert a hard copy document to digital form (softcopy). The process of converting a printed format into a digital format is called scanning. For example, photos, original artwork, drawings, and text can all be scanned.

Types of scanners

Scanners come in different shapes and sizes. They can be categorised into four types: hand-held scanners, flatbed scanners, drum scanners, and sheet-fed scanners.

Hand-held scanners

These scanners are held in the hand and moved over the material being scanned. They are small, portable, and cheap. They improve efficiency at shopping places such as supermarkets and bookshops. They are generally used with barcodes, such as on books in bookshops and libraries and on groceries in supermarkets. Figure 3.5 shows a hand-held scanner.

Figure 3.5: *Hand-held scanner*

Flatbed scanners

These scanners provide a flat glass surface to hold a sheet of paper, book, or other documents for scanning.

These are the most common scanners in homes and offices. The document to be scanned is placed face down on the glass surface of the scanner. The scanning head and the light source under the glass automatically scan the document at a constant speed. Scanners can be multi-purpose as they can scan flat originals of various sizes. They can also be connected to a document feeder to scan multipage documents. Figure 3.6 illustrates a flatbed scanner.

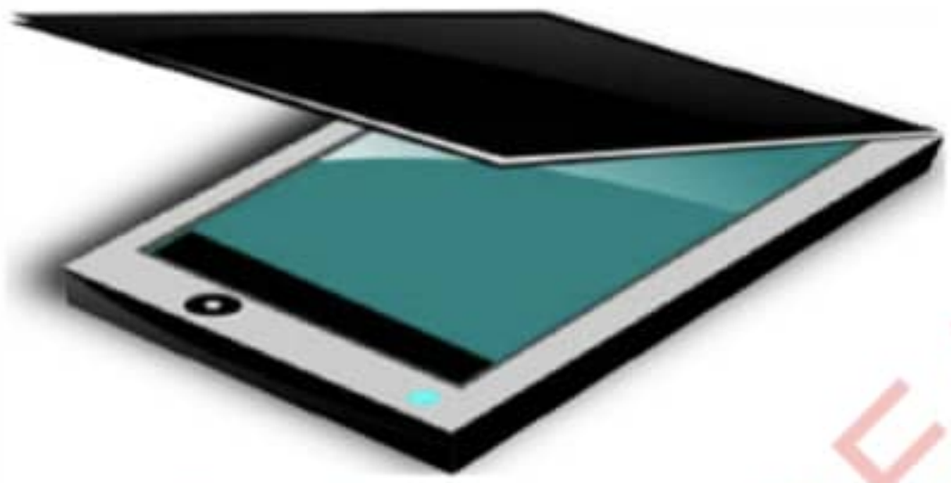


Figure 3.6: *Flatbed scanner*

Drum scanners

These are special scanners used to scan reflective and transparent materials at extremely high quality. These scanners provide high-quality, detailed features, dynamic range, and colour interpretation of the scanned materials. Figure 3.7 presents a drum scanner.

Figure 3.7: *Drum scanner*

Sheet-fed scanners

These are digital imaging systems specifically designed for scanning loose sheets of paper. They work as flatbed scanners, except that a document is fed through the scanner and moves along the beam to be read. These scanners are not useful for books but for single sheets only (see Figure 3.8).

Figure 3.8: *Sheet-fed scanner*

Advantages of scanners

(i) They produce accurate and high-resolution images.

(ii) Scanned images can easily be shared, added to an electronic document, or edited.

Disadvantages of scanners

(i) Most scanners can only scan flat objects.

(ii) The quality of scanned items may differ from that of the original one.

(iii) Some scanners are relatively slow.

Things to consider when using scanners

(i) Scanned images may lose their original quality based on the type of scanner used.

(ii) A scanned image file can be very large and take up large memory space.

(iii) The quality of the scanned image depends on the quality of the source document.

Installing a scanner

Installing a scanner to a computer involves connecting the scanner hardware and installing the necessary software (drivers) to enable communication between the scanner and the computer. The steps for installing a new scanner are outlined as follows:

Steps

(i) Unpack and connect the scanner

(a) Unbox the scanner and remove any protective packaging.

(b) Connect the scanner to the computer using the appropriate cable. Most modern scanners use a USB connection, so plug the USB cable into an available USB port on the computer and the other end into the scanner.

(ii) Power **ON** the scanner

Turn on the scanner by pressing its power button or using the power switch if applicable.

(iii) Check for automatic driver installation.

(a) For many scanners, especially newer models, Windows, macOS, or Linux operating systems may automatically detect and install the required drivers when you connect the scanner.

(b) If this happens, a notification will appear that the driver has been successfully installed.

(iv) Manual driver installation

(a) If automatic driver installation fails, install the drivers manually using CDs or DVDs that come with the scanner and contain the necessary drivers.

(b) Insert the disc into your computer's CD/DVD drive and follow the on-screen instructions to install the drivers.

(v) Download drivers from the manufacturer's website

(a) If the scanner doesn't come with an installation disc or you prefer the latest drivers, visit the manufacturer's website and search for the specific scanner model.

(b) Look for the "Support" or "Downloads" section, then download the appropriate drivers for your operating system. Then, run the downloaded file and follow the installation instructions.

Note: Driver is a software that is installed to allow

communication between the device such as printer, phone and the computer.

(vi) Complete the installation

Once the drivers are installed, the computer should recognise the scanner. Sometimes, restarting the computer after driver installation may be necessary for the changes to take effect.

(vii) Test the scanner

(a) Open the preferred scanning application (often included with the scanner or available for download from the manufacturer's website).

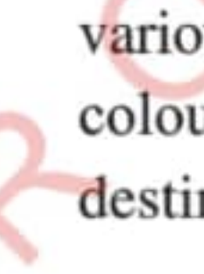
(b) Use the software to initiate a scan to test the scanner's functionality.

(viii) Configure scanner settings

Depending on the scanning needs, it might be necessary to adjust various settings, such as resolution, colour mode, file format, and scan destination.

Activity 3.2

Use the school facilities to practise the steps of installing a scanner.



Questions

1. Did you face any challenges in installing the scanner? If yes, how did you solve the challenge?
2. Try the same procedures to install a printer on your computer.

Joysticks

A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling. Joysticks are commonly used to control video games. They usually have one or more push buttons whose state can also be read by a computer. A popular variation of joysticks used in modern video game consoles is the analogy stick. Joysticks are also used for controlling machines such as cranes, trucks, underwater unmanned vehicles, wheelchairs, and surveillance cameras. Miniature finger-controlled joysticks have been adopted as input devices for smaller pieces of electronic equipment such as mobile phones. Figure 3.9 shows an example of joysticks.

Figure 3.9: *Examples of joysticks*

Digital cameras

Camera technology has evolved with the advancement of technology in other fields. In their old technology, cameras used film to capture images. Printed photos were produced using special machines known as Darkroom equipment. Most modern cameras use digital technology. They capture images as film cameras do, but images are stored in digital format.

Images are mostly stored on memory cards instead of being printed on films. They can then be copied to computers for editing, storing, printing, or uploading to websites and other online applications. Digital cameras are also embedded or integrated into many devices, such as smartphones and speed radars used by the traffic police. Figure 3.10 shows a digital camera.

Figure 3.10: *Digital camera*

Advantages of digital cameras

(i) They instantly produce images.

(ii) Images can be shared immediately with other devices or uploaded online.

(iii) An image may be viewed or discarded if not needed.

(iv) They are environmentally friendly because they do not need toxic chemicals to develop films and produce printed photos.

Disadvantages of digital camera

(i) The quality of images is limited by the resolution of the digital camera.

(ii) Some digital cameras have limitations when taking photos in places with poor light.

Microphones

Sound is recorded using microphones. After recording, the sound is transferred to computer storage or transmitted to public address systems. Sometimes the word microphone is informally referred to as a mic. The microphone may be connected to a computer or other devices using a cable or wirelessly through a sound card. Some computers, such as laptops, have built-in microphones. Figure 3.11 presents different microphones.

Figure 3.11: *Different designs of microphones*

Touch screens

A touch screen is a special computer screen that you can control by touching it with your finger or a special tool called a stylus. You can see things on the screen and touch them to do different things, like zooming in or out. Some devices like phones, tablets, and laptops have a special keyboard on the screen that you can touch to type.

Behind the touch screen, there is a light called infrared light. When you touch the screen, you stop the light, and the device knows where you touched it. This way, it knows what you want to do.

Touch screens are used in many places like shops, restaurants, supermarkets, and airports. They help people use computers and other devices more easily and quickly. Figure 3.12 shows an example of a laptop with a touchscreen display.

Figure 3.12: *Notebook computer with a touchscreen display*

Connecting input and output devices to a computer

Input devices are connected to a computer through connecting cables or wireless connections. Computers have ports known as connection points or interfaces with other peripheral devices. Such ports connect peripheral devices to a computer through a cable and a socket. Figure 3.13 (a), (b), and (c) shows some cables that are used to connect the ports of USB, HDMI, and VGA, respectively.

(a) *USB* (b) *HDMI* (c) *VGA*

Figure 3.13: *Different types of connecting cables*

Exercise 3.1

1. Briefly explain some of the considerations to be made when choosing an input device for a particular task.
2. Use various sources to explore the emerging field of 3D scanning and its applications in various industries, including architecture, engineering, manufacturing, and healthcare.
3. Differentiate between keyboards and mice as input devices.

Processing

Data entered into a computer is of no use if it is not processed. A part of the computer responsible for processing data is the Central Processing Unit (CPU).

Central Processing Unit

The CPU is a central hardware component that acts as the brain of a computer. It does all processing activities that occur inside the computer.

The CPU (see Figure 3.14) is found inside the computer case and is mounted on the motherboard.

Figure 3.14: *Top and bottom view of the CPU (processor)*

The CPU takes data and instructions from the main memory and processes them based on the instructions given by a program. The CPU performs four basic tasks: fetching, decoding, manipulating, and outputting. The CPU consists of two major parts: the Arithmetic Logical Unit (ALU) and the Control Unit (CU).

ALU: The arithmetic logic unit performs arithmetic operations on the data. Common arithmetic operations performed by the ALU are addition, multiplication, subtraction, and division.

It also performs logical operations (e.g., AND, NOT, OR) on binary digits, such as comparing two quantities for equality or determining whether a condition is true or false.

The following are the functions of ALU:

1. It helps ensure that information goes in and out of a computer's different parts in the right order.
2. It interprets instructions.
3. It controls data flow inside the processor.
4. It gets messages from the outside and turns them into signals that tell the computer what to do.
5. It controls other execution units that is; data, buffers, and registers contained within the CPU.

CU: The control unit directs the CPU's operation. The CU usually uses a special decoder to change secret codes into signals that tell the other parts of the computer what to do. These parts include memory, arithmetic logic units and input and output devices. The following are the functions of CU:

1. It takes one job at a time from the main memory.
2. It gathers the resources needed to get that job done.
3. It sends instructions to ALU on how to perform an operation.
4. It receives and sends the results of the ALU operations to primary memory.

CPU installation

The steps for installing CPU on a motherboard of a desktop computer.

Steps

(i) Lift the metal arm slightly away from the CPU socket, as in Figure 3.15.

Figure 3.15: *Lifting CPU metal arm*

(ii) Hold the CPU by its edges and insert it effortlessly into the socket, as seen in Figure 3.16.

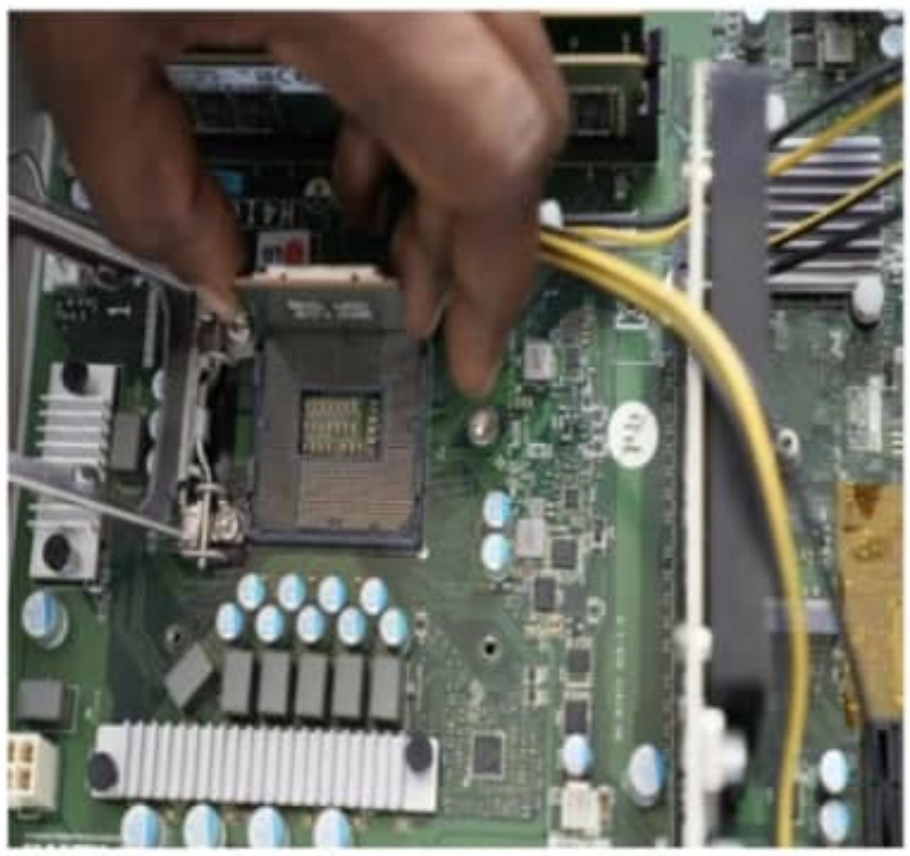


Figure 3.16: *Inserting a CPU into the socket*

(iii) Push the metal arm into its position,

(iv) Apply the thermal paste on the CPU chip as in Figure 3.17 and

Figure 3.17: *Apply the thermal paste on the CPU*

(v) Install the CPU heat sink.

Activity 3.3

Use school's computers to practise the installation of CPU.

Questions

1. Did you face any challenges in installing the CPU?
2. If yes, how did you overcome them?
3. What do you think will happen if you don't apply a CPU heat sink?

Motherboard

The motherboard is the main circuit board in the computer. It has many chips, connectors, and other electronics mounted on it. Figure 3.18 shows an example of a typical PC motherboard.

Figure 3.18: *PC motherboard*

All the essential components are plugged into the motherboard through different slots and ports. Some of these components include expansion cards, processors, RAM, hard drives, and optical drives.

Expansion slots

The expansion slots are located on the motherboard to accept the insertion of expansion cards. Expansion cards give the computer new features or increased performance. Such slots include the Industry Standard Architecture (ISA) slot, Peripheral Component Interconnect (PCI), and PC card slots. The main function of these slots is to expand the functionality of a computer system. For example, a high-end graphics card can be inserted in one of these slots to improve the computers graphics processing capability.

Ports and interfaces

The motherboard has a certain number of sockets that are used to connect to external devices (peripherals). These ports act as an interface between the motherboard and those external devices. Examples of common ports on a modern motherboard are the USB, VGA, HDMI, RJ45, and sound ports. Figure 3.19 shows computer ports.

Figure 3.19: *Motherboard ports*

Exercise 3.2

1. What is the primary function of a CPU in a computer, and how does it execute instructions?
2. Explain the role of the motherboard in a computer system and how it connects various hardware components.
3. Provide examples of key components typically found on a motherboard and their functions.

Storage

Storage refers to the process of recording, retaining, and organising data or information for future use. Storage is important in computing. It enables us to preserve and

access vast amounts of data efficiently and securely. Storage technologies continue to change, with advancements in capacity, speed, reliability, and energy efficiency. This enables us to store and manage larger volumes of data with greater ease and convenience. Computer storage is primarily used to store data and instructions that are being processed. It is also used to permanently store data and information that can be retrieved in the future. Therefore, storage is classified into two types: primary memory and secondary or auxiliary storage, as shown in Figure 3.20.

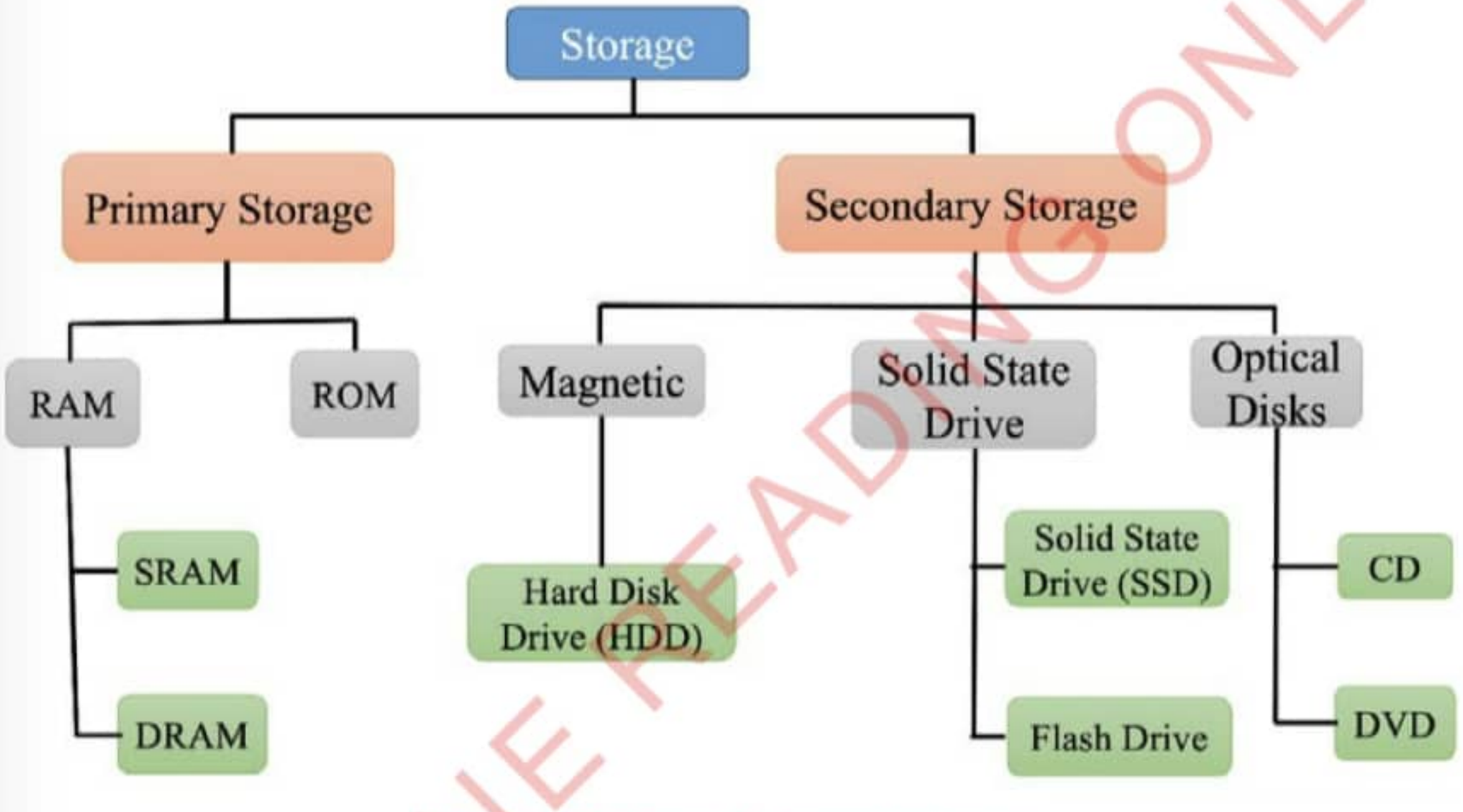


Figure 3.20: *Types of a computer storage*

Measuring memory capacity

The smallest unit of memory a computer can handle is the bit (binary digit 0 or 1). Bits are usually combined into larger units to hold a greater range of values. This is because computers do not work with bits individually, but they group eight bits together to form a byte. Each byte maintains one (1) eight-bit pattern. Bytes are used to quantify the amount of data digitally stored or transmitted. The capacity of computer memory is determined by the amount of data it can hold. Memory capacity is denoted using various units, as shown in Table 3.1.

Table 3.1: *Memory capacity chart*

Data measurement	Size
Bit	Single binary digit (1 or 0)
1 Kilobyte (KB)	1,024 bytes
1 Megabyte (MB)	1,024KB

Data measurement	Size
1 Gigabyte (GB)	1,024MB
1 Terabyte (TB)	1,024GB
1 Petabyte (PT)	1,024TB

That is, 1 byte = 8bits, 1KB = 1024B, 1MB = 1024KB, 1GB =1024MB, and 1TB = 1024GB.

Primary storage

Primary memory is computer memory that the processor accesses first or directly. It stores running applications and data that are temporarily or permanently stored in a specific memory location. The CPU interacts directly with this memory to perform read and write operations. Primary memory has the following characteristics:

(i) It is the working memory of the computer, and;

(ii) It is faster than secondary memory.

There are two types of primary storage: Random Access Memory (RAM) and Read Only Memory (ROM).

Random Access Memory

RAM is the temporary storage of running programs, input data, and intermediate results. The input data enters the computer using the input devices and is stored in RAM before processing. After processing, results are stored in RAM before being sent to the output and storage device. RAM is a volatile memory; it loses information when the computer is switched off. Therefore, any information that needs to be kept for a longer time must be saved in secondary storage before the computer is turned off. Furthermore, RAM stores data and instructions that need to be operated by the CPU. When a person switches on the computer or opens a certain application, the set of instructions is first brought to RAM from ROM or from secondary memory to enable operation. Figure 3.21 shows a RAM module.

Figure 3.21: *Random Access Memory module*

There are two categories of RAM depending on the technology used to construct them; these are Dynamic RAM (DRAM) and Static RAM (SRAM).

DRAM is the most common type of memory and is mostly used as main memory since it is small and cheap. It uses transistor and capacitor technology.

It can store each bit of data in a separate capacitor within a particular integrated circuit. The transistors and capacitors are paired to make a memory cell. The transistor acts as a switch that lets the control circuitry on the memory chip read the capacitor or change its state. Figure 3.22 shows a DRAM module.

Figure 3.22: *DRAM module*

Installing RAM modules

The following are steps for installing RAM modules.

Steps

(i) Ensure the compatibility of RAM with your motherboard by checking RAM type, speed, and maximum capacity.

(ii) Make sure that the RAM modules match the motherboard's specifications.

(iii) Shut down the computer.

(iv) Disconnect the power cord from the electrical outlet.

(v) Wear an antistatic wrist strap to prevent electrostatic discharge.

(vi) Remove the side panel of a computer case.

(vii) Look for the RAM slots on the motherboard.

(viii) Align the notch on the bottom edge of the RAM module with the slot on the RAM slot on the motherboard.

(ix) Insert the RAM module into the slot at a slight angle, making sure the notch slides into the corresponding slot (see Figure 3.23).

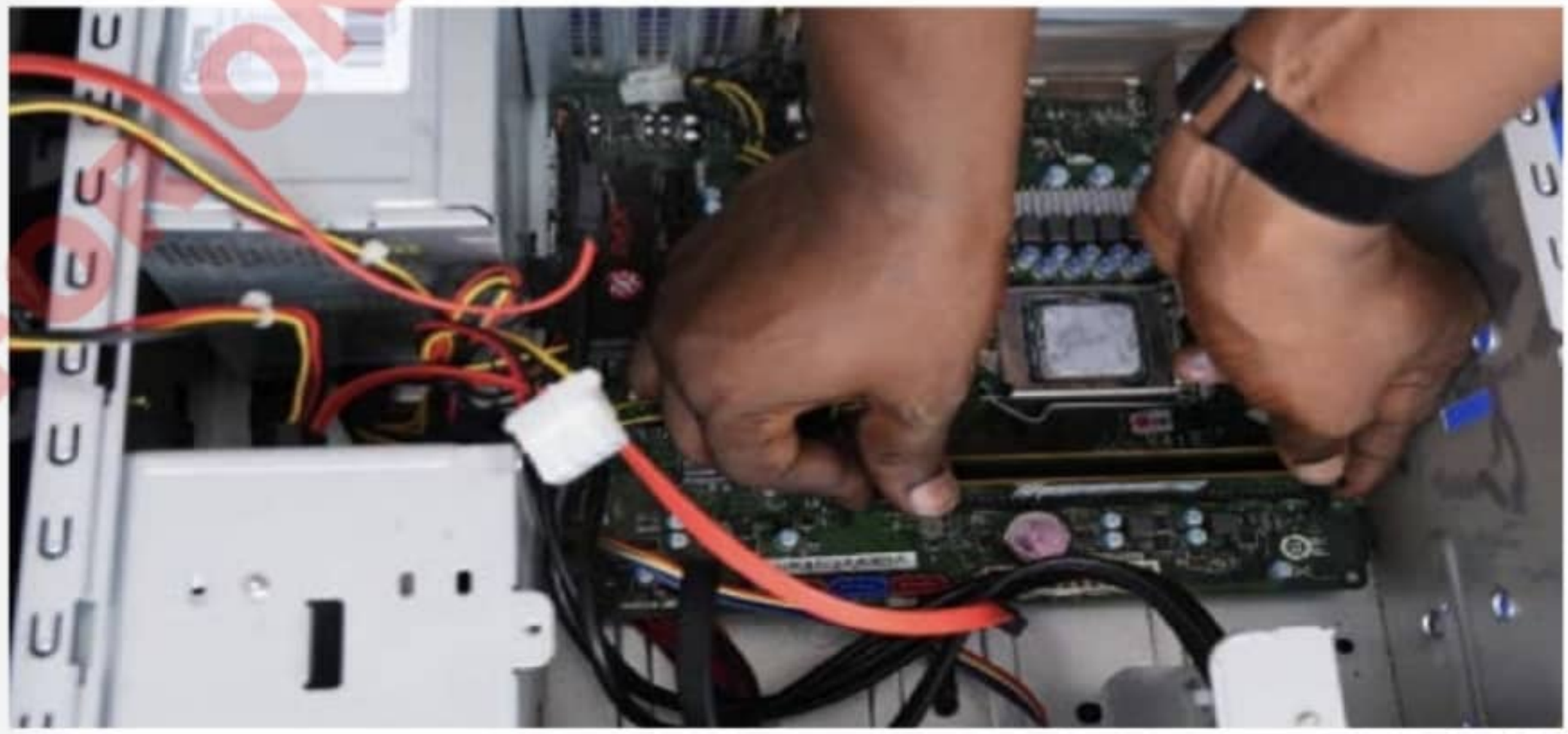


Figure 3.23: *Installing RAM Module*

Activity 3.3

Under the guidance of your teacher, use the school's computers to practise installation of RAM modules.

Questions

1. Did you face any challenges in installing RAM modules?
2. If yes, how did you overcome the challenge?

SRAM uses multiple transistors to store data. It is faster than DRAM and is normally used as cache memory or high-speed memory. Figure 3.24 shows an example of an SRAM chip.

Figure 3.24: *Static Random-Access Memory (SRAM) chip*

Read Only Memory

The Read Only Memory (ROM) is a permanent storage memory that stores data that can be read only but not to be rewritten. ROM is non-volatile; its contents are not lost even when the power is turned off. ROM helps to increase the efficiency of the CPU as it can perform specific tasks. It is used to store fixed contents that facilitate the computer operation. For example, ROM hosts the start-up program that loads the operating system into primary memory. Figure 3.25 shows a ROM chip on a motherboard.

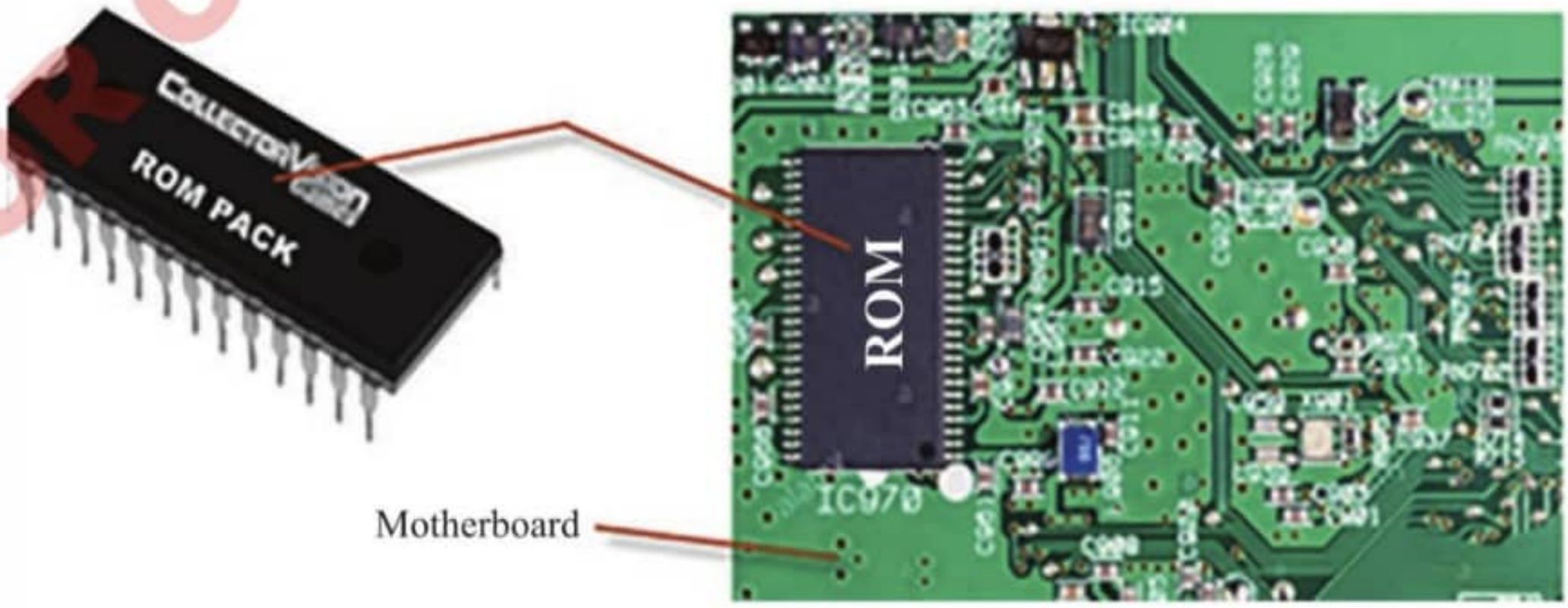


Figure 3.25: *ROM chip on a motherboard*

Types of ROM

There are two types of ROM: Programmable Read Only Memory (PROM) and Erasable Programmable Read Only Memory (EPROM). Once a PROM chip has been programmed, information cannot be changed. However, EPROM data can be deleted and rewritten

Other types of memory

Cache memory

Cache memory is a very special type of high-speed memory that users cannot access. It is very small. It is located in between the CPU and the main memory. The main function of cache memory is to increase the availability of instructions and data that are frequently used by the CPU. Cache memory stores those instructions and data often used when performing a specific task to increase CPU efficiency. Cache memory accomplishes its task by building a small amount of memory, known as primary or level 1 cache, right into the CPU. Level 1 cache is very small, normally ranging between 2 kilobytes (KB) and 64 KB.

Registers

Registers are small and high-speed memory locations found in the CPU that are used to retain information temporarily. These are special memory units that are not parts of the main memory but store data and instructions that the CPU is currently working on. The registers receive information, hold it temporarily, and make it available to the CPU when required. A computer uses several registers, where each register performs a specific function.

Secondary memory

The instructions, data, and outputs in a computer system usually need to be kept for future use. The area where these components are permanently stored is known as secondary memory. Secondary memory is simply referred to as storage or auxiliary memory. Data from secondary storage is initially transferred to primary memory (main memory) for the CPU to use. Secondary storage is particularly useful for storing large amounts of data that can't fit in the main memory. It holds all the data and programs on a computer, including the operating system.

It is worth noting that secondary memory is slower than primary memory. Still, it has the advantage of being non-volatile, meaning it doesn't lose data when the computer is turned off. Secondary storage devices come in various forms, including optical, magnetic, more USB flash drives or solid-state storage (SDD).

Characteristics of secondary memory

Secondary memory has the following characteristics:

(i) Has a larger capacity compared to primary memory;

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Secondary memory has the following characteristics:

(i) Has a larger capacity compared to primary memory;

(ii) It is non-volatile; and

(iii) It is slower in terms of reading and writing data than primary memory.

Secondary storage is available through auxiliary devices, such as magnetic discs, flash memory, and optical devices (CDs, DVDs, and Blue-Ray). These types of storage are distinguished by their relative speed, capacity, size, and reliability.

Magnetic hard disks

Hard disks or hard drives are thin but rigid metal, glass, or ceramic platters covered with a substance that allows data to be held in the form of magnetic spots. They are firmly fastened inside the system unit, making it part of the system. This is the main storage of installed programs and data on the computer. The disk provides relatively quick access to data on an electromagnetically charged surface or set of surfaces. Hard disks have larger capacities and can store and retrieve information much faster. Figure 3.25 (a) and (b) show the top and inside view of a magnetic hard disk. A typical hard disk has a very large capacity and can store billions of bytes (1 byte is equivalent to the memory required to store a single letter such as 'A').

(a) Top view of a disk *(b) Inside view of a harddisk*

Figure 3.26: *View of a disk*

Activity 3.4

Use the internet to find out different types of hard disks.

Question

Discuss the advantages and disadvantages of the type of hard disks.

Flash memory

Flash Memory (FMs) is a type of data storage device that uses NAND-based flash memory to store and retrieve data electronically. FMs have become increasingly popular in recent years as they offer several advantages over traditional Hard Disk Drives (HDDs). FMs have found widespread use in various applications, including personal computers, laptops, servers, gaming consoles, and even smartphones. They are particularly popular for improving computers overall performance and responsiveness and are often used in combination with HDDs or as standalone storage devices.

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FMs tend to be more expensive on a per-gigabyte basis compared to HDD's. However, as technology advances and economies of scale come into play, FMs prices gradually decreased, making them a more affordable option for consumers and businesses. Examples of FMs are Solid State Disc (SDD's), USB flash drives, and memory cards.

Solid State Disc

The Solid-State Disc (SSD) has no moving parts. They are differ from HDDs, which have spinning disks and read/write heads. Since there are no moving parts, access times are faster, power consumption is lower, and durability is higher. SSDs are substantially faster than regular hard drives. They provide faster data read and write speeds. This results in faster boot times, quicker application loading, and increased system performance. SSDs outperform HDDs in terms of reliability. Since there are no moving parts, there is less wear and tear, lowering the possibility of mechanical failure. SSDs are also more resistant to physical shock and vibration. Figure 3.27 shows the SSD and HDD.

(a) *SSD* (b) *Magnetic HDD*

Figure 3.27: *SSD and magnetic HDD*

USB flash drive

USB flash drives are also known as memory sticks. They are small, portable, durable, reliable, removable, and rewritable devices plugged into a computer's USB port. These are commonly used for storage, data backup, and transferring files between

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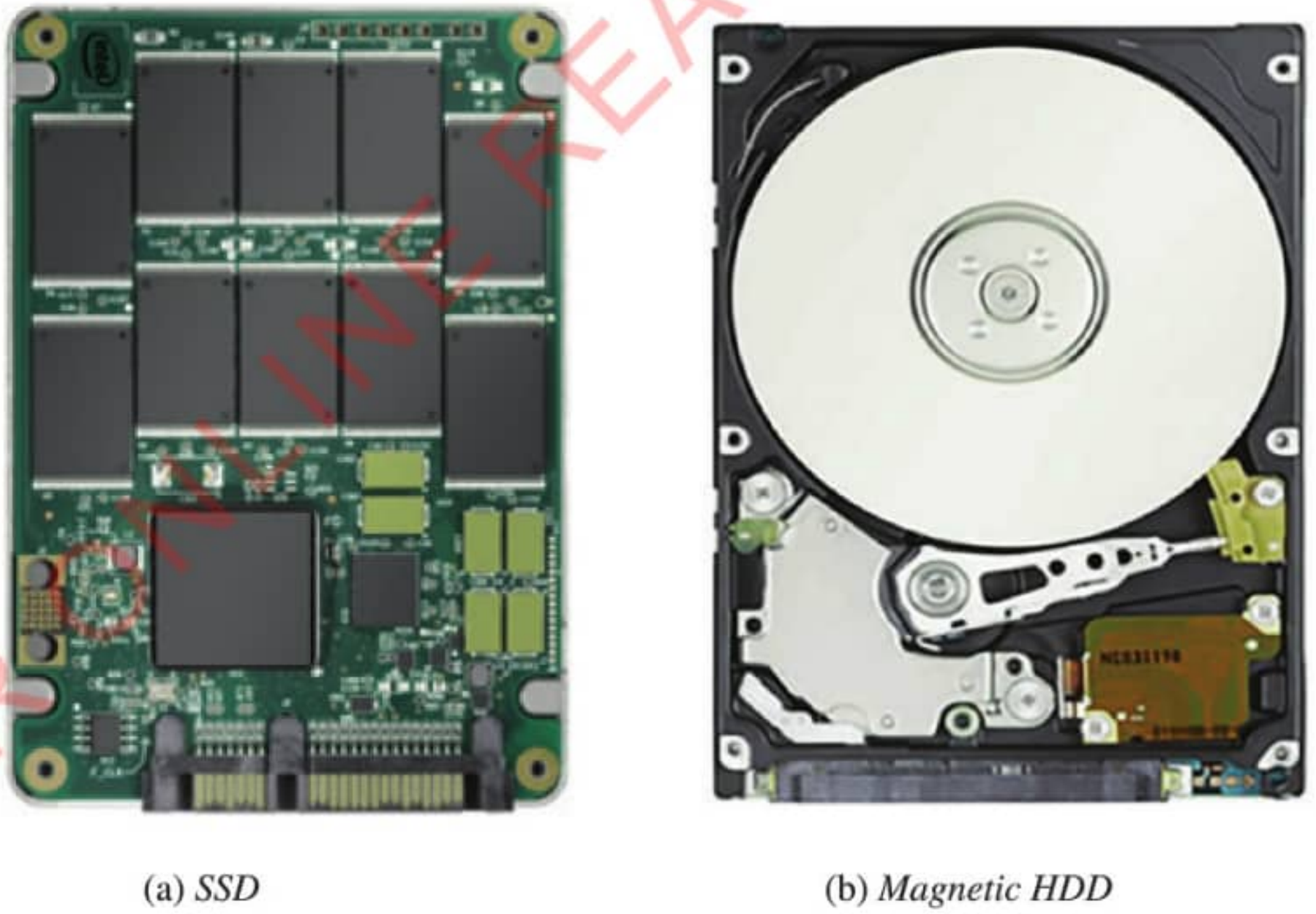


(a) *SSD* (b) *Magnetic HDD*

Figure 3.27: *SSD and magnetic HDD*

USB flash drive

USB flash drives are also known as memory sticks. They are small, portable, durable, reliable, removable, and rewritable devices plugged into a computer's USB port. These are commonly used for storage, data backup, and transferring files between

devices. USB flash drives have proved to be the best rewritable storage media among the public due to the common availability of USB ports built into most models of personal computers. Figure 3.28 (a) and (b) shows the inside and outside of USB flash disk.

(a) *Inside view of USB flash disk*

(b) *Top view of USB flash disk*

Figure 3.28: USB flash disk

Memory cards

Memory cards are used in many electronic devices, including digital cameras, mobile phones, laptops, MP3 players, and video game consoles. They are small, re-recordable, and able to retain data without power. Figure 3.29 shows some examples of memory cards. Memory cards are like flash disks in terms of speed and reliability, except they are much smaller.

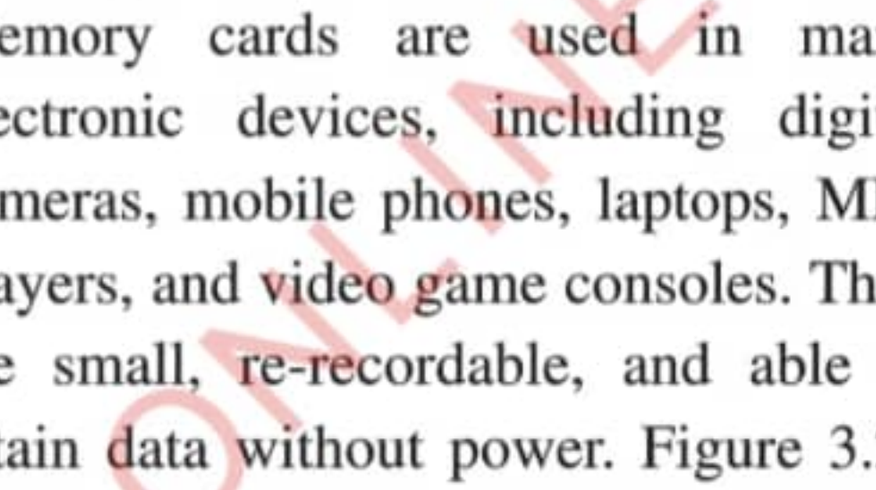


Figure 3.29: *Sample of a memory card*

Optical discs

Optical discs are storage media that use lasers to read and write data. The most common types of optical discs are CDs (Compact Discs), DVDs (Digital Versatile Discs), and Blu-ray discs. Optical drives are commonly found in desktop and laptop computers. They are also found in some gaming consoles and home entertainment systems.

Compact Disc

A Compact Disc (CD) (see Figure 3.30) is a type of optical disc that is smaller than a hard disc. It uses laser beam technology to read and write data. CD drives can store 650 - 700 MB of data on one side of a CD. There are three basic types of CD: CD-ROM, CD-R, and CD-RW:

(i) Compact Disc- Read Only Memory (CD-ROM) is like a commercial music CD. Read-only means the user cannot write or erase its content,

(ii) CD-R (CD-Recordable) can be written only once and read many times but cannot be rewritten or erased,

(iii) Compact Disc-Re-Writable (CDRW) can be rewritten or erased multiple times.

Figure 3.30: *Compact Disc*

Digital Versatile Disc (DVD) and BLU RAY

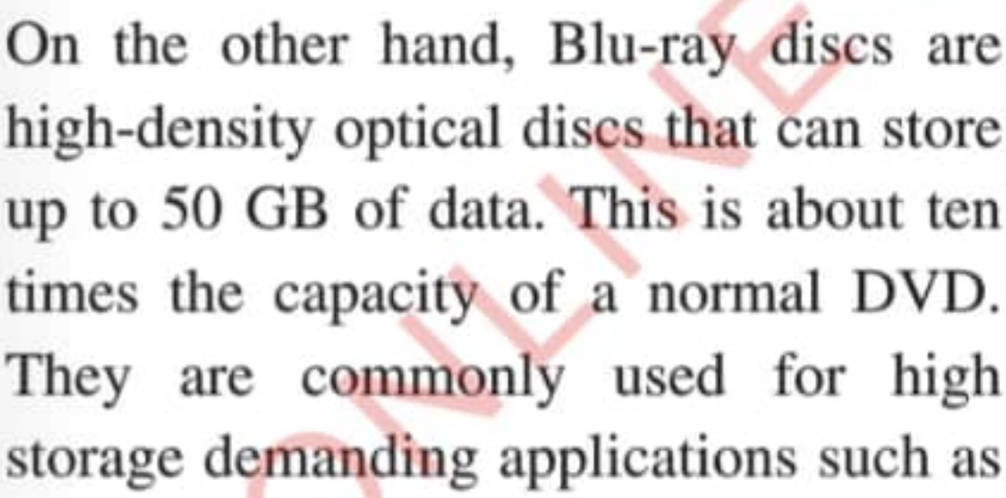
DVDs use a laser beam to read and write data. They are very similar to CDs except that more data can be packed into the same amount of space. A DVD drive can store 4.7 GB of data on one side. Furthermore, some DVDs are dual-sided and can store data on both sides. Some have dual layers, storing 9.4 GB and 8.5 GB of data, respectively. There are three basic types of DVDs:

(i) Digital Versatile Disc-Read Only Memory (DVD-ROM),

(ii) Digital Versatile Disc-Read Recordable (DVD-R),

(iii) Digital Versatile Disc-Read Rewritable (DVD-RW).

On the other hand, Blu-ray discs are high-density optical discs that can store up to 50 GB of data. This is about ten times the capacity of a normal DVD. They are commonly used for high storage demanding applications such as games. Figure 3.31 shows an example of the appearance of DVD and BLU-RAY discs.



DVD *BLUE-RAY*

Figure 3.31: *Example of DVD and BLU-RAY discs*

Exercise 3.3

1. Explain the differences between primary storage and secondary storage (auxiliary storage) in a computer.
2. Outline examples of common auxiliary storage devices and discuss their respective advantages and disadvantages.
3. Describe the purpose and operation of cache memory in a computer.
4. What is the difference between volatile and non-volatile memory in a computer system?
5. What are the advantages and disadvantages of using solid-state drives (SSDs) compared to hard disk drives (HDDs) for data storage?
6. What is the importance of registers in computer processing?
7. Differentiate between RAM and ROM and explain their importance in computer systems.

Output devices

After data have been processed, results should be presented to users for consumption. The devices responsible for presenting results to the user are called output devices. Therefore, output devices can be defined as peripheral devices that the computer uses to give out information after processing data. Some of the most common output

devices include monitors, projectors, plotters, and printers.

Monitors

A monitor, also known as the Visual Display Unit (VDU) or the screen, is used to display information in the form of text, pictures, or video. The monitor forms images using tiny dots, called pixels, which are arranged in a rectangular form. The sharpness of the image depends on the number of pixels per inch in the monitor and the size of the pixels. The smaller the pixels, the better the image clarity or resolution. It takes more than one million illuminated pixels to form the whole character, such as the letters in the word "help". A finite number of characters can be displayed on the screen at once. The screen can be divided into a series of character boxes, a fixed location on the screen where a standard character can be placed. Monitors are classified into two types based on display technology: Cathode Ray Tube (CRT) and Liquid Crystal Display (LCD).

Cathode Ray Tube monitors

CRT monitors produce an image using an electron beam produced by the cathode ray tube. They are characterised by their small size, weight, and high, power consumption. These monitors use the same technology as old TVs and have become rare these days. Figure 3.32 shows an example of a CRT monitor.

Figure 3.32: *CRT monitor*

Liquid Crystal Display

LCD is a widely used electronic display device that operates by applying a varying electric voltage to a layer of liquid crystal, thereby inducing changes in its optical properties. LCD screens have replaced CRT displays in most applications due to several advantages:

(i) LCDs are lighter and more compact, making them suitable for portable devices like smartphones, digital cameras, and laptops.

(ii) LCDs consume less power, making them more energy-efficient than CRT displays.

(iii) LCDs do not suffer from image burn-in, a common issue with CRT displays, where a static image displayed for a long time can cause permanent damage.

LCD displays are the most common type of display you will find today. The main drawback of these monitors is that they

are very expensive. Figure 3.33 shows examples of flat-panel LCD displays.

Figure 3.33: *LCD monitor display*

Image projectors

Image projectors are used to display output from a computer onto a plain white screen such as a wall or whiteboard. It is a creative way of presenting computer output to an audience. This technology has almost replaced the traditional overhead projector. An overhead projector is used to project enlarged images printed on transparent materials onto a wall or screen using an overhead mirror. Figure 3.34 shows an example of a projector.

Figure 3.34: *Front and back view of a projector*

Printers

A printer is an output device that produces text and graphics on a physical medium such as paper. Printed information is often called a hard copy because the information exists physically. The output from the printer is more permanent than that presented on a monitor. Printers can be grouped into impact and non-impact printers.

Impact printer

An impact printer creates letters and images on a piece of paper using a striking device that hits an ink ribbon. Then, the ink ribbon makes direct contact with the printing surface, like paper. Examples of impact printers are dot matrix and daisy wheel printers. Figure 3.35 shows an example of an impact printer.

Figure 3.35: *Impact printer*

Advantages of impact printers

The advantages of impact printers are:

(i) This printer can manage printing work in tough conditions, like

industrial workplaces and point-of-sale (POS). Normally, such places can have a lot of dust and big challenges in temperature.

(ii) It is useful for businesses that need extra copies of documents to keep records or give receipts to customers.

(iii) Usually, it uses ribbons and paper that are cheaper than the toner or ink cartridges in regular printers. This can mean lower running expenses, especially for businesses that do a lot of printing.

(iv) These printers are less likely to experience specific problems that can trouble non-impact printers, like blockages in the printhead or ink cartridges drying up. This makes them a dependable option for continuous printing.

(v) It is commonly used where noise is not a problem, like on factory floors or warehouses.

Disadvantages of impact printers

Impact printers have several disadvantages compared to modern non-impact printers. The disadvantages of an impact printer are:

(i) They are relatively noisy when they operate.

(ii) They are relatively slow, making them less suitable for high-volume printing tasks.

(iii) They produce lower print quality compared to non-impact printers.

(iv) They can only print in black or one additional colour. This reason makes them unsuitable for tasks that need full-colour printing.

(v) They require regular maintenance compared to non-impact printers. Cleaning and replacing consumables like ribbons and print heads are necessary to maintain print quality and prevent paper jams.

Non-impact printers

A non-impact printer forms characters and graphics on print media without striking the paper. Examples of non-impact printers are inkjet, thermal, and laser printers. Figure 3.36 shows an example of a non-impact printer.

Figure 3.36: *Non-impact printer*

Advantages of non-impact printer

The advantages of non-impact printers are:

(i) They produce high-quality text and graphics with sharp and clear details.

(ii) They are much faster than impact printers.

(iii) They can produce full-colour prints, making them versatile for various applications. Those applications include marketing materials, photographs, and creative projects.

(iv) They often handle a variety of media types, including standard paper, envelopes, labels, glossy photo paper, and more. This flexibility is valuable for different printing needs.

(v) They are easy to use, with user-friendly interfaces. They often come with software that simplifies the printing process, such as automatic duplex printing and wireless printing capabilities.

(vi) It requires less maintenance compared to impact printers. They don't have components that wear out quickly, like print heads in impact printers, and they are less prone to jams.

Disadvantages of non-impact printers

(i) They require more expensive consumables compared to impact printers.

(ii) Their maintenance or repairs are more costly. For instance, replacing a malfunctioning laser printer drum or printhead can be expensive.

(iii) Inkjet printers can suffer from print head clogs if they are not used regularly.

(iv) Laser printers can have a longer warm-up time compared to impact printers.

(v) They print colourful pictures, but sometimes the colours may not be perfect.

Plotters

A plotter is a large type of hard copy output device. It is mostly used for printing geographical, architectural, and engineering drawings. Examples of printouts of plotters include maps and advertisement posters to be placed on billboards. Plotter uses mechanical pens or inkjet nozzles to precisely place ink on the paper, resulting in sharp and clear output. It is designed to be robust and can operate continuously for extended periods without overheating or causing print quality issues. This versatility allows for a wide range of applications, from technical drawings to signage and banners. Figure 3.37 shows an example of a plotter.

Figure 3.37: *Plotter*

Advantages plotters

(i) They have high precision and accuracy in producing detailed and intricate designs.

(ii) They are capable of printing on large paper sizes, making them ideal for producing architectural blueprints, engineering drawings, and other large-scale designs.

(iii) They can work with various media types, including different types of paper, vinyl, fabric, and even certain types of wood.

(iv) They can endure heavy use and can handle large print volumes of work.

Disadvantages plotters

(i) They are more expensive compared to regular printers.

(ii) They are larger and bulkier than regular printers. Hence, they require a dedicated space to accommodate their size. Therefore, they are not suitable for small or cramped workspaces.

(iii) They are relatively slower in printing speeds compared to regular printers.

(iv) Many are limited to monochrome or grayscale output. If colour printing is a requirement, it is important to ensure that the chosen plotter model supports the desired colour capabilities.

Speakers

Speakers are devices attached to a computer to give out sound. Most laptop computers and some desktop computer monitors have built-in speakers. Other computers come with separate wired or wireless speakers. Figure 3.38 shows speakers.

Figure 3.38: *Speakers*

Exercise 3.4

1. What is the primary function of an output device in a computer system? Provide examples of commonly used output devices.
2. What are the advantages of LCD screens over CRT displays?

3. Explain the difference between a plotter and a printer as output devices. What are the key characteristics and typical uses of each?
4. What is the role of speakers as output devices in a computer system?

Chapter Summary

Computer hardware is an important component of modern computing systems. Computer hardware refers to the physical components of a computer system. It includes the tangible parts that you can see and touch. Hardware is subdivided into input, output, processing, storage, and devices. Input devices, such as mice and keyboards, are used to send data to the computer for processing. Output devices are used to present the processing results to the user. To work properly, input devices need special software to be installed on the computer. This software is known as a device driver.

Processing is done by the central processing unit (CPU), which consists of two main parts, namely, the control unit (CU) and the arithmetic logic unit (ALU). The CU controls the overall functioning of the computer, including memory access and instruction fetching and decoding.

The ALU is responsible for performing arithmetic and logic operations. Computer memory consists of primary and secondary memory. Forms of primary memory include random access memory (RAM), registers, and cache memory. Secondary memory is characterised by higher capacity, slower access speed, and non-volatility. Secondary storage comes in many forms, including magnetic discs, flash discs, and optical discs. Primary memory has a relatively low capacity but higher access speed than secondary memory.

Registers and cache memory are located inside the CPU. Common units for denoting the storage capacity of computer memory are megabytes (MB), gigabytes (GB), and terabyte (TB). The role of input devices is to input data into the computer, while the output devices are used to present processed data to the user.

Revision exercise 3

1. Explain the differences between primary and secondary storage devices.
2. What is the importance of an output device?
3. What is the role of speakers as output devices in a computer system compared to printers?
4. What are some common uses of a joystick in computer systems?
5. What are some advantages and disadvantages of using a touch screen as an input device?

Computer software

Introduction

The intermediary connecting users and hardware is called software. The software enables computers to perform diverse tasks and plays a central role in our daily lives. The development and evolution of software continue to shape technology and society. In this chapter, you will learn the concept of computer software. The competencies developed will enable you to deepen your understanding of computers.

Think

Computer hardware without software

Concept of computer software

Computer software refers to a set of programs (instructions) and data that tell a computer how to perform specific tasks or functions. These programs and data are intangible and exist as digital information stored on various types of media or in the computer's memory.

Importance of computer software

Computer software plays an essential role in today's world, and its importance can be understood from various perspectives:

(i) It automates tasks, making them faster and more efficient. This helps streamline business operations, reducing human error and increasing productivity.

(ii) It can be easily updated and modified, allowing businesses and individuals to adapt to changing requirements and technological advancements.

(iii) Well-designed software can guide computers to perform tasks at all time without needing breaks or benefits, resulting in significant cost savings over time. Hence,

it can replace manual labour and reduce operational costs.

(iv) Guide hardware to analyse large volumes of data quickly and accurately, providing valuable insights for informed decision-making.

(v) Guide hardware to facilitate people and organisations to connect and collaborate across geographical boundaries.

(vi) Guides innovation by providing a platform for the development of new products and services.

Types of computer software

Computer software can be classified into two types: system software and application software.

System software

System software is the software that provides the basic functions to operate a computer. The software guides basic hardware on how they should interact. System software provides services directly to the user or some other software. Examples of system software include operating systems, system utilities, and device drivers.

Operating systems

An operating system (OS) is software that manages all other application programs in a computer. It is a collection of programs that coordinate the functionality of hardware and application software in a computer system. It also acts as an interface between the user and the computer hardware. The OS controls the execution of programs and manages computer resources. Generally, an OS is the most basic system software. Every computer system must have an OS to run other programs and manage computer hardware. Some popular PC operating systems are Windows, Linux, UNIX, and Macintosh (Mac).

Functions of an operating system

Generally, the functions of an operating system are as follows:

Process management: During the operation of a computer system, different tasks can run at the same time. The operating system is responsible for starting, stopping, and allocating resources to running processes. A person may perform several tasks simultaneously, such as listening to music while working on a document. An OS that allows performing multiple tasks at once is called a multitasking OS. It is the operating system that manages these processes to get multiple tasks running at the same time.

Memory management: The operating system manages computer memory resources. It allows each process to run in its own isolated memory space without interference from other processes. When a process terminates, the OS reclaims

the memory that was allocated to that process.

File management: File management involves controlling the creation, updating, deleting, and protecting files from unauthorised users. Data and programs are stored as files in the secondary storage of a computer system, and the operating system manages both.

Hardware management: The operating system interacts with devices through device drivers and other related software for a particular device. The operating system is the intermediary between programs and hardware. This means that for a program to access a particular device, it must request the OS. The OS fulfills this request by interacting with the device's driver. The OS also provides options for configuring devices so that an application may use it. Just like files, devices must be secured, and multiple requests to access them must be coordinated. The OS performs all these tasks.

Interrupt management: OS ensures all activities do not overlap to overwhelm the computer and cause it to stop working. Sometimes, both input and output devices need to use computer resources. Therefore, they interrupt the CPU so that it can allocate resources to them.

Error handling: The operating system constantly controls and monitors the computer system to detect errors and, avoid faults in the computer system.

Security management: Several measures can be used to protect the computer system from threats, such as viruses and unauthorised access to computer resources. One of the common security measures is to use passwords to prevent unauthorised access to the computer. This is done and monitored by the OS.

Categories of operating systems

There are four categories of OS: single-user, multi-user, single-user and single task, single-user and multi tasking operating systems.

Single-user operating systems

Single-user operating systems provide single-user access to a computer system at a time. If another user needs access to the computer system, that user must wait for the current user to exit. Most recent personal computer (PC) OS support multiple users. Two examples of single-user operating systems are Microsoft Disk Operating System (MS-DOS) and Microsoft Windows 95. However, both have been discontinued.

Multi-user operating systems

Multi-user operating systems allow more than one user to access the computer system at once. Access to the

computer system is normally provided via a network so that users access the computer remotely using a terminal or another computer. Today, these terminals are generally personal computers that use a network to send and receive information to multi-user computer systems. The dvantages of multi-user OS include allowing many users to share resources such as hardware and software, which are normally expensive. This means the cost is divided amongst the users. Multi-user operating systems, however, come with several drawbacks, including decreased performance. They have a higher software cost compared to single-user OS software. Also, they have a greater requirement for processing, RAM, and disk space. Examples of multi-user operating systems are UNIX, Virtual Memory System (VMS), and Windows servers.

Single-user, single-task OS

This type of OS allows one user to do one thing at a time. An example of a single-user, single-task operating system is the one used by personal digital assistants (PDAs). PDAs are also known as handheld computers.

Single-user, multi-tasking OS

This type of OS allows a single user to run multiple applications on the computer simultaneously. This type of operating system is found on most personal computers. Some versions of Microsoft Windows are single-user, and multi-tasking operating systems.

Operating system platforms

There are four commonly used operating system platforms: Windows, UNIX, Macintosh (Mac), and Linux.

Windows Operating Systems

The Windows family of operating systems was developed by Microsoft Corporation to run on personal computers, servers, smartphones, and embedded devices. It is the most widely used operating system in the world. Windows OS provides a Graphical User Interface (GUI), virtual memory management, multitasking, and support for many peripheral devices. The development of Windows OSs has gone through different versions and will keep changing as the technology advances. The versions of Windows OSs from the early 1990s are shown in Table 4.1

Table 4.1: *Evolution of Windows OS*

S/n	Windows version	Year of release
1	Windows NT family	1993
2	Windows 95	1995
3	Windows 98	1998
4	Windows ME	2000
5	Windows 2000	2000
6	Windows Server 2000	2000
7	Windows XP	2001
8	Windows Server 2003	2003
9	Windows Vista	2007

S/n	Windows version	Year of release
10	Windows Server 2008	2008
11	Windows 7	2009
12	Windows Server 2012	2012
13	Windows 8	2012
14	Windows 10	2015
15	Windows 11	2021

Macintosh operating system (MacOS)

The Macintosh Operating System (MacOS) has developed by Apple Inc. The MacOS runs only on Apple computers. MacOS is mostly preferred for graphical design. Table 4.2 shows the evolution of MacOS.

Table 4.2: *Evolution of MacOS versions*

S/n	Mac OS version	Years of released
1	Mac OS X 10.6	2009
2	OS X 10.7	2011
3	OS X 10.8	2012
4	OS X 10.9	2013
5	OS X 10.10	2014
6	OS X 10.11	2015
7	MacOS 10.12	2016
8	MacOS 10.13	2017
9	MacOS 11.14	2018
10	MacOS 11.15	2019
11	MacOS 11	2020
12	MacOS 12	2021
13	MacOS 13	2022
14	MacOS 14	2023

Linux operating system

The Linux OS is a free and open-source operating system. It is mostly used through a command line by advanced users. In addition, it provides a graphical Windows-like interface. The Linux OS runs on most PCs from popular PC manufacturers. Linux has many distributions or flavours. Commonly used Linux distributions include Ubuntu, Linux Mint, Fedora, Red Hat, and OpenSUSE.

UNIX operating system

Unix is an operating system that originated in the late 1960s at AT and T's Bell Labs. It is known for its design simplicity, modularity, and powerful command-line interface. Unix has been a foundational operating system and has significantly influenced the development of various modern operating systems, such as Linux, MacOS, and various Berkeley Software Distribution variants. Its influence on the development of other operating systems continues to be felt in modern computing environments, particularly in server infrastructures and high-performance computing clusters.

Managing files and folders

A folder is a container in which many files can be placed into groups and organised on the computer. A file is a collection of data stored in one unit identified by name. It can be a document, picture, audio, video, application, or

other collection of data. There are different types of files, including data files, program files, and system files. In the Windows OS, each file has an extension which is added to the end of the file name to help identify its type. A standard file extension following the names of files (.) can indicate whether a particular file is a system, program, or data. The period separates the extension from the filename itself. The most common file extensions include:

(a) .txt: a plain text file;

(b) .doc/docx: data file created in MS Word;

(c) .xls/xlsx: data file created in MS Excel;

(d) .ppt/pptx: data file created in MS PowerPoint;

(e) .jpg, .jpeg, .gif, .bmp, .png, .tif: images in various formats, and

(f) .pdf: Portable Document File.

The next sections describe how to create folders and files, and other operations we can do on them.

Creating a file

To create a file, you will need to follow these steps:

(i) Open the software program that you want to use to create the file. This could be a word processor, such as Microsoft Word or Google Docs, a spreadsheet program, such as Microsoft Excel or Google Sheets, or a presentation program, such as Microsoft PowerPoint or Google Slides.

(ii) Click on the **File** menu and select **New**.

(iii) Choose the type of file that you want to create. For example, if you want to create a Word document, you will select **Blank Document**, as shown in Figure 4.1.

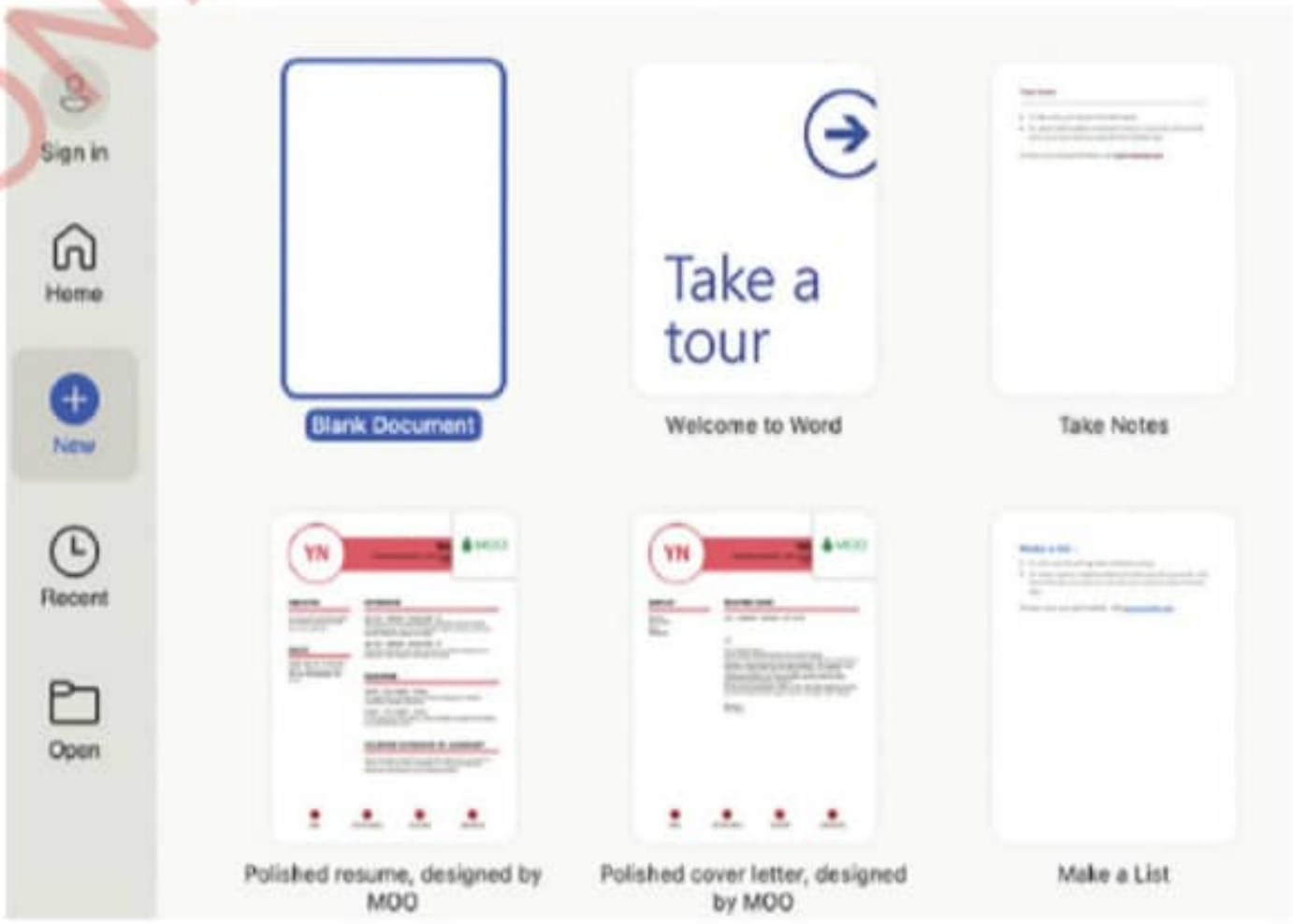


Figure 4.1: *Choosing file type*

(iv) A new file will open. You can now start adding content to your file.
(v) When finished, click the File menu.
(vi) Click **Save as** icon.
(vii) Choose a location to save your file and enter a filename.
(viii) Click on the **Save** button.

Your file will now be saved. You can open it again at any time by double-clicking on the filename.

Create a folder

To **create a folder**, follow these steps:

(i) Open the location where you want to create the folder. This could be on your desktop, or in a document library.
(ii) Right-click an empty area and select New.
(iii) Follow the arrow under the new command.

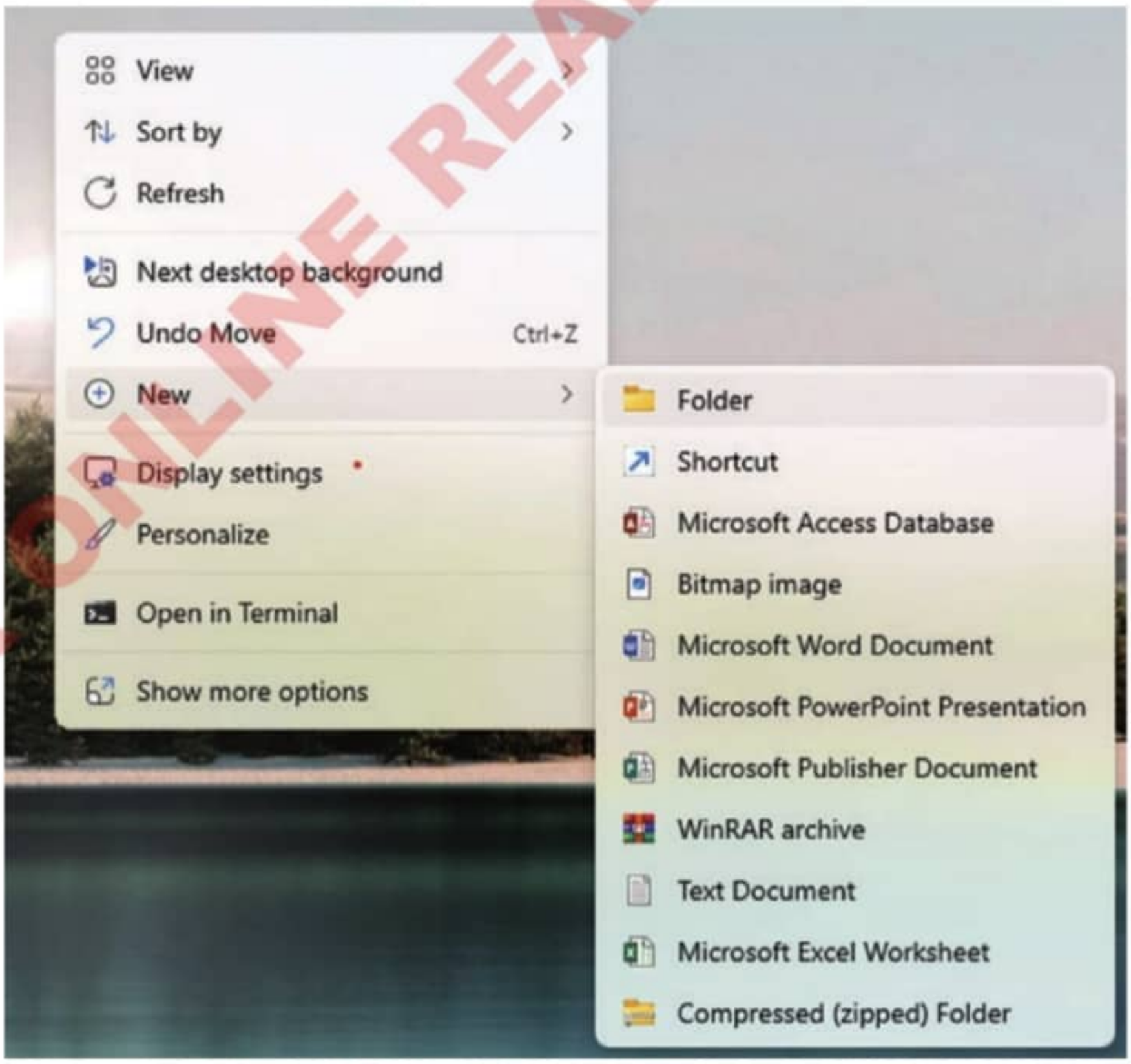


Figure 4.2: *Submenu for the folder create command*

(iv) Click **Folder** from the submenu, as shown in Figure 4.2

(v) Type a name in the specified area (see Figure 4.3) for the folder and press Enter.

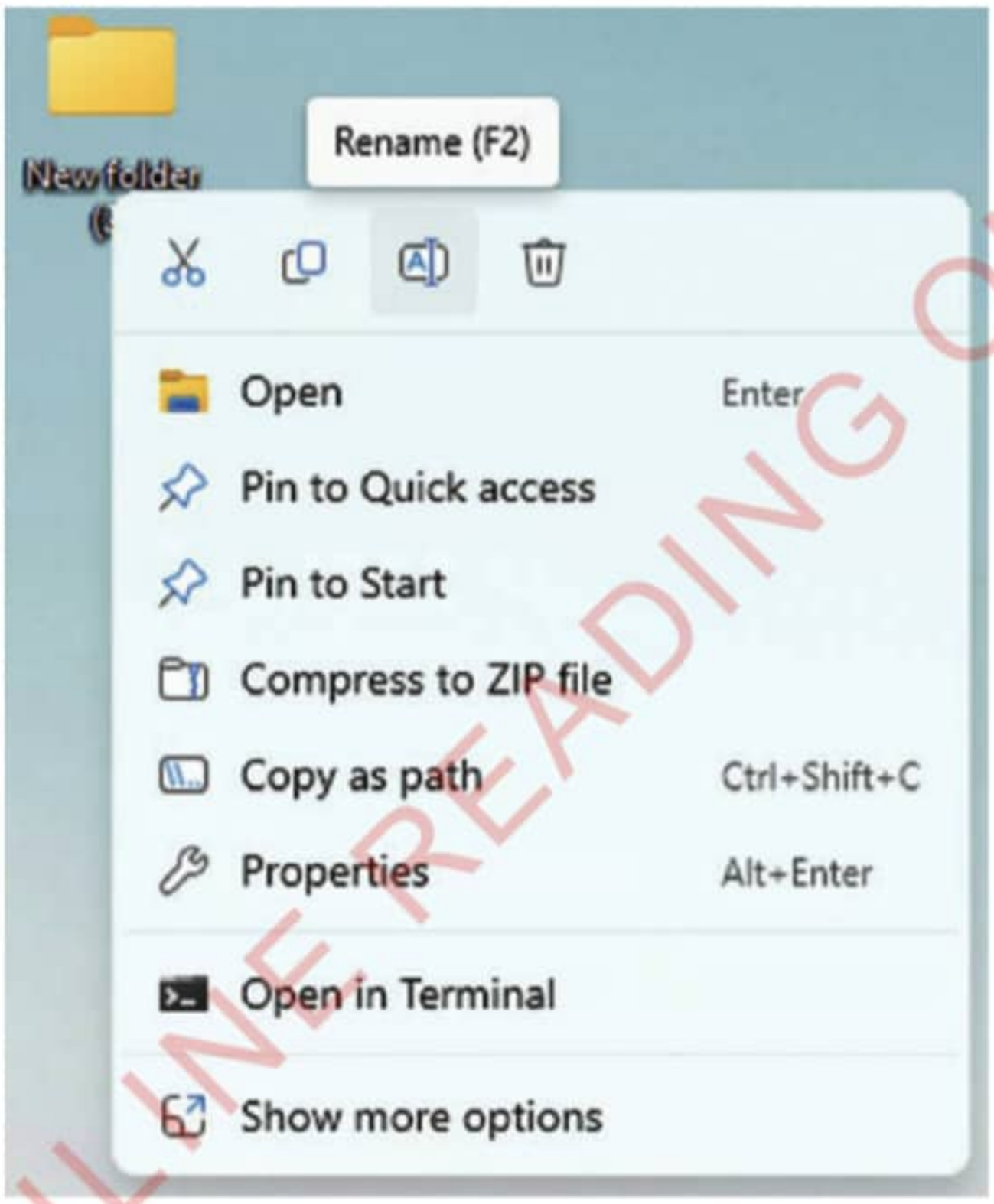


Figure 4.3: *Typing the name of a new folder*

(vi) The new folder will be created. You can now add files and folders to the new folder.

Delete a file or folder

To **delete a file or folder**, follow these steps:

(i) Locate the file or folder that you want to delete,

(ii) Right-click on the file or folder, a menu appears,

(iii) Click on the **Delete** icon (see Figure 4.4),

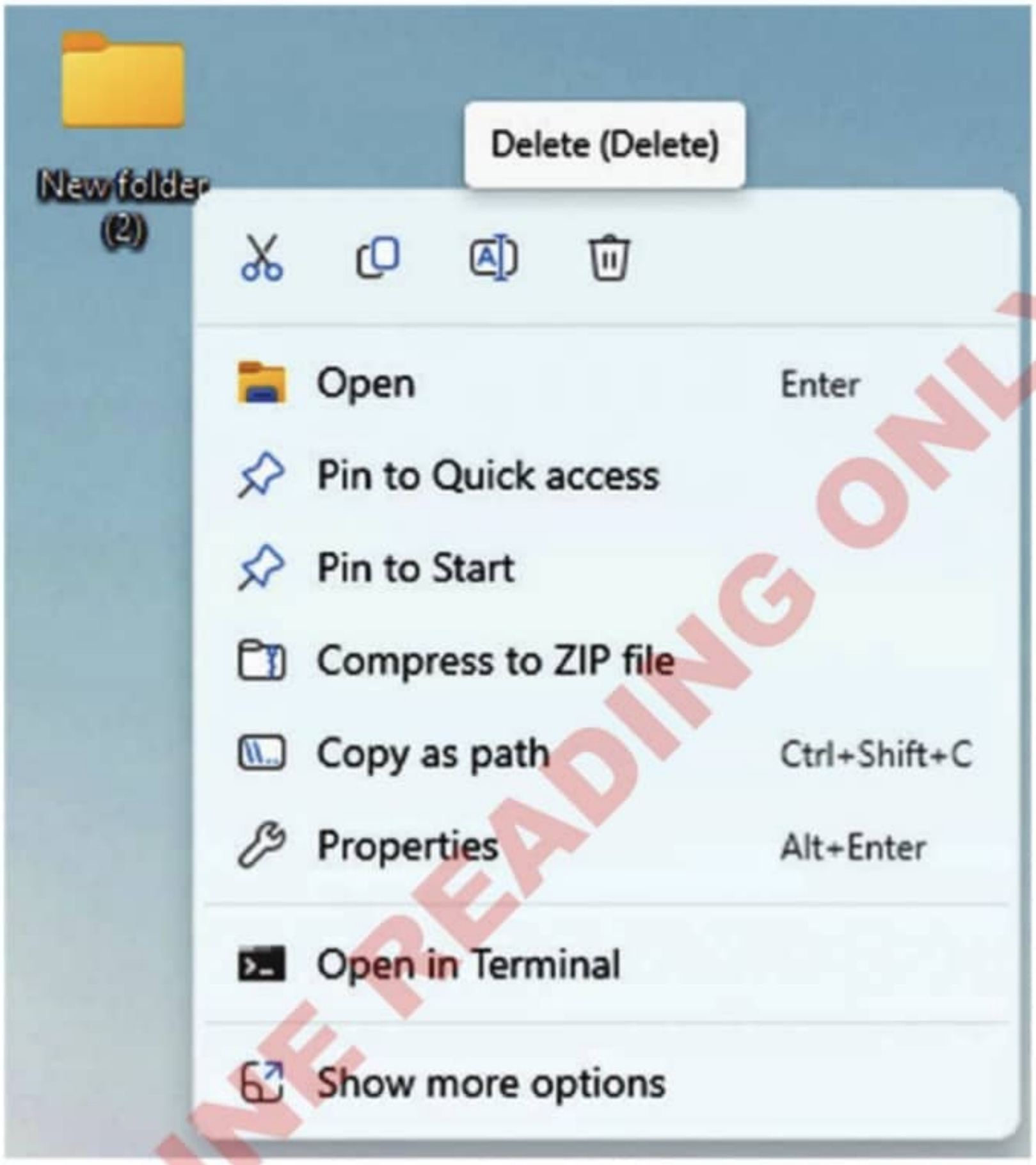


Figure 4.4: *Submenu for deleting a file*

(iv) If prompted, click **Yes** to confirm that you want to delete the file or folder.

Note: The file or folder will be moved to the Recycle Bin. You can empty the Recycle Bin to delete the file or folder permanently.

Restore deleted folders and files

Deleted folders and files are put in a special place in secondary storage called the recycle bin. Once needed again, they can be restored to their original location. To restore a deleted folder or file, use the following steps:

(i) Open the Recycle Bin (see Figure 4.5). You can find the Recycle Bin icon on your desktop. If you cannot find it, you can search for it in the Start menu.

Figure 4.5: *Example of recycle bin* **icon**

(ii) Locate the deleted folders or files that you want to restore. You can browse the Recycle Bin window to find the deleted folders or files you want to restore.

(iii) Select the deleted folders or files and select "Restore the selected items."

(iv) The deleted folders or files will be restored to their original location once you have clicked "Restore". You can then open and use them as usual.

Note:

1. If you are restoring multiple folders or files, you can select them all and then right-click and select **Restore**.
2. If you want to restore a folder to a different location, you can right-click on the folder and select **Restore to**.
3. You cannot delete files or folders that are currently in use. You must close all programs that are using the file or folder before you can delete it.

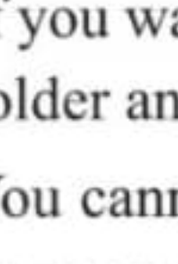
Activity 4.1

Create the following files and folders on your desktop:

(i) My_document.docx

(ii) My_presentation.pptx

(iii) My_folder



Questions

1. Rename the file "my_document.docx" to "my_renamed_document.docx"
2. Copy the file 'my_presentation.pptx' to the folder "my_folder"
3. Paste the file "my_renamed_document.docx" to the folder "my_folder"
4. Delete the file "my_renamed_document.docx" from the folder "my_folder".

System Utilities

System utilities are software used to maintain and configure of the computer system. Some system utilities are shipped with the operating system and can offer basic functionalities. These include, for example, defragmentation tools, disk formatting utilities, and system restore utilities. Another set of utilities are third-part utilities, which are not shipped with the operating system but are used to improve the performance of the system. Examples and uses of some utility programs are shown in Table 4.3.

Table 4.3: *Examples of types of utility programs and their uses*

Type of utility	Functions
Disk cleaner	Clean or remove unnecessary files from a hard disk
Disk defragmenter	Remove fragments from hard disk volumes so that the computer runs faster and more efficiently.
Backup	Archive data to protect it from accidental loss, for example, in case a hard disk drive fails
Data recovery	Recover a file or information that has been deleted.
Anti-viruses	Protect or recover programs and data against viruses and remove viruses from a computer .
Data compression	Reduce the size of data to save storage and transportation space (bandwidth)

Device drivers

Device drivers are software that allows a specific device to communicate with the computer's operating system. Devices that need drivers are those whose features are not familiar to the operating system. For example, a printer, a scanner, a mouse, a keyboard, a USB device, a network card, and a sound card all need drives when connected to a computer for the first time.

Application software is software that handles a specific user task, such as writing a report. Some examples of application software are word processors, spreadsheets, databases, presentation software, and web browsers.

Word processors

Word processing is simply computerised typewriting. A word processor allows you to quickly create, format, and edit text. The software also helps in correcting mistakes before printing. There are many word processors, but the most popular are Microsoft Word and Open Office Writer. Figure 4.6 shows an example of document editing in MS Word.

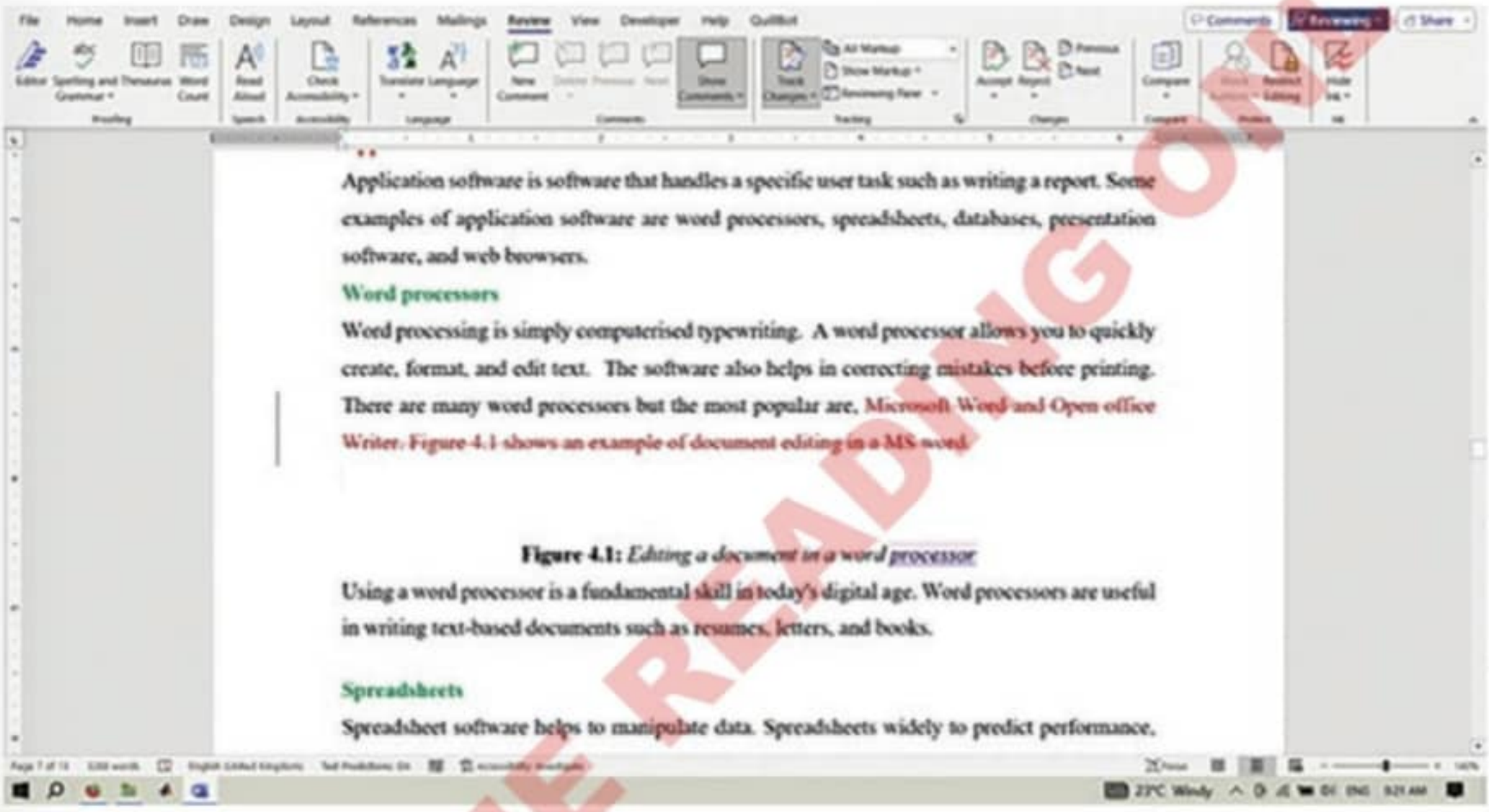


Figure 4.6: *Editing a document in a word processor*

Using a word processor is a fundamental skill in today's digital age. Word processors are useful in writing text-based documents, such as assignments, resumes, letters, and books.

Spreadsheets

Spreadsheet software helps to manipulate data, and it is widely used to predict performance, compute tax, prepare payroll, generate charts, and compute revenue in businesses. In schools, spreadsheets can help in lesson preparation and performing administrative work, such as preparing the school budget, calendar, attendance register, and analysing examination results. The most popular spreadsheet software are Open Office Calc and Microsoft Excel. Figure 4.7 shows an example of data being manipulated in a spreadsheet.

	A	B	C	D	E	F	G	H	I	J	K	L
1	KAKAKUONA SECONDARY SCHOOL											
2	STUDENTS RESULTS											
3	S/N	NAME	SEX	BOX	TOWN	MATHS	KISWAHILI	ENGLISH	TOTAL	AVERAGE	POSITION	REMARKS
4	1	JOHN JOHN JOHN	M	124	IRINGA	91	84	72	247	82	1	
5	2	VITUS VITUS VITUS	M	203	TUNDUMA	78	70	65	213	71	5	
6	3	MARIA MARIA MARIA	F	22	SONGEA	23	76	67	166	55	10	
7	4	ALVIN VITUS MBUGITA	M	100	MROROGORO	68	90	70	228	76	2	
8	5	RAHMA AMANI NTIBANSIGA	F	3452	KASULU	52	50	30	132	44	12	
9	6	MAOMBI CHAP CHAP	F	665	MPANDA	54	80	65	199	66	7	
10	7	NITUME MIMI BWANA	F	76	KAHAMA	59	76	67	202	67	6	
11	8	ASANTE TAUSIA MENYORI	F	34	BUCHOSA	16	86	92	194	65	8	
12	9	JUMA ALEX MBWANI	M	120	ARUSHA	67	43	23	133	44	11	
13	10	ANETH JOHN BUKEZA	F	3851	DAM	56	78	60	194	65	8	
14	11	JULITHA TITUS MWAULAMBO	F	45	DSM	76	56	87	219	73	4	
15	12	SAULOME KANDONGA NJUU	F	53	NKANKA	67	76	80	223	74	3	

Figure 4.7: *Data manipulation in a spreadsheet*

All electronic spreadsheet programs have some common features, including the following:

(i) Ability to perform automatic re-calculation of values when changes of value occur in related cells.

(ii) Ability to allow a user to work on multiple worksheets simultaneously.

(iii) Availability of different functions, such as statistical function, which simplify calculation tasks.

Presentation software

Presentation software is used to create and deliver, electronic presentations. A presentation created using presentation software consists of units called slides. Like a page in word processing software, slides are frames used to hold the content of your presentation, which can include text and graphics. A series of slides arranged according to the logical flow of a presentation form an electronic presentation. Each slide in a presentation may contain different combinations of text and graphics. Figure 4.8 shows an example of slide presentation software.

Figure 4.8: *Slides in a presentation software*

When delivering a presentation, a multimedia projector or any other projection media can be used to display slides to the audience. There are various existing presentation software options. Common ones include Microsoft PowerPoint, Apache OpenOffice Impress, and Google Slides.

Database management systems

Database management systems are software that helps in organise and store data so that it can be easily retrieved and updated. It is hard to find an enterprise software solution or a website on the Internet that does not use a database for data storage. The most popular database management systems are Microsoft Access, Microsoft SQL Server, Oracle, and MySQL.

Software installation

Software installation refers to the process of setting up and configuring a software program on a computer or computing device to make it available for use. For a new application or software to be used on a computer, it needs to be installed before running and utilising its features. Before installing of any software, you should understand the purpose and process of installation. Be familiar with the process of uninstallation, automatic updates, and OS compatibility.

(i) *Purpose of software installation:* It is necessary because computer programs are typically distributed in a compact form, such as installation files or setup packages. These files need to be unpacked, copied, and configured on the system in specific locations, along with any necessary dependencies, to ensure that the software can function correctly.

(ii) *Installation process:* The installation process can vary depending on the operating system and the complexity of the software being installed. It usually involves several steps like downloading or obtaining the installer, running the installer, obtaining the license agreement and configuration, copying files, registering dependencies, and finalising.

(iii) *Uninstallation:* Software installation is not a one-way process. Users can typically uninstall the software if they no longer need it or wish to free up space on their system. Uninstalling a program removes its files, configurations, and registry entries (on Windows) from the system, restoring the system to its state before the software was installed.

(iv) *Automatic updates:* Some software installations include mechanisms for automatic updates, allowing the software to download and install the latest patches and improvements, ensuring that users have the most up-to-date version.

(v) *Operating System compatibility:* It is essential to ensure that the software being installed is compatible with the operating system on the target computer. Different operating systems have different installation formats and requirements.

Steps for software installation

The process of installing software can vary depending on the Operating System you are using. Installing software involves several steps. These can vary based on the OS and the specific software being installed.

Step 1: Obtain the file for installation:

Obtain the installation file for the software you want to install. This file may be downloaded from the internet, provided on a physical media like a CD or DVD, flash drive, or distributed within an organisation's network.

Step 2: Check system requirements:

Before starting the installation, review the system requirements for the software. Ensure that your computer meets the minimum specifications for running the software.

Step 3: Run the installer:

For Windows OS, double-click on the downloaded installation file to start the installation process. On some other OS, right-click on the file and select "Run as administrator" to ensure proper permissions. Select the operating system you want to install.

Step 4: License agreement:

The process presented a license agreement or terms of service. Read the agreement carefully and, if agreed, click "Accept" or "Agree" to proceed with the installation.

Step 5: Choose installation options:

Some software installers provide options for customisation. Choose the installation that fits. Create shortcuts or select specific components or features to install. Click "Next" or "Install" to continue.

Step 6: Wait for installation:

The installer will now copy the necessary files on the computer and set up the software. Depending on the software's size and complexity, this process may take a few moments to several minutes.

Step 7: Complete installation:

Once the installation process is finished, a message indicating

that the software has been successfully installed may appear. Click "Finish" or "Close" to exit the installation wizard.

Step 8: Check for updates:

After installation, it is a good idea to check for updates to ensure that the latest version of the software has any bug fixes or improvements. Some software may have an automatic update feature.

Step 9: Test the software:

Launch the newly installed software and ensure that it runs correctly. Test out its features and functionalities to verify that everything is working as expected.

Activity 4.2

Referring to the steps of software installation, use the internet to perform the following installation:

(i) Log on the website https://www.libreoffice.org/

(ii) After opening the site, explore the link where you can download the latest version of LibreOffice software and download it.

(iii) After the download is complete, install the LibreOffice software on your computer.

Questions

Describe the steps involved in installing a LibreOffice software application on your computer. Include the necessary precautions that ensure a successful installation.

Exercise 4.1

1. Describe the importance of computer software in relation to Computer Science.
2. Differentiate between system software and application software.
3. Describe the steps for installing and uninstalling software.

Chapter Summary

Computer software refers to the programs that enable a computer to perf
specific tasks. Software can be categorised into two types: system so
and application software. System software includes operating systems s
Windows, MacOS, Unix, and Linux, which manage the computer's res
and allow communication between hardware and software components
system software also includes device drivers which enable hardware comp
to work with the operating system, and utility software, which is used to pe
specialised tasks.

On the other hand, application software, on the other hand, consists of pro
designed for specific tasks, such as word processors, web browsers,
players, graphics editors, and more. Software developers create and ma
these applications to cater for the diverse needs of users.

Revision exercise 4

1. What would happen if the computer we have today could not have
   software?
2. Explain the relationship between hardware and software in a com
   system.
3. How does the choice of software impact the functionality of a comp
   system?
4. Describe the importance of drivers and compatibility when connec
   peripheral devices to a computer.
5. Explain why using drivers specifically designed for the operating s
   is crucial.

Chapter Five

Computer system handling and care

Introduction

Handling and caring for computer systems is essential for ensuring the proper use and protection of computers in reference to practices and precautions taken. In this chapter, you will learn the concepts of computer handling and care, hardware care, software care, and safe handling practices. The competencies developed will enable you to use computers safely.

Think

Safe use of a computer systems

Concept of computer handling and care

Meaning of computer handling and care

Computer handling and care covers the practices and precautions implemented to ensure the proper use and protection of computers. This involves taking care of both the hardware and software components of a computer system. Proper computer handling and care are crucial for ensuring the long life and optimal functioning of the computer.

Importance of computer handling and care

The importance of observing proper computer handling and care are:

(i) To provide physical and software security measures for a computer.

(ii) To ensure smooth computer system performance by implementing regular software updates.

(iii) It helps users work without frustration, leading to higher satisfaction levels and morale.

Aspects of computer handling

Computer handling attributes include hardware care, software care, and safe handling practices.

Hardware care

Hardware care involves different aspect, such as cleanliness, temperature control, and ventilation. Also, it involves power management, relocation of a computer, and control the effect of the liquid on computer hardware.

Cleaning

Computers should be kept in a clean and conducive environment to function properly. However, it is advisable to regulaly clean of the computer hardware and its peripherals to remove dust and dirt effectively. Such peripherals include keyboard, mouse, and monitor. This may be achieved by utilising suitable cleaning equipment and solutions. The reason is to minimise the risk of potential harm to the various components.

Removing dust

The presence of dust in computer hardware can have several negative effects on performance and overall reliability. Dust is a common environmental impurity that can accumulate inside a computer over time. This occurs if the system is not adequately protected or regularly maintained. Some of the main effects of dust on computer hardware are:

(i) *Reduced cooling efficiency:* Dust can block air vents, cooling fans, and heat sinks within the computer. This obstruction hinders the airflow and disrupts the cooling process, leading to increase temperature inside the system. Higher temperatures can cause components like the central processing unit (CPU) and graphics processing unit (GPU) to overheat. That overheat may result in performance throttling or even hardware failure.

(ii) *Increased noise:* When cooling fans are clogged with dust, they must work harder to maintain the required temperature. This often results in increased fan noise as they spin at higher speeds. The noise can be distracting and annoying to users, and it may also be an indication of potential hardware issues.

(iii) *System instability and crashes:* Overheating caused by dust accumulation can lead to system instability and unexpected crashes. The computer may freeze or shut down suddenly.

(iv) *Shorter component lifespans:* Excessive heat due to dust can cause stress on internal components, reducing their lifespan significantly. Processors, graphics cards, and other critical hardware can wear out faster

and become more prone to failure if subjected to prolonged high temperatures.

(v) *Impaired performance:* Dust can affect the electrical connections between components, causing intermittent connectivity issues or data transfer errors. This can result in reduced performance and slower response times, impacting the overall user experience.

(vi) *Fire hazard:* While rare, a significant buildup of dust can pose a fire hazard, especially if it accumulates near electrical components. Dust is flammable, and in extreme cases, it can catch fire if exposed to a spark or overheated component.

Cleaning dust from computer hardware

The following steps guide you on how to clean dust from various components of a desktop computer:

(i) Collect cleaning materials, such as soft cloths, an electric air blower, isopropyl alcohol (Ethanol or hydrogen peroxide), and a soft brush.

(ii) Carefully remove the side panel of the computer case. Some cases may have screws to be unscrewed, while others may have latches or buttons to release the panel.

(iii) Observe the interior of the computer to locate areas with significant dust buildup. Pay attention to the cooling fans, heat sinks, and any other dustly components.

(iv) Use an electric air blower to blow away the loose dust. Hold the fans and prevent them from spinning while blowing the air to avoid potential damage.

(v) Use a soft brush to gently loosen the dust. Avoid applying excessive force, as some computer components are delicate and can be damaged easily.

(vi) Use a soft cloth to wipe down the surfaces inside the computer case. You can lightly dampen the cloth with isopropyl alcohol for more thorough cleaning. However, make sure not to get any liquid on sensitive electronic components.

(vii) Pay special attention to cleaning the cooling fans and vents thoroughly. Dust buildup on these components can significantly impact airflow and cooling efficiency.

(viii) Clean peripheral devices, such as a keyboard and mouse by blowing away loose material using compressed air from an electric air blower. If surfaces are dusty, wipe them down with a slightly damp cloth.

(ix) Carefully reassemble the computer

case and ensure all components are securely in place. Reconnect all cables and peripherals. Now, you can switch on the computer and check if everything functions correctly.

It is recommended to establish a regular cleaning routine be established based on the specific environment and usage of one's computer. Generally, adhering to a cleaning schedule of every three to six months is considered a good practice. When cleaning computers take, the following safety precautions:

(i) Never use a vacuum cleaner to clean the interior of the computer, as it can create static electricity and damage sensitive components.

(ii) Do not use water or household cleaning solutions on the internal components of the computer.

(iii) Always ensure the computer is unplugged and disconnected from the power source before cleaning.

Cleaning keyboard

A keyboard allows dust and particles to enter and accumulate in it over time. Periodic cleaning of the keyboard will prolong its lifespan and prevent malfunction. The guidelines for cleaning a keyboard are as follows:

(i) Clean the keyboard regularly to remove dust, dirt, and debris that can accumulate between the keys (see Figure 5.1).

Figure 5.1: *Remove dust, dirt, and debris from a keyboard*

(ii) Use a blower to blow away the particles or gently shake the keyboard upside down (see Figure 5.2).

Figure 5.2: *Using a blower to blow away dust*

(iii) Wipe the surface and keys with a soft cloth slightly dampened with water or a mild cleaning solution.

(iv) Avoid using harsh chemicals or excessive moisture, as they may damage the keyboard.

(v) Use a keyboard cover or silicone skin to help protect the keyboard from dust, dirt, and spills.

(vi) Refrain from eating or drinking near the keyboard to prevent spills and crumbs from getting inside (see Figure 5.3).

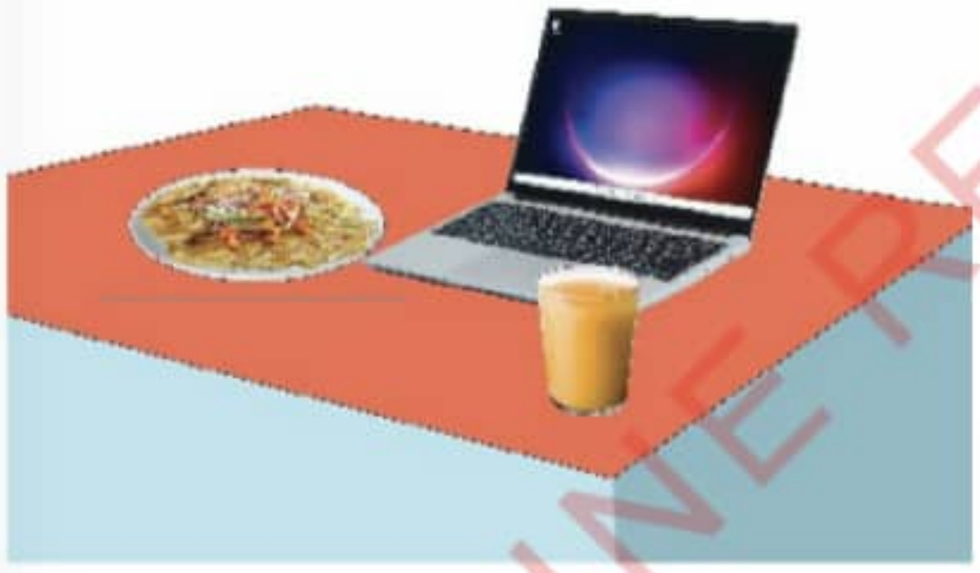


Figure 5.3: *Food placed near the computer*

Cleaning an optical mouse

To clean an optical mouse, follow these general steps:

(i) *Disconnect the mouse:* Unplug the optical mouse, from your computer or device.

(ii) *Turn the mouse upside down:* This allows you to access the bottom of the mouse, where the optical sensor and pads are located.

(iii) *Inspect and clean the pads:* Check the pads on the bottom of the mouse for any accumulated dirt or debris. Too much contaminated debris can make mouse movement stiff. Use a toothpick, a clean, lint-free cloth or a cotton cloth dampened with mild soap and water to gently wipe the pads and remove dirt or grime (see Figure 5.4).

Figure 5.4: *Cleaning mouse and a mouse pad*

(iv) *Clean the optical sensor:* The optical sensor is usually located in the centre of the mouse's bottom surface. Use a clean, lint-free cloth or a cotton swab dampened with mild soap and water to wipe the sensor gently. (see Figure 5.5). Be careful not to apply excessive pressure or get any liquid inside the mouse.

Figure 5.5: *Cleaning the optical sensor mouse*

(v) *Remove accumulated lint and debris:* Use a can of compressed air to blow away any dust or debris that may have accumulated on the surface of the mouse or in between the buttons. Hold the can upright and use short bursts of air to avoid spraying any liquid.

(vi) *Allow the mouse to dry:* After cleaning, allow the mouse to air dry completely before reconnecting it to your computer or device.

Cleaning a computer monitor

To clean a computer monitor, follow these general steps:

1. *Turn off the monitor:* Before cleaning, make sure to turn off the monitor and unplug it from the power source. This ensures your safety and prevents any damage to the monitor.
2. *Use a microfiber cloth:* Use a soft, lint-free microfiber cloth to wipe the screen gently. Microfiber cloths are designed to be gentle and won't scratch the surface of the monitor. Avoid using paper towels, tissues, or rough fabrics, as they can potentially damage the screen.
3. *Dampen the cloth:* Moisten the microfiber cloth with distilled water or a screen cleaning solution specifically designed for monitors. Do not spray liquid directly onto the screen: it can seep into the monitor and cause damage. Only use a small amount of liquid to dampen the cloth.
4. *Wipe the screen:* Gently wipe the screen in a circular motion or from top to bottom, as shown in Figure 5.6. Avoid applying excessive pressure, as it can damage the screen. Pay extra attention to areas with smudges or fingerprints.

Figure 5.6: *Cleaning a computer monitor*

5. *Dry the screen:* After cleaning, use a dry microfiber cloth to the screen gently. Ensure no moisture left on the surface before turning the monitor back on.

Activity 5.1

Use steps outlined for cleaning dust on hardware to clean the computer mouse, monitor, and keyboard.

Question

What caution did you take while cleaning?

Managing temperature and ventilation

In caring for your computer system, ensure that the computer is placed in a well-ventilated, temperature-controlled environment to prevent overheating. Avoid exposing the computer system to extreme heat, cold, or humidity. Ensure there are no blockages around the air vents if needed, consider using cooling pads or fans. For conducive airflow, ensure that cooling fans and vents are unobstructed to prevent overheating. Dust and debris can accumulate and block airflow, so periodic cleaning is important.

Impact of temperature on computer hardware

The temperature has a significant impact on computer hardware. It plays a crucial role in the performance, stability, and lifespan of the computer components. Both low and high temperatures can have adverse effects on the hardware.

Some of the effects of temperature on computer hardware are outlined as follows:

(i) High temperatures can lead to thermal throttling, where the hardware reduces its performance to prevent overheating.

(ii) Exposing computer hardware to extreme temperatures, especially high ones, can shorten its lifespan. Electronic components degrade faster under elevated temperatures. This may lead to premature failure of critical hardware components like CPUs and memory modules.

(iii) Overheating due to high temperatures can cause system instability. Components can produce errors, crashes, and unexpected shutdowns when they reach their thermal limits. This instability can lead to data loss and potential damage to the operating system or other software.

(iv) Extreme heat can cause irreversible damage to computer hardware. For instance, high temperatures can warp or melt delicate circuitry, resulting in permanent hardware failure.

(v) Frequent and significant temperature fluctuations can cause thermal expansion and contraction of components. Over time, this can weaken solder joints and connections, leading to possible electrical failures.

(vi) Extreme heat can reduce the lifespan of hard drives and increase the risk of data loss.

(vii) Extreme heat can degrade battery life, reducing the time a device can run on a single charge.

(viii) If temperatures are too low, the computer might not warm up enough to operate optimally, leading to issues with performance and even condensation problems.

Optimal temperature management

Managing temperatures effectively can enhance the performance, stability, and lifespan of a computer hardware. To ensure the best performance and longevity of computer hardware, it is important to manage temperatures effectively. The areas to be considered are as follows:

(i) Ensure that the computer case has adequate ventilation and proper airflow. Clean the dust regularly to prevent obstruction of air vents and cooling fans.

(ii) Invest in quality cooling solutions, such as CPU coolers and GPU coolers. Aftermarket coolers can often provide better thermal performance than stock coolers.

(iii) Use monitoring software to keep track of the hardware's temperatures to help identify potential overheating issues.

(iv) Keep the computer away from extreme temperatures and direct sunlight.

(v) When using a laptop, place it on a hard, flat surface to allow proper airflow and prevent overheating.

(vi) Perform regular cleaning and maintenance to ensure that cooling systems and airways are free from dust and debris.

Effects of humidity on computer hardware

Humidity can have both short-term and long-term effects on computer hardware. Modern computer components are designed to withstand a certain level of humidity. However, excessive or prolonged exposure to high humidity levels can lead to various issues. Some of the effects of humidity on computer hardware are:

(i) High humidity levels can cause moisture to condense on electronic components, leading to corrosion. Corrosion can damage metal contacts, connectors, and other exposed parts of the hardware. Over time, this can result in poor electrical connections, data transfer errors, and eventually, hardware failure.

(ii) Moisture and condensation can create unintended electrical paths on the motherboard and other

components, causing short circuits. Short circuits can immediately damage affected component or even the entire system.

(iii) Prolonged exposure to high humidity can accelerate the degradation of various hardware components. Those hardware components include the motherboard, graphics card, memory modules, and storage devices. This can result in premature component failure and reduced overall system reliability.

(iv) If humidity reaches critical levels and causes electronic components to malfunction, it can lead to data loss on storage devices.

(v) High humidity can affect the performance of computer components. For instance, memory modules may have reduced data transfer rates, and processors may not be able to function optimally due to the presence of moisture.

(vi) When a computer is moved from a cold to a warm and humid environment, condensation can form on the internal components. This sudden change in temperature can create water droplets, which can cause damage when the system is powered on.

Preventing the effects of humidity

To protect computer hardware from the negative effects of humidity, consider the following preventive measures:

(i) Ensure that the room or environment where the computer is located has a proper humidity level.

(ii) Use air conditioning or dehumidifiers to help control humidity levels and reduce the risk of condensation.

(iii) Ensure the computer case has adequate ventilation to allow for proper airflow and help dissipate any moisture.

(iv) Avoid placing the computer in areas prone to extreme humidity levels, such as damp basements or directly beside windows with condensation.

(v) Consider using silica gel packets inside the computer case or storage containers to absorb excess moisture.

(vi) Perform regular cleaning and maintenance to remove dust and debris from the computer as dust can attract moisture and worsen the effects of humidity.

Effects of liquids on computer hardware

The effect of liquids on computer hardware can be extremely damaging and potentially catastrophic. Liquid spills on computer components can cause various issues that may impair performance, lead to system failure, and even damage the hardware beyond repair. The following are the effects of liquid spills on computer hardware:

(i) Any liquid that contains water is an excellent conductor of electricity. When it encounters the exposed circuits on a motherboard or other components, it can cause a short circuit. This sudden surge of electricity can damage or destroy sensitive electronic components, such as the CPU and RAM.

(ii) Some liquids such as water and juice contain impurities or minerals that can be corrosive to electronic components. When liquid spills occur, these corrosive substances can gradually wear away metal contacts and connections, leading to oxidation and reduced conductivity. Over time, this corrosion can cause intermittent faults or permanent damage to the hardware. It can also cause unpredictable behaviour, and damage various components, including the motherboard, graphics card, hard drive, and power supply unit. These components are essential for the proper functioning of the computer, and any damage to them can lead to system instability or failure. The computer may fail to power on, freeze, crash, or show abnormal performance issues.

(iii) If liquid spills onto storage devices, such as hard drives, it can cause data loss. The liquid can interfere with the read/write heads or damage the storage medium. This makes accessing the data stored on the affected drive difficult on impossible.

Safety measures for liquid spill over a computer

If a liquid spill occurs on a computer or any electronic device, you can take the following measures to minimise the damage:

(i) Immediately turn off the computer and unplug it from the power source to prevent further electrical issues.

(ii) Unplug any external peripherals connected to the computer, such as the keyboard, mouse, and external drives.

(iii) If the liquid spill was minor, carefully dry the affected areas using a soft, absorbent cloth. However, avoid using excessive force or spreading the liquid to other parts of the computer.

(iv) If the spill is significant or involves a substantial amount of liquid, or if the computer shows signs of malfunction, it is better to seek professional help from a qualified technician. They can properly assess the extent of the damage and perform necessary repairs.

Prevention

It is essential to take preventive measures to avoid liquid spills and their potential damage to computer hardware. Here are some tips to keep your computer safe:

(i) Never place drinks or liquids near the computer or electronic devices.

(ii) When using a laptop, consider using a tray or stand to elevate it. Keep liquids further away from the device.

(iii) Be mindful of the surroundings and avoid risky behaviour that could lead to liquid spills near the computer.

Activity 5.2

Apply the safety principles and measures to protect your computer against dust, liquid, and temperature.

Question

What precautions should be taken while caring for your computer?

Exercise 5.1

1. Explain how to handle the effects of humidity on a computer.
2. Which computer parts might be affected if a computer is not properly maintained for a long time?

Power Management

To address the potential hazards arising from power fluctuations and electrical surges, it is recommended that protective measures be implemented aimed at effectively managing power supply. These measures aim to minimise or eliminate power fluctuations. Power fluctuations considerably diminish the lifespan of equipment or even result in computer damage. The damage may lead to data loss. In some instances where the electrical power provided to a computer system is inconsistent or unstable, there is a possibility that the system's components may not function properly. Some common examples of power fluctuation are:

Brownouts

This is a reduced voltage level of electric power that lasts for a period. Brownouts occur when the power line voltage drops below 80 percent of the normal voltage level. The normal voltage level in Tanzania ranges between 220V and 240V. Brownouts are common and can sometimes be detected by light dimming, often during heavy load periods or severe weather conditions. As power demands increase, the risk of brownouts increases. Figure 5.7 shows a dimming light.

Figure 5.7: *Dimming light*

Spikes

A spike is a sudden increase in voltage that lasts for a short time and exceeds 100 per cent of the normal voltage on a line. Spikes can be caused by lightning strikes or may occur when the electricity comes back on after a blackout.

Surges

A power surge is a drastic increase in voltage above the normal value. An electrical surge lasts for a few nanoseconds. In some cases, repeated electrical surges can degrade the quality of the device over time. In unusual cases, electrical surges can lead to fires that can affect the entire house. Figure 5.8 shows an electrical fire caused by a power surge.

Figure 5.8: *Fire caused by a power surge*

Dealing with power problems

Most electrical and electronic devices are engineered to function effectively even when the voltage supply fluctuates within a range of ±10% from the standard value. If the voltage supplied exceeds or falls below the acceptable range, these devices can potentially have operational malfunctions or sustain physical harm. Hence, it is imperative to guarantee an uninterrupted and consistent provision of power to computer systems. Computer systems are protected by the utilisation of any equipment, such as Uninterruptible Power Supplies (UPS), surge protectors, or voltage stabilisers.

Uninterruptible Power Supplies

A UPS is an electrical equipment that provides power backup when the input power source fails. The UPS provides near-instantaneous protection from input power interruptions via the energy stored in its batteries. The capacity of the UPS to provide power to a device varies from a few minutes to a few hours. The aim is to give sufficient time to start a standby power source save data and properly shut down the protected equipment. UPSs are typically used to protect hardware, such as computers, telecommunication equipment, or other electrical equipment. UPSs provide protection against an unexpected power disruption that could damage the equipment, disrupt business, or cause data loss.

UPSs contain batteries that provide power when the computer (connected device) senses a loss of power from the primary source. When a power surge occurs, the UPS intercepts it so that it does not damage the protected equipment.

UPSs give notification (normally by beeping continuously) of the power loss, which gives time to save any data and exit gracefully before the UPS runs out of power. Figure 5.9 shows examples of different UPSs.

Figure 5.9: *Different uninterruptible power supply units*

Steps for configuring the UPS

(i) Ensure that the UPS you wont to use can handle the power requirements of a given computer. Check the voltage rating of the computer's power supply (PSU) to ensure it is within the capacityof the UPS. The UPS should also have the enough outltes to accomodate all the devices to be connected.

(ii) Check the wattage rating of the computer's power supply unit (PSU) to ensure it is within the capacity of the UPS. UPS should also have enough outlets to accommodate all the devices that need to be connected.

(iii) Place the UPS in a suitable location near the devices to be protected. Ensure there is enough space around the UPS for proper ventilation, as it generates some heat during operation.

(iv) Most UPS units come with their batteries disconnected to avoid fire hazards during shipping. Open the battery compartment or access panel on the UPS and connect the battery as per the manufacturer's instructions.

(v) Plug the UPS into a wall outlet using the provided power cord. Allow the UPS to charge fully before connecting the devices. The time required for a full charge varies depending on the UPS model.

(vi) Identify the UPS outlets: Typically, UPS units have different types of outlets:

(a) *Battery backup outlets:* These outlets provide battery backup during power outages. Connect devices to these outlets.

(b) *Surge-protected outlets:* These outlets offer protection against power surges and spikes but do not provide battery backup. Connect non-essential peripherals, such as printers or speakers to these outlets.

(vii) Connect the computer monitor and CPU to UPS, as shown in Figure 5.10

(a) Plug the power cord of your computer's power supply into one of the battery backup outlets on the UPS.

(b) Connect the monitor and other essential peripherals to the battery backup outlets as well (see Figure 5.10).

Figure 5.10: *Connection points of UPS with CPU and monitor*

(viii) Turn ON the UPS using the power button or switch located on the front or back of the unit.

(ix) After connecting everything, you can perform a test to ensure that the UPS is functioning correctly. Unplug the UPS from the wall outlet to simulate a power outage and verify that the device continues running from the battery backup outlets.

Surge protectors

A surge protector is an appliance designed to protect electrical appliances from voltage spikes and surges. It is also called a surge suppressor. A surge protector attempts to limit the voltage supplied to an electrical appliance by blocking current to reduce voltage below a safe threshold. Figure 5.11 shows different surge protectors.

Figure 5.11: *Examples of surge protectors*

Voltage stabiliser or voltage regulator

A voltage stabiliser is an electrical appliance used to feed constant voltage to electrical appliances, such as refrigerators and computers. It protects them from damage due to voltage fluctuations. When there is a drop in incoming voltage, it gives a higher voltage, which compensates for the loss in output voltage. When there is a rise in the incoming voltage, the reverse happens, and the voltage on the output side remains almost unchanged. Figure 5.12 shows examples of voltage stabilisers.

Figure 5.12: *Examples of voltage stabilisers*

Relocation of a computer

When moving a computer, shut it down properly and disconnect all cables. Use appropriate packaging or protective cases to prevent damage during transportation. Consider the following important tips when moving computers from one area to another.

(i) When transporting the computer, it is important to always use a carrying case.

(ii) If you do not plan on using the computer for an extended period, make sure to turn it off, close it, and place it in the carrying case to preserve the battery.

(iii) Before carrying the computer, remember to close and disconnect all cords.

(iv) To minimise static electricity, consider placing a dryer sheet in the case.

(v) Avoid lifting or carrying the computer by its screen.

(vi) The carrying case should only be used to carry the computer. It should not be overloaded with heavy or sharp objects that could cause damage. It is also important not to place any bottles containing liquid in the carrying case.

Activity 5.3

Read various sources of information on the aspect of computer handling and care. Pay particular attention to aspects of computer handling not covered in this chapter. Summarise your findings and document your results in your portfolio.

Questions

1. Do you think this task has helped you to raise awareness of computer handling and care? Explain your opinion.
2. Apart from schools, outline other areas where competence in computer handling may be vital.

Exercise 5.2

1. The computer is an electronic device that can be affected by power fluctuation. With an example, discuss this statement.
2. What is the significance of exercising hardware handling measures?
3. Explain how a voltage stabiliser protects a computer.
4. What is the difference between UPS and a voltage stabiliser in protecting a computer system?

When dealing with software, it is important to be cautious with viruses. Viruses can infiltrate a computer system through removable storage devices or the internet. Prior to use, removable storage devices should always be scanned for viruses. It is also recommended to scan hard drives regularly for viruses, preferably every two weeks. Any programs downloaded from the internet should undergo virus scanning. To ensure maximum protection, it is advisable to install the most up-to-date antivirus software and update it every two weeks.

Computer updates: Update the operating system, drivers, and software applications regularly. This ensures the software has the latest security patches and bug fixes.

Antivirus and security: Install and regularly update antivirus software to protect the computer system against malware and other security threats. Be cautious when downloading and installing software from untrusted sources. One of the key considerations in caring for a computer includes having good anti-viruses software to protect computer and data from virus, worms, and other threats. Viruses are among the issues that usually cause computers to fail.

Activity 5.4

Implement the steps of installing antivirus.

Questions

1. What challenges did you encounter during the process?

2. Which utility programs are available in your computer system apart from the one you have installed? How do you apply them?

Exercise 5.3

1. Why is it advised to update your computer system regularly?
2. Computer malware is harmful to your computer system. Discuss.

Safe handling practices

Safe handling practices of computers are of two categories: proper shutdown and physical handling of peripherals.

Proper shutdown

Always shut down the computer using the appropriate shutdown procedure to avoid data corruption and system errors. Proper computer shutting down involves following a specific procedure to ensure that all running processes are safely stopped and the system is powered off correctly. Here are some general steps for a proper shutdown:

(i) *Save your work:* Make sure that you save any open documents or files before proceeding with the shutdown process.

(ii) *Close applications:* Close all running applications and programs to ensure they have properly saved any changes and are ready to be closed.

(iii) *Log out:* If you are using a user account, log out of the account before shutting down the computer. This ensures that all user-specific settings are saved and closed properly.

(iv) *Start menu shutdown:* In most operating systems, you can initiate the shutdown process by clicking on the Start menu, selecting the Power button, and then choosing the Shutdown option. This will initiate the shutdown sequence.

(v) *Wait for the shutdown process:* Once you have initiated the shutdown, wait for the computer to complete the shutdown process. This may involve closing background processes, saving system settings, and powering off the hardware components.

(vi) *Power off:* After the shutdown process is complete, you can safely power off the computer by pressing the power button or disconnecting the power source, depending on your computer's configuration.

It is crucial to understand that shutting down the computer forcefully may result in the loss of data or instability in the system. The forcefully shutting down of the computer includes unplugging it from the power source or pressing and holding

down the power button. By adhering to the correct shutdown procedure, you can ensure that your computer shuts down safely. By doing so, you can safeguard the integrity of your data and system settings. Note that the procedure may differ from one operating system to another.

Activity 5.5

Apply the instructions on procedures for proper computer shutdown as described in this section, and demonstrate how to shut down the computer the right way.

Question

What precautions should be taken while doing these activities?

Handling peripherals

Handle computer peripherals, such as the keyboard, mouse, and cables, with care to prevent damage or disconnection. When handling the keyboard, mouse, and cables, it is important to exercise caution to prevent damage or disconnection. Here are some guidelines for proper handling:

Keyboard handling

(a) *Type gently:* Type on the keyboard with a light touch. Avoid pounding or excessive force, as it can cause keys to become loose or break.

(b) *Avoid excessive bending:* Avoid bending the keyboard excessively or placing heavy objects on top of it. Excessive pressure or bending can damage the internal components.

Mouse handling

(a) *Handle gently:* Hold the mouse gently and avoid holding it too tightly. Excessive force can damage the buttons or scroll wheel.

(b) *Use a mouse pad:* To ensure smooth mouse movement and prevent wear on the mouse is feet, use a mouse pad or a smooth surface.

(c) *Avoid dropping:* Avoid dropping the mouse or hitting it with anything. Dropping the mouse can cause internal damage or misalignment of components.

Cable handling

Ensuring the correct handling of computer cables is crucial for preventing damage and achieving optimal performance. Here are some vital guidelines to follow:

(a) *Disconnect power sources:* Before working with the keyboard, mouse, or cables, ensure that you disconnect all power sources, such as unplugging the computer or removing batteries from wireless devices.

(b) *Avoid excessive bending or twisting:* Do not excessively bend or twist computer cables, as this can cause internal wires to break or wear out. Gently route cables in a way that

minimises stress on the connectors and cables themselves.

(c) *Do not pull on the cable:* When disconnecting a cable, avoid pulling on the cable itself. Instead, firmly hold the connector and gently disconnect it. Pulling on the cable can damage the connectors or cause the cable to detach from the connector.

(d) *Secure cables properly:* Use cable management solutions, such as cable ties, clips, or cable sleeves to keep cables organised. This prevents cables from knotting or getting knotted with other objects. This handling helps to avoid accidental pulls that can damage the cables.

(e) *Avoid sharp objects or excessive pressure:* Keep cables away from sharp objects or areas where they may be pinched or crushed. Sharp objects can cut or damage the cable insulation, while excessive pressure can cause internal wire damage.

(f) *Protect cables during transportation:* When transporting devices or equipment that have cables attached, ensure that the cables are properly secured and protected. Avoid placing heavy objects on top of cables or subjecting them to excessive pressure.

(g) *Regularly inspect cables:* Periodically check the condition of your cables for any signs of wear or damage. If you notice any issues, replace the cables promptly to prevent further damage or potential hazards.

Activity 5.6

Apply the instructions on procedure for handling the computer peripherals as described in this section, and demonstrate how to use and relocate computers properly.

Questions

1. What precautions should be taken while doing these activities?
2. Did you face any challenges while practicing this? How did you solve them?

Password protection

Use strong and unique passwords to protect your computer and accounts from unauthorised access. To do this, follow these steps:

(i) *Create complex passwords:* Use a combination of uppercase and lowercase letters, numbers, and special characters, e.g., Michael@12345. Avoid using easily guessable information like your name, birthdate (avoid: 2020), or common words.

(ii) *Make passwords long:* The longer the password, the harder it is to

crack. Aim for at least 8 characters, but consider using even longer passwords when possible. It is recommended to use both normal characters (alphanumeric) and special characters (symbols and punctuation) for strong security.

(iii) *Avoid reusing passwords:* Each account should have a unique password. Reusing passwords across multiple accounts increases the risk of unauthorised access if one account is compromised.

(iv) *Use a password manager:* Consider using a password manager tool to securely store and generate strong passwords for your accounts. This helps you remember complex passwords without the need to write them down or reuse them.

(v) *Enable two-factor authentication (2FA):* Enable two-factor authentication for your accounts whenever possible. This adds an extra layer of security by requiring a second verification step, such as a code sent to your phone, in addition to your password.

(vi) *Regularly update passwords:* Change your passwords periodically, especially if you suspect any compromise or if you have been notified of a data breach. Regularly updating passwords helps mitigate the risk of unauthorised access.

(vii) *Be cautious of phishing attempts:* Be vigilant when entering your password online. Avoid clicking on suspicious links or providing your password on untrusted websites. Always verify the legitimacy of the website or email before entering your credentials.

(viii) *Data backup*: Regularly back up your data, both locally and to the cloud, to protect against data loss due to hardware failures or accidental deletions.

Activity 5.7

Apply the instructions on procedures for safely handling of the computer using password as described in this section and demonstrate how to create a strong password.

Questions

1. What precautions should be taken while doing activity 5.7?
2. Did you face any challenges while practicing this? How did you solve them?

Physical security

Keep the computer in a secure location to prevent theft or unauthorised access. Consider using cable locks or security devices if necessary. Use these tips to ensure physical security.

(i) *Choose a secure physical location:* Place your computer in a secure area where it is not easily visible or accessible to unauthorised

individuals. If possible, keep it in a locked room or cabinet.

(ii) *Use cable locks or security devices:* Consider using cable locks or security devices to secure your computer physically. These devices attach to your computer and can be fixed to a desk or other fixed object. Such locking makes it difficult for someone to steal or remove the computer without the appropriate key or combination.

(iii) *Secure the premises:* Ensure that adequate security measures are in place at the location where your computer is kept. This may include installing security cameras, alarms, or access control systems to deter unauthorised access and theft.

Activity 5.8

Apply the instructions on procedures for safely handling of the computer as described in this section and demonstrate how to secure computer physically.

Questions

1. What precautions should be taken while doing these activities?
2. Did you face any challenge while practicing this? How did you solve them?

Chapter Summary

Computer handling is caring for the computer system and its accessories so that they perform their work properly. Computer system handling involves a wide range of tasks and responsibilities. They include hardware and software management, proactive maintenance, security measures, data protection, and disaster preparedness. The goal is to ensure that the computer system operates optimally and meets the requirements of its users. By proactively addressing these aspects, organisations and individuals can ensure that their computer systems operate reliably, securely, and efficiently. Computer care measures include power management, using utility software for optimising performance, and securing computers from viruses and other malware.

Revision exercise 5

1. Discuss possible risks a computer is likely to face if proper handling measures are not observed.
2. What potential risks or situations could arise if a computer user fails to back up their data regularly?
3. Describe how overheating can impact the computer system's performance.
4. Why is it important to keep operating systems and software applications up to date?
5. Describe the steps you would take to remove malware on a computer.

Chapter Six

Computer system maintenance

Introduction

During the process of using computer systems, various problems may occur and lead to poor performance and operational costs. Regular maintenance of a computer system is a vital practice that helps to avoid these problems and ensure reliable performance and cost-effectiveness. In this chapter, you will learn the concept of computer system maintenance, and how to perform preventive, corrective, and routine maintenance of computer systems. The competencies developed will enable you to demonstrate the ability to manage computer systems effectively.

Think

Computer system without maintenance

Concept of computer system maintenance

Read scenario 6.1 about computer system maintenance, then answer the questions that follow.

Scenario 6.1: *Kode's working with a computer at home*

Kode works from home as a freelance graphic designer. He appreciates that his computer is very important in his work. Therefore, he wants to ensure the reliability and performance of his computer every time he works to produce a graphical design. To be confident with his work at the office, Kode conducts the following activities regularly:

(i) Updates the operating system, design software, and antivirus software for security.

(ii) Frequently performs malware scans to detect and remove potential threats to computer security.
(iii) Review startup programs and deactivate unnecessary ones for improved boot times.
(iv) Removes unnecessary applications and files.

Questions

1. Why is Kode engaging in all these activities?
2. What lesson have you learned from the scenario?
3. Apart from home, where else can you apply these procedures?

Meaning of computer system maintenance

Scenario 6.1 highlights the importance of maintaining computer systems to maximise the service life of computer systems and minimise downtime. When computer systems are neglected, they deteriorate over time and finally get damaged. That damage leads to a waste of time and money spent on repairing computer systems.

Computer system maintenance refers to a set of activities and practices aimed at ensuring the smooth functioning, reliability, security, and optimal performance of a computer system over time. Computer maintenance usually includes software aspects like re-installation and physical of computer hardware maintenance.

Importance of computer maintenance

Generally, the importance of computer system maintenance is:

(i) To keep the computer system running smoothly.
(ii) To identify and address potential issues before they lead to system failures.
(iii) To help protect a computer from vulnerabilities malware, viruses, and hackers could exploit.
(iv) To improve data security through regular data backups. This is done by ensuring important files are safe and recoverable in case of hardware failure, accidental deletion, or security breaches.
(v) To extend the service life of hardware components.
(vi) To prevent conflicts and compatibility issues that could arise from outdated software.

(vii) To prolong the service life of your hardware and reduce the need for costly repairs or replacements.

Tools for performing computer maintenance

Computer maintenance requires both physical and soft tools. Some of these tools include solvents (e.g., ethanol/ hydrogen peroxide), soft-bristle brush such as a clean, unused soft brush, compressed air can, or an air compressor. Other tools are lint-free cloths or paper towels, electrostatic discharge or anti-static wrist strap, data backup software, anti-virus, and anti-malware software.

Electrostatic Discharge

Electrostatic Discharge (ESD) is the sudden flow of electricity between two electrically charged objects, typically caused by contact or an electrical short circuit. ESD occurs when static electricity accumulates on one object and then discharges to another object with a different electrical potential. ESD can damage sensitive electronic components and devices, often leading to malfunctions or permanent damage. To prevent electrostatic discharge, especially when working with sensitive electronic components, it is essential to wear wrist straps with grounding cords properly connected to a grounded surface. The wrist strap ensures that both you and your body have the same electrical potential, preventing static charge buildup and providing a safe path for any accumulated charge to dissipate to the ground. Figure 6.1 shows the image of the antistatic wrist strap.

Figure 6.1: *Antistatic wrist strap*

It is advisable to exercise caution when opening a computer system, by utilising the ESD or antistatic wrist strap. This precautionary measure helps reduce the potential discharge of static electricity, hence minimising the possibility of harm to critical components, such as computer motherboards, graphics cards, and memory modules. Therefore, before disassembling the internal component, it is very important to wear a small case antistatic wrist strap.

Types of computer system maintenance

The common types of computer system maintenance are preventive maintenance, corrective maintenance, and routine maintenance. These categories of computer system maintenance will be elaborated in more detail in the next section.

Exercise 6.1

1. What are the potential consequences of neglecting computer system maintenance?
2. Why is wearing the Antistatic wrist strap said to be very important during computer maintenance?

Preventive maintenance

Preventive maintenance involves proactive measures taken to prevent potential problems and system failures. It includes tasks like regular hardware cleaning and inspections to identify and address potential problems before they cause any harm. You can have both hardware and software preventive maintenance.

Hardware preventive maintenance

Preventive maintenance is a proactive approach to maintaining your computer's health and performance. By regularly performing hardware preventive maintenance, potential risks can be prevented from becoming major problems and extend the life of the computer. Examples of preventive maintenance tasks for computer hardware are:

(i) Airflow management,

(ii) Power connection check,

(iii) Hard drive health assessment,

(iv) Temperature monitoring,

(v) Cleaning keyboard, mouse, monitor, and motherboard,

(vi) Battery maintenance (laptops),

(vii) Regularly checking fans and heatsinks, and

(viii) Inspection of RAM and expansion cards.

This book will cover some of these tasks.

Motherboard cleaning

Cleaning motherboard is an important maintenance task to ensure the proper functioning of a computer. Cleaning helps to prevent dust and debris from causing overheating or other issues. Cleaning your computer's motherboard requires care and attention to detail, because it is a delicate and crucial component. Figure 6.2 shows a person cleaning a motherboard using a soft brush.

Figure 6.2: *Cleaning a motherboard*

Materials needed:

(i) Ethanol/ hydrogen peroxide (90% or higher concentration)

(ii) Soft-bristle brush (e.g., a clean, unused soft brush)

(iii) Compressed air can or an air compressor
(iv) Lint-free cloths or paper towels
(v) Electrostatic discharge or anti-static wrist strap
(vi) Anti-static wrist mat
(vii) Silicon skin

Procedure:

1. *Prepare a clean workspace:* Find a clean, good lighting area and smooth surface.
2. *Turn off and unplug your computer*: Ensure that a computer is completely powered off and unplug it from the electrical outlet. Also, disconnect any peripheral devices.
3. *Ground yourself:* To prevent static discharge that could damage sensitive components, wear an anti-static wrist strap, and connect it to your wrist. If you don't have a wrist strap, touch a metal part of a computer case to discharge any static electricity.
4. *Open the computer case*: Carefully remove the side panel of your computer case to access the motherboard. Refer to your computer's manual for guidance if you're unsure how to do this.
5. *Remove components (if necessary):* Depending on the level of cleaning required, you may need to remove certain components connected to the motherboard, such as RAM sticks or expansion cards. Ensure you disconnect any power cables and gently release any retaining clips before removing components.
6. *Blow away dust:* Use compressed air to blow away loose dust and debris from the motherboard. Hold the can or air compressor at a distance to prevent direct contact, as high-pressure air can damage components.
7. *Brush away stubborn dust:* For dust that doesn't come off easily with air, gently sweep it away with a soft-bristle brush. Be careful not to apply excessive pressure or touch sensitive components.
8. *Clean with isopropyl alcohol:* Dampen a lint-free cloth or paper towel with isopropyl alcohol. Carefully wipe the motherboard's surface, paying special attention to areas with stubborn dirt or residue. Avoid letting excess liquid drip onto the motherboard.
9. *Inspect for residue:* After cleaning, inspect the motherboard closely for any remaining residue. If you find any, use a cloth or paper towel lightly moistened with isopropyl alcohol to clean those areas.
10. *Allow to dry:* Let the motherboard air dry completely before reassembling your computer. Ensure there's no moisture left, as it can cause damage when the computer is powered on.
11. *Reassemble and power on:* Reassemble your computer, ensuring

all components are properly seated and connected. Plug in your computer, power it on, and check if it operates as expected.

Activity 6.1

Apply the instructions on the procedures for motherboard cleaning as described in this section, and demonstrate how to clean the motherboard.

Questions

1. What precautions should be taken while doing these activities?
2. Did you face any challenges while practicing this? How did you solve them?

Cleaning a RAM

Cleaning RAM modules is generally not recommended because RAM is a sensitive electronic component. Therefore, unnecessary handling or cleaning can potentially damage it. However, if you suspect that your RAM modules are dirty or have visible dust on them, here is a cautious approach for cleaning RAM:

Materials needed:

(i) Compressed air can or an air compressor

(ii) Soft-bristle brush (clean and unused)

(iii) Anti-static wrist strap (recommended)

(iv) Lint-free cloth or paper towels

Procedure:

1. *Prepare a clean workspace:* Find a clean, well-lit area to work in, preferably with an anti-static surface. Use an anti-static mat or work on a non-conductive surface like a wooden table to prevent static discharge.
2. *Turn off and unplug the computer:* Ensure that the computer is completely powered off and unplug it from the electrical outlet. Disconnect any peripheral devices.
3. *Ground yourself:* To prevent static discharge that could damage sensitive components, wear an anti-static wrist strap, and connect it to your wrist. If you don't have a wrist strap, touch a metal part of the computer case to discharge any static electricity.
4. *Open the computer case:* Carefully remove the side panel of your computer case to access the RAM modules. Refer to your computer's manual for guidance if you are unsure how to do this.
5. *Blow away dust:* Use compressed air to blow away any loose dust or debris around the RAM slots and on the RAM modules themselves. Hold the can or air compressor at a distance to prevent direct contact with the components.

6. *Brush away stubborn dust:* If there is stubborn dust or dirt on the RAM modules, gently sweep it away with a soft-bristle brush. Be extremely gentle and avoid applying pressure or touching the gold contacts on the RAM module.
7. *Inspect for residue:* After cleaning, inspect the RAM modules closely for any remaining residue. If you find any, use a lint-free cloth or paper towel lightly moistened with isopropyl alcohol to clean those areas. Be careful not to touch the gold contacts.
8. *Allow to dry:* If you use isopropyl alcohol for cleaning, make sure the RAM modules are completely dry before reinserting them into the RAM slots.
9. *Reassemble:* Reinsert the RAM modules into their respective slots, ensuring they are properly seated and secured. Reattach any components or cables you may have disconnected.
10. *Power on:* Plug in your computer, power it on, and check if it operates as expected.

Activity 6.2

Apply the instructions on procedures for RAM cleaning as described in this section, and demonstrate how to clean the RAM.

Questions

1. What precautions should be taken while doing these activities?
2. Did you face any challenges while practicing this? How did you solve them?

Software preventive maintenance

Software preventive maintenance involves taking proactive measures to keep your computer software in good working condition. This is done to prevent issues and ensure system stability. Examples of software preventive maintenance tasks are:

1. *Software updates:* Keep the operating system, drivers, and firmware up to date to enhance stability and security.
2. *Performance monitoring:* Regularly monitoring the performance of the software can help identify any potential issues early on. This includes checking for slowdowns, crashes, or other signs of poor performance. Performance monitoring tools can provide valuable insights into how the software is performing and help identify areas that need improvement.
3. *Data backup:* Perform regular backups of important data to prevent data loss in case of hardware failure.

Use external drives or cloud storage for redundancy.

4. *Anti-virus and anti-malware scans:* Conduct regular scans using up-to-date antivirus and anti-malware software to detect and remove potential threats that could harm your hardware.

Activity 6.3

Develop a preventive maintenance plan for a computer system outlining the schedule for routine tasks like cleaning, updates and backups.

Questions

1. What challenge did you face in preparing the plan?
2. How did you overcome it?

Exercise 6.2

1. What are the conditions that must be met when doing preventive maintenance?
2. Why it is important to dry RAM using isopropyl alcohol before inserting into the slot?
3. Why is it necessary to perform computer maintenance in a clean workspace?

Corrective maintenance

Corrective maintenance is also known as "breakdown maintenance" or "run-to-failure" maintenance. It is a strategy where maintenance activities are performed after a problem or failure has occurred. In this approach, the device or system is used until it breaks down, and then repairs or replacements are carried out to restore it to a working condition. This approach to maintenance has several disadvantages;

(i) The risk of downtime and potential production losses due to unexpected failures increases.

(ii) It can lead to more extensive damage and costly repairs. This is particularly true if signs of failure are ignored which can lead to catastrophic failures.

Hardware corrective maintenance

Hardware corrective maintenance involves addressing and fixing hardware issues when they arise to restore the proper functioning of computer components. Examples of hardware corrective maintenance are:

(i) Motherboard and hard disk replacement;

(ii) Repairing a broken laptop screen,

(iii) Fixing a faulty Power Supply Unit (PSU);

(iv) Replacing a dead or failing graphics card;

(v) Repairing a faulty CPU cooler,

(vi) Fixing a malfunctioning keyboard;

(vii) Repairing a non-functioning mouse;
(viii) Fixing a cracked or damaged laptop chassis;
(ix) Replacing a faulty RAM module;
(x) Fixing a network card issue;
(xi) Repairing a printer paper jam;
(xii) Re-setting BIOS and CMOS battery replacement;
(xiii) Fixing overheating issues with a laptop;
(xiv) Keyboard and printer maintenance;
(xv) Restoring functionality to a non-responsive monitor;
(xvi) Fixing a faulty optical drive and
(xvii) Repairing a damaged laptop battery.

This section will demonstrate the aspects of motherboard and hard disk replacement. Also, it will demonstrate how to reset BIOS and CMOS battery replacement, and keyboard, and printer maintenance.

Motherboard replacement

Replacing a motherboard requires careful handling and attention. Ensure the compatibility of the replacement motherboard with the existing components. These components include CPU, RAM, system case, power supply, heat sink/fan assembly, thermal compound, motherboard standoffs, and screws.

Steps for replacement

(i) Back up all the important data to an external or cloud storage device.
(ii) Shut down the computer properly and disconnect the power cord from the electrical outlet.
(iii) Disconnect all cables and peripherals from the computer, including the monitor, keyboard, mouse, and any external devices.
(iv) Remove the side panel of the computer case. Most cases have screws or latches that hold the panel in place, as shown in Figure 6.3.

Figure 6.3: *Removing the side panel*

(v) Take photos or note current connections to ensure correct reconnection later, then disconnect and remove connected components.
(vi) Remove any expansion cards such as graphics and sound cards, from their respective slots.
(vii) Remove RAM modules and the CPU and keep them in a safe place.
(viii) Unscrew the motherboard from the case using a screwdriver. Pay attention to any hidden screws or clips that may hold the motherboard in place.

(ix) Lift the motherboard out of the case, taking care not to damage any components or cables, as shown in Figure 6.4.

Figure 6.4: *Removing the motherboard*

(x) Carefully place the new motherboard into the case, aligning the mounting holes with the standoffs.

(xi) Secure the new motherboard to the case using screws, ensuring it is firmly held in place, as shown in Figure 6.5.

Figure 6.5: *Securing the new motherboard using screws*

(xii) Reconnect all cables to the new motherboard, including power connectors, data cables, front panel connectors, and any other peripherals.

(xiii) Reinstall RAM and CPU into the appropriate slots on the new motherboard, as shown in Figure 6.6.

Figure 6.6: *Reinstall RAM*

(xiv) Double-check all connections to ensure everything is secure and properly plugged in.

(xv) Close the computer case and secure it with screws.

(xvi) Reconnect the monitor, keyboard, mouse, and any other peripherals.

(xvii) Connect the power cord to the power supply and plug it into an electrical outlet.

(xviii) Press the power button to turn on the computer.

Activity 6.4

Apply the instructions on the procedures for replacing a motherboard as described in this section, and demonstrate how to replace a motherboard.

Questions

1. What precautions should be taken into consideration while doing these activities?
2. Did you face any challenges while practicing this? How did you solve the them?

Hard disk replacement

Replacing a Hard Disk Drive (HDD) in a computer is a relatively simple process. Obtain the correct type of hard disk and the necessary cables for connecting the HDD to the computer's motherboard and power supply. The following steps will guide you to make the correct replacement:

Steps

(i) Choose a clean, static-free surface to work on.

(ii) Ensure the computer is powered off and unplugged from the electrical outlet.

(iii) Identify the drive to replace (see Figure 6.7).

Figure 6.7: *Identifying available drive*

(iv) Disconnect the data and power cables from the HDD and remove the hard disc,

(v) Connect one end of the SATA power cable to the motherboard, as shown in Figure 6.8.

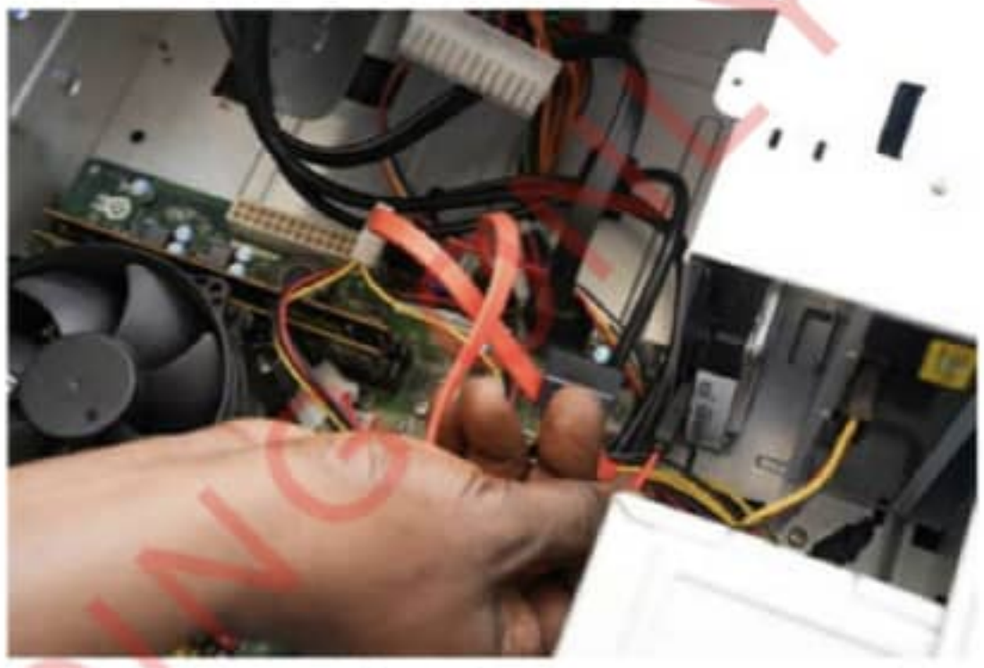


Figure 6.8: *Aligning notches*

(vi) Organise the cables inside the case to improve airflow and keep them out of the way of fans and other components.

(vii) Carefully put the side panel back on the case and secure it with screws or latches.

(viii) Connect the power cord to the power supply and plug it into an electrical outlet.

(ix) Power on the computer to ensure the HDD is detected in the BIOS.

Activity 6.5

Apply the instructions on the procedures for replacing a hard disk as described in this section, and demonstrate how to replace a motherboard.

Questions

1. What precautions should be taken into consideration while doing these activities?
2. Did you face any challenges while practicing this? How did you solve them?

Printer maintenance

Proper maintenance of the printer is important to ensure consistent print quality, prevent paper jams, and extend the printer's lifespan. Follow the steps for maintaining a printer:

Steps:

(i) Turn off and unplug the printer before cleaning to ensure safety.

(ii) Use a soft, lint-free cloth to clean the exterior of the printer, removing dust, and dirt, as shown in Figure 6.9.

Figure 6.9: *Removing dust and dirt from a printer*

(iii) Clean the paper trays and input/ output trays to prevent paper dust buildup.

(iv) Wipe the printhead or laser lens with a soft cloth.

Activity 6.6

Implement the steps for maintaining the printer to the school printer.

Questions

Why should you always:

1. Keep printer drivers and firmware up to date.
2. Periodically check for any loose or damaged parts, such as paper guides or rollers, and promptly address any issues.
3. Use high-quality paper that is suitable for the type of printer.
4. Use genuine ink or toner cartridges recommended by the printer manufacturer.

Basic Input Output System re-setting

The Basic Input/Output System (BIOS) serves as the firmware interface between the computer hardware and the operating system. BIOS settings are a set of configurable options that control the fundamental functions of

computer hardware. These settings can be accessed and modified through the BIOS setup utility, typically during the boot-up process.

Important aspects of BIOS settings include accessing BIOS, the purpose of settings, security options, boot order, CPU and RAM setting, peripheral management, power management, updating date and time, updating bios, factory defaults, and bios password.

(i) *Access BIOS settings:* Usually, you need to press a specific key during the computer startup, such as F2, F12, Delete, or Escape. The key to press depends on the motherboard and computer manufacturer.

(ii) *Focused on the purpose of settings:* BIOS settings control various hardware parameters and configurations, such as CPU settings, RAM timings, boot sequence, and peripheral device management.

(iii) *Setting BIOS security options:* BIOS settings often include security options like setting a BIOS password or enabling secure boot to protect the computer from unauthorised access and malware.

(iv) *Settings boot order:* Boot order determines the sequence in which the computer checks for bootable devices. This is important when selecting a primary boot device, such as a hard drive or a USB drive. You can configure the boot order in BIOS settings.

(v) *CPU and RAM settings:* BIOS allows you to adjust CPU-related parameters like clock speed, voltage, and hyperthreading.

(vi) *Specify memory timings:* Extreme Memory Profile (XMP) settings and the amount of RAM allocated to integrated graphics, if applicable.

Moreover, BIOS settings also deal with peripheral management, power management, updating date and time, updating BIOS, factory defaults, and BIOS passwords. BIOS peripheral management allows you to enable or disable these hardware components and peripherals, such as USB ports, onboard audio, and integrated graphics. Power management includes power-related options like Advanced Configuration and Power Interface (ACPI) settings, fan control, and sleep mode configurations. BIOS settings also allow you to set the system date and time, which is crucial for accurate timekeeping and timestamping. Figure 6.10 shows different options for BIOS setup utility.

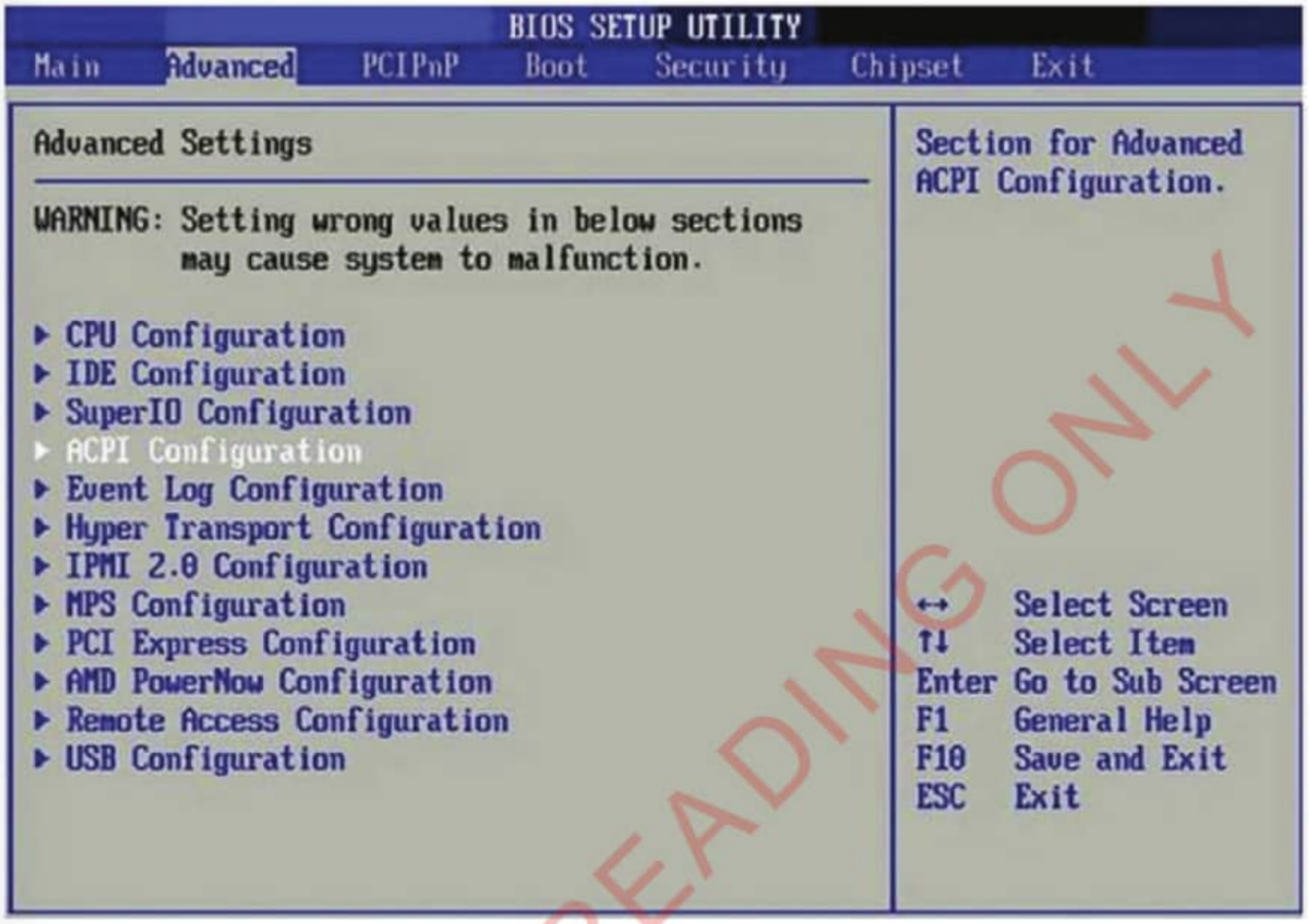


Figure 6.10: *BIOS setup utility*

These settings also provide room to update the BIOS itself. However, it is important to note that updating the BIOS can provide bug fixes, performance improvements, and compatibility updates. Therefore, it should be done cautiously, as a failed BIOS update can render the system unusable. Most BIOS setups offer an option to restore the settings to their default values, which can be helpful if you encounter issues after making changes. Finally, setting a BIOS password can add an extra layer of security by requiring a password to access and modify BIOS settings.

Replacing a CMOS battery

A Complementary Metal-Oxide-Semiconductor (CMOS) battery is commonly referred to as a CMOS battery. It is a small, round, coin-shaped battery used in computers and other electronic devices to power a special type of memory called CMOS memory. The CMOS battery provides a low-level, constant source of power to maintain this data. The CMOS chip stores important system information, including the system's date and time, BIOS settings, and hardware configuration. When you turn off your computer, the CMOS battery

helps maintain this data even when the computer is not powered.

If the CMOS battery becomes weak or dies, it can result in issues like incorrect system date and time or BIOS settings getting reset to default values. Replacing the CMOS battery is a straightforward process and can often resolve these issues, ensuring the proper functioning of the computer's basic settings and information storage.

Software corrective maintenance

Software corrective maintenance involves identifying and addressing issues in software applications to ensure they function correctly and efficiently. Examples of software corrective maintenance include resolving compatibility issues, component and compliance updates, and user account and access issues.

Exercise 6.3

1. What reasons, in your opinion, can necessitate replacing a RAM?
2. What circumstance can cause the Basic Input Output System to reset on your computer system?
3. Why is it necessary to reconnect the data and power cables after replacing a hard disk?

Routine maintenance

Routine maintenance is a proactive approach to facilities or systems. It is also, referred to as planned or scheduled maintenance because it is carried out on a regular basis. Unlike corrective maintenance, which involves fixing issues after they occur, routine maintenance is performed at predetermined intervals to prevent breakdowns, prolong the service life of assets, and ensure optimal performance. It is a key component of a well-structured maintenance program and is essential for the smooth operation of computer systems.

Hardware routine maintenance

Routine maintenance for computer hardware is essential to keep your systems running smoothly and prevent potential issues. Examples of routine hardware maintenance tasks include disk cleanup, defragmentation, inspecting power connections, hard drive health checks, battery maintenance (laptops), and monitor cleaning. Other examples are external component inspection, regular checking of fans and heatsinks, and inspection of RAM and expansion cards. The next section presents the routine maintenance for disk cleanup, disk defragmenter, and check disk.

Disk cleanup

Many files on the hard drive are not needed after a given length of time, but they continue to exist on the disk. These must be eliminated manually or using an automated Disk Cleanup application. Steps on how to delete or cleanup temporary files in the computer system are outlined as follows:

Steps

1. Type **"disk cleanup"** into the taskbar search box, as shown in Figure 6.11.

Figure 6.11: *Typing in the task bar*

2. Choose **"Disk Cleanup"** from the list of results, as shown in Figure 6.12.

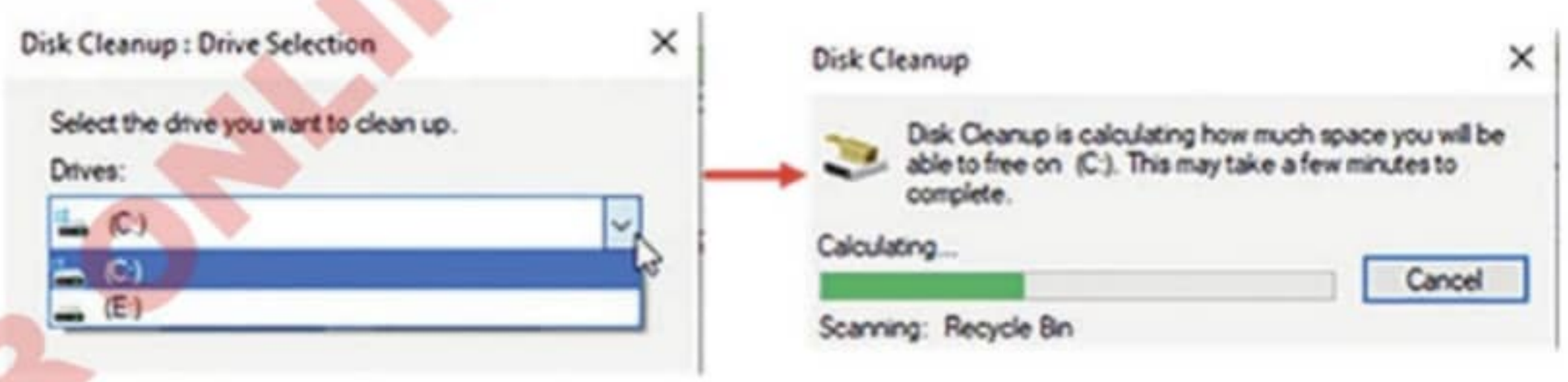


Figure 6.12: *Choosing a drive*

3. Select **OK** after choosing the drive you want to clean up.
4. Under "Files to delete" choose the file types you want to delete.
5. Select it to see a description of the file type, as shown in Figure 6.13.

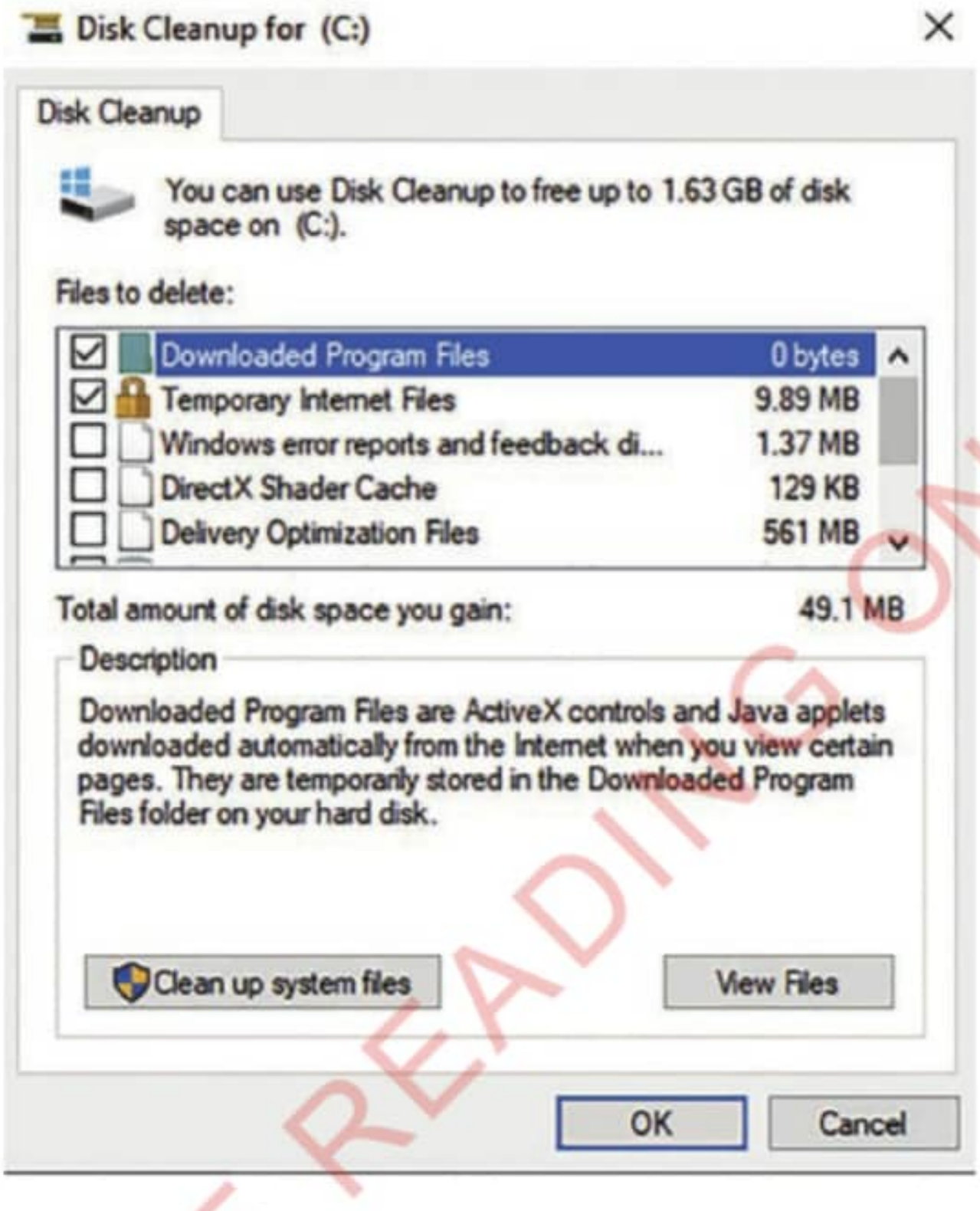


Figure 6.13: *Choosing file type*

6. Click **OK**.

Activity 6.7

Follow the instructions given on how to delete and clean temporary files.

Question

Explain why it is necessary to implement these steps.

Disk Defragmenter

There is a possibility that files are not stored in one area or sequence but are divided into various pieces before being stored. This is due to the possibility that the file is too large to fit in a single available hard disk space. The disk defragmenter rearranges all files so that they are all saved in the same place to make program run faster. The steps of disk defragmentation are outlined next.

Steps:

(i) Type **defrag** into the taskbar search box, as shown in Figure 6.14.

(ii) Select **Defragment and Optimize Drives**, as shown in Figure 6.14.

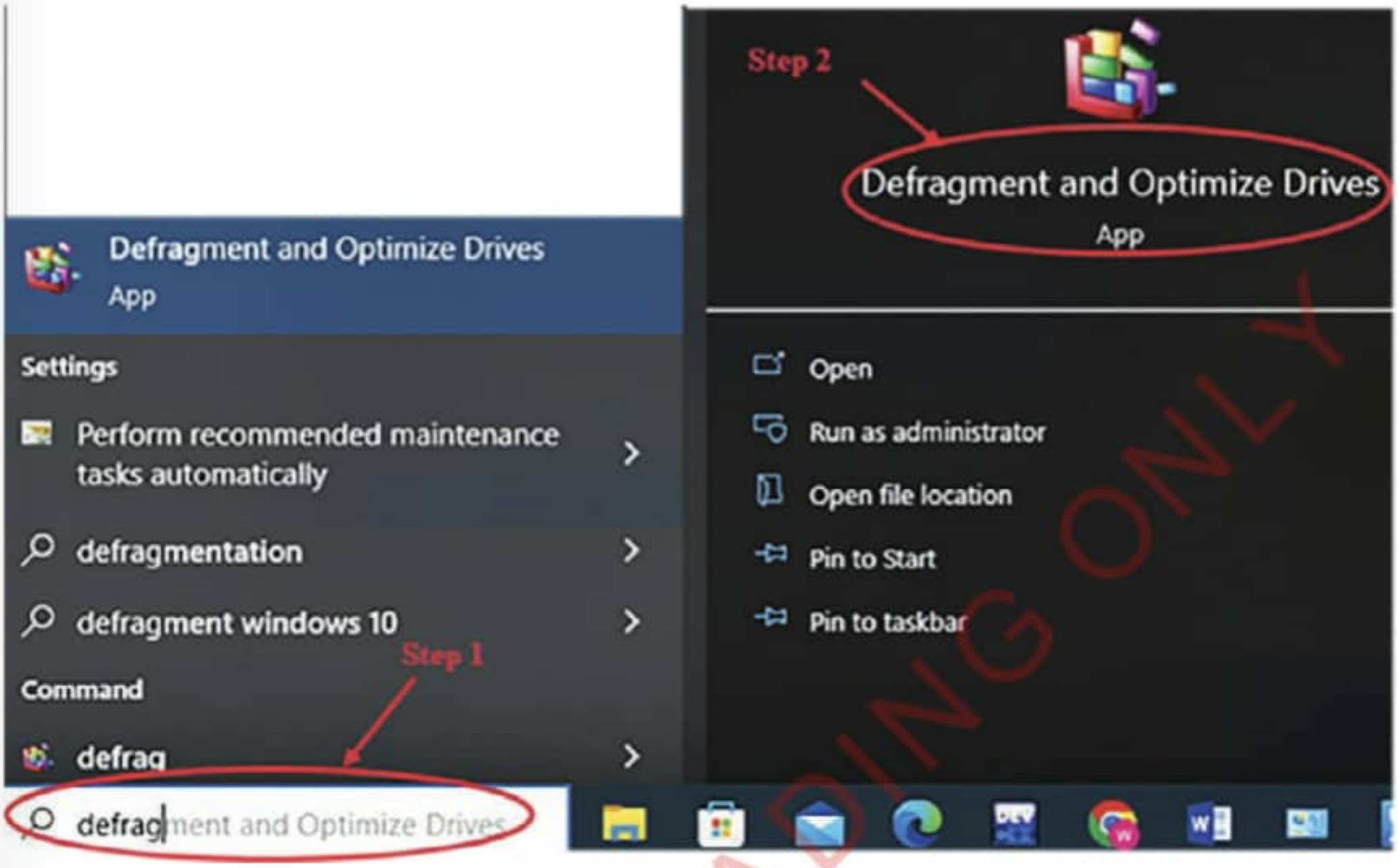


Figure 6.14: *Defragment search box*

(iii) Select the disk drive to be optimised, as shown in Figure 6.15

(iv) Select the **Optimize button**, as shown in Figure 6.15.

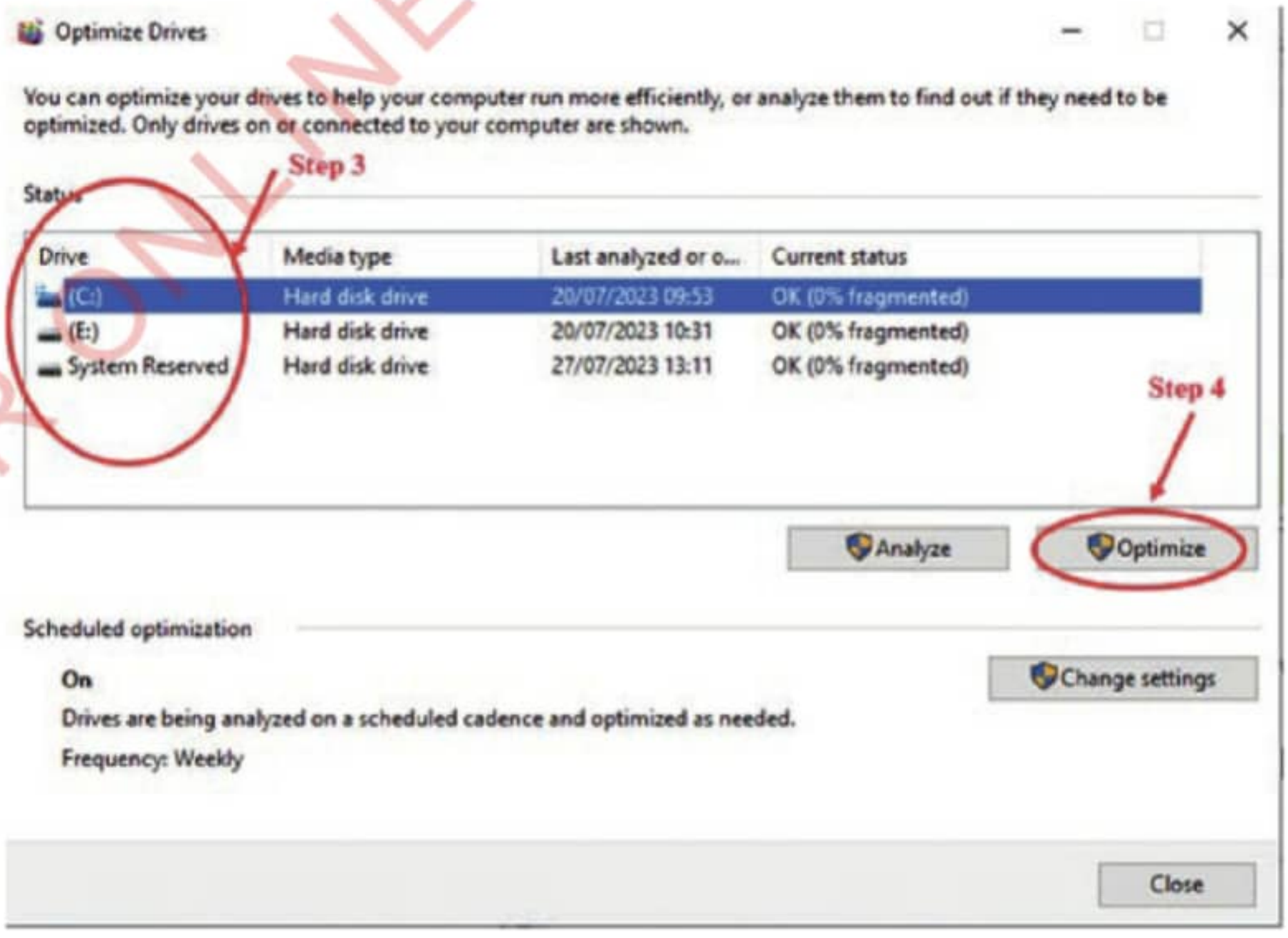


Figure 6.15: *Optimise drive*

Activity 6.8

Use the steps outlined to implement disk defragmentation.

Question

How often are you supposed to do disk defragmentation?

Check Disk

Conducting a check disk (CHKDSK) or scan disk is important in computer maintenance activity. It is designed to maintain the health of the file system.

The primary goal of utilising this tool is to identify and rectify any errors that could have a risen on the hard drive or storage device. Scan disk guarantees the stability and reliability of the file system, safeguarding against possible data loss and system issues. The steps to check the disk for errors are outlined in the next steps:

Steps

(i) Open the 'File Explorer' , right click the drive to be checked and then select 'Properties; as shown in Figure 6.16.

Figure 6.16: *Scan Disk-Properties*

(ii) Click **Check** to check for errors as shown in Figure 6.17.

Figure 6.17: *Scan disk-tools "Check"*

Activity 6.9

Use the steps outlined to checking disk for errors

Question

How often are you supposed to check for disk errors?

Routine software maintenance

Routine software maintenance involves regular tasks to keep the computer's software running smoothly and securely. Examples of routine software maintenance includes operating system updates, software updates, driver updates, anti-virus and anti-malware updates, firewall maintenance, password changes, data backup, software license management, and regular scans for malware and viruses.

Software updates

Computer software needs to be updated regularly with the newest security updates and features. If it is not updated, it may be vulnerable to security breaches, and some features may not function properly. An internet connection is normally required when updating software.

It is particularly important to make sure the operating system is always up to date. This is because the operating system is responsible for the overall functioning of a computer system. Any problem will affect the entire system. Every operating system provides a mechanism for updating itself either manually or automatically.

Activity 6.10

To update Windows manually, follow the steps shown in Figure 6.18.

Figure 6.18: *Steps for updating Windows OS manually*

Questions

1. What problems can arise if the operating system is not updated regularly?
2. Which one do you think is better, automatic or manual operating system update? Why?

Exercise 6.4

1. Assume you are working in a very busy office that produces a lot of data daily. Explain why and when you will use preventive, corrective, and routine maintenance.
2. Explain what can happen to a computer system if the disk is not regularly checked.
3. Why are disk cleanup and defragmentation essential for maintaining the efficiency of a computer hard drive?

Project work 6.1: Assembling a personal computer

Use reliable online sources or other resources to identify the important components to be used in assembling a newly desktop computer.

Hint: The name of each component should have detailed specifications and compatibility with each other.

Chapter Summary

Computer system maintenance refers to a set of activities and practices to ensure smooth functioning, reliability, security, and best performance. Proper maintenance helps extend the life of the system, reduces downtime, and minimises the risk of data loss or hardware failure. computer maintenance includes software installation and managing disks. The specific installation and managing steps may vary based on the Operating System you are using (Windows, macOS, or Linux). The general guide on how to manage disks before software installation involves data backup, checking disk space, disk partitioning, disk formatting, boot order, and reboot.

Computer system maintenance are preventive maintenance, corrective maintenance, and routine maintenance. Corrective maintenance, also known as "breakdown maintenance" or "run-to-failure" maintenance is a strategy where maintenance activities are performed after a problem or failure has occurred. In this approach, the equipment or system is used until it breaks down, and then repairs or replacements are carried out to restore it to working condition.

Routine maintenance is the process of identifying, analysing, and

resolving problems or issues that occur in a system, device, software, or equipment. It involves a systematic approach to diagnosing and fixing problems to restore the system's functionality and ensure it operates as intended.

Revision exercise 6

1. Imagine a scenario where a computer is overheating frequently. Identify potential causes of overheating and describe the preventive measures that can be taken to address this issue.
2. What makes a computer system owner decide to defragment a disk drive?
3. Imagine you are a computer technician at school. A student informs you that their computer is running slower than usual, and they are unable to save their work. What steps would you take to restore the computer functionality?

Chapter Seven

Computersystemtroubleshooting

Introduction

Sometimes computers can have problems that prevent them from working properly. Fixing these problems is important to make sure computers work as expected. In this chapter, you will learn about computer system troubleshooting. The competencies developed will enable you to effectively manage technical issues, increase efficiency and reduce expenses, retrieve lost data, improve security, and help others.

Think

Effective and efficient performance of a computer system

Concept of computer troubleshooting

Read scenario 7.1 then answer the questions that follow.

Scenario 7.1: *Troubleshooting*

Quietly at a corner of the school library, Kode sat hunched over his laptop, frustration evident on his face. His laptop had suddenly frozen, and he had been trying to get it working again for the past 45 minutes. The impending deadline for his project report was adding to his stress. Kode took a deep breath and decided to trace and correct faults step by step. He closed his eyes momentarily, recalling some computer troubleshooting tips he had learned recently. He opened his eyes, determined to resolve the issue.

Questions

1. Do you think Kode's situation can happen in the working environment?
2. What measures will you take if this happens to you?

Meaning of troubleshooting

Scenario 7.1 provides a real-life example of what occurs in the daily work environment. It is essential to learn methods for overcoming challenges that arise to enhance work efficiency and decrease downtime. Like any other digital device, a computer may stop working or fail to start due to software or hardware failure. Computer problems can be resolved through troubleshooting techniques.

Troubleshooting is the process of identifying, analysing, and resolving problems or issues that occur in a system, device, software, or equipment. The goal is to fix the identified problems, restore the system's functionality and ensure it operates as intended. This process involves investigating various components, configurations, settings, and interactions within the system.

Aspects of troubleshooting

The main aspects of troubleshooting are:

(i) *Problem identification:* The first step in troubleshooting is to clearly identify the problem or symptoms reported by users or detected in the system. It is essential to gather as much information as possible to understand the nature of the problem.

(ii) *Root cause analysis:* Once the problem is identified, the next step is to determine the root cause of the issue. This involves examining various factors, such as hardware, software, network connections, and user interactions to pinpoint what is causing the problem.

(iii) *Isolating and testing:* Troubleshooting often involves isolating components or elements within the system to determine whether the problem is related to a specific part or a broader system issue. Testing different configurations or using alternative components can help in this process.

(iv) *Solution implementation:* After identifying the root cause, the appropriate solution is implemented to fix the issue. This may involve adjusting settings, updating software, and replacing faulty hardware.

(v) *Verification:* Once the solution is implemented, it is important to verify whether the problem is resolved. Retesting the system and verifying that the issue has been resolved conforms to the success of troubleshooting.

(vi) *Documentation:* Documenting the troubleshooting process and its outcomes is crucial for future reference and to share the knowledge with others who may encounter similar problems.

Troubleshooting strategy

When troubleshooting a computer system, it is recommended to follow a general and systematic approach before exploring specific issues. Following this strategy will enable you to save

troubleshooting time, use less effort, and avoid frustration. This approach involves asking a series of questions whose answers lead you to the most probable source of trouble. The flowchart in Figure 7.1 suggests a sample of a computer troubleshooting strategy.

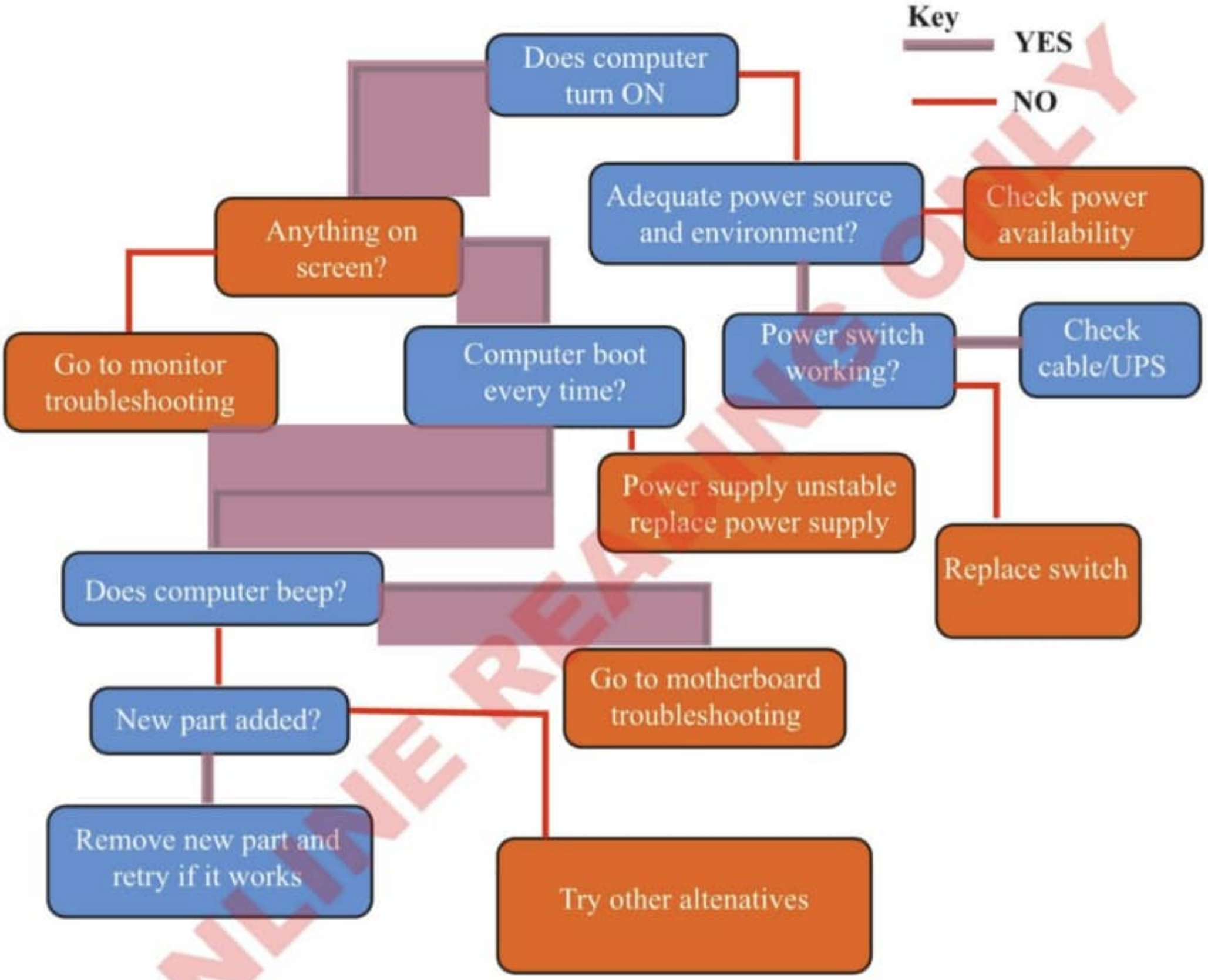


Figure 7.1: *Sample of computer troubleshooting flowchart*

Categories of troubleshooting

Troubleshooting can be categorised into several broad categories based on the type of systems or problems being addressed. The common categories of troubleshooting include:

(i) *Hardware troubleshooting:* This involves diagnosing and fixing issues related to computer hardware components, such as CPU, memory, motherboard, graphics card, hard drive, and peripherals like printers and scanners.

(ii) *Software troubleshooting:* This focuses on problems related to software applications, operating systems, and their interactions. This can include issues like software crashes, compatibility problems, and configuration errors.

(iii) *Performance troubleshooting:* It involves optimising system performance by diagnosing and addressing issues that lead to slow response times, resource utilisation problems, and performance limitations.

(iv) *Electrical troubleshooting:* This involves identifying and fixing electrical problems in various systems, such as power supply issues, circuit overloads, and electrical component failures.

Hardware troubleshooting

Computer hardware problems could be caused by a wide range of factors. Resolving the problems is always a process of trial and error, regardless of what is causing the problem. In some situations, there might be a need to try several different methods before finding a solution. In other cases, the problem might be simple to resolve. The guidelines to follow when performing hardware troubleshooting are as follows:

(i) Write down each step you will take in troubleshooting.

(ii) Write notes on each error message that comes from your computer.

(iii) Always check the cables for problems related to computer hardware, such as monitor, mouse, and keyboard.

(iv) Restart the computer when you have finished to troubleshoot the problem. Restarting the computer helps to refresh the hardware.

Computer hardware troubleshooting focuses on devices, such as monitors, mice, and keyboards. Common hardware problems include booting or power failure, application slowness, frozen or stuck applications, slow-running applications and frozen computers. Approaches to troubleshoot these problems are described below.

Booting failure

Computer booting is the process of starting a computer as initiated by a hardware action, such as pressing power or using a software command. If the power button does not initialise the booting of the computer, try the following alternative options:

(i) Inspect the power cord to ensure it is securely connected to both the back of the computer case and the power outlet.

(ii) Make sure the outlet connecting to it is functional, and verify this by plugging it into another electrical device.

(iii) When a computer is connected to a surge protector, check if the protector is switched on. You might need to reset the surge protector by turning it off and then on again. To confirm its proper functionality, you can also plug in a lamp or another device into the surge protector.

(iv) If a problem occurs with a laptop, the battery might be depleted. Connect the AC adapter to a wall socket, and then attempt to power

on the laptop. If it still does not start, you might have to wait a few minutes and retry.

Application slowness

When an application is running slowly, the following troubleshooting measures can be taken.

(i) Close and restart the application, or

(ii) Close all running applications.

Frozen or stuck application

For a frozen computer application, the following measures can be taken depending on the type of OS.

For Windows OS:

(i) Press and hold the Ctrl, Alt, and Delete keys simultaneously to open the Task Manager (see Figure 7.2).

(ii) Locate the unresponsive application or process in the list of running applications.

(iii) Select the unresponsive application by clicking on it.

(iv) Click the "End Task" button to force the selected application to close.

For Mac OS:

(i) Press and hold the Command, Option, and Esc keys simultaneously. The "Force Quit Applications" window will appear, showing a list of currently running applications;

(ii) Select the unresponsive application in the list; and

(iii) Click the "Force Quit" button to close it.

Slowly running applications

In the case where all applications in the computer run slowly, the following options should be observed as the measures.

(i) Perform a virus scan. There is a possibility that malicious software is running in the background, causing the slowdown.

(ii) Attempt to free up space by removing any unnecessary files or programs.

(iii) Utilise disk defragmenter for HDD or cleanup option for SSD.

(iv) Repeat the process performed on frozen or stuck applications.

Frozen computer

A computer may experience total unresponsiveness or freezing. The following options may be useful alternative measures for that problem.

(i) Reboot the computer. For a Windows PC, press and hold the keys Ctrl+Alt+Delete on the keyboard to access the Task Manager (see Figure 7.2) or;

(ii) Choose Windows Explorer from the Processes tab and click on Restart or;

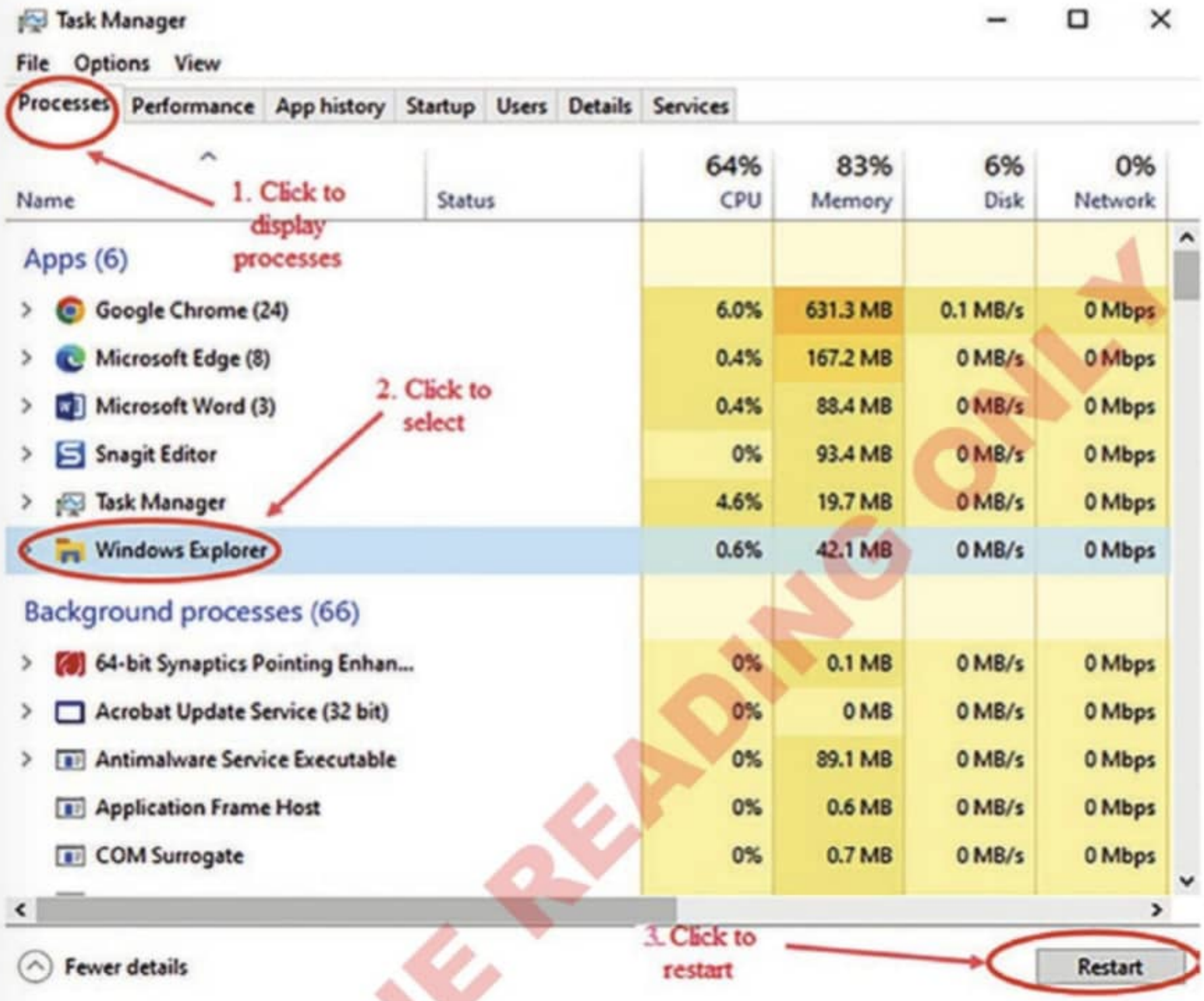


Figure 7.2: *Windows Explorer from the Processes tab*

(iii) Perform a forced shutdown by pressing and holding the Power button marked with a power symbol ⏻. Press and hold the power button for 5 to 10 seconds to force the computer to power off or; and

(iv) If the computer remains unresponsive to shut down, disconnect the power cable from the electrical outlet. For laptop users, remove the battery to force the computer to power off.

Note: Option (iv) should be the last solution after attempting the other solutions mentioned earlier.

Activity 7.1

Apply the steps outlined in this section to troubleshoot a computer that is experiencing booting failure, application slowness, frozen or stuck applications, slow running applications, or frozen computers.

Questions

1. Which task among these is likely to happen more often?
2. What might be the causes of this behaviour?

3. How do you identify and resolve hardware-related issues like crashes or freezing?

Keyboard and mouse problems

It is common for the keyboard and mouse to misbehave. The following are possible measures to apply to resolve their problems.

(i) For a wired mouse or keyboard, ensure that it is properly connected to the computer, or

(ii) For a wireless mouse or keyboard, verify that they are powered on and have charged batteries.

Sound problems

When you have a computer that has sound problems, check the following suggested measures.

(i) Verify the volume level by clicking the audio button located either in the top-right or bottom-right corner of the screen. Ensure that the sound is enabled and the volume is set to an appropriate level,

(ii) Examine the audio player controls and confirm if the sound is activated, and the volume is raised within the player,

(iii) Inspect the cables to ensure that external speakers are connected, powered on, and correctly plugged into the appropriate audio port or a USB port. The audio output port is identified by the green colour, or

(iv) Test audio output through headphones or external speakers by connecting them to the computer to determine if sound is heard through them.

Black screen

The black screen problem shows no image. The following are possible measures to be taken to solve the problem.

(i) The computer might be in sleep mode. Activate it by clicking the mouse or pressing any key on the keyboard,

(ii) Ensure the monitor is connected to a power source and turned on,

(iii) Verify that the computer is connected to a power source and turned on or

(iv) If you are using a desktop computer, check that the monitor cable is securely connected to both the computer tower and the monitor.

Monitor problems

Monitors have several problems that can be caused by electrical current or electromagnetic interference from the speaker, fan, or mobile phone. The next steps may be followed to work on such problems;

(i) If the problem is caused by a power supply or surge protector, plug the monitor into the wall socket separately. Else use an Uninterruptable Power Supply (UPS) if the cause is electrical current problems, or

(ii) Move all devices that emit electromagnetic waves far away from the desktop.

Scenario 7.2:
Computer crash

Imagine you are a computer laboratory technician at your school. One of the teachers, Kimati, has been experiencing frequent crashes on his computer. Each time the crash occurs, the computer displays a blank screen, and the mouse red light does not show up.

Question

How will you assist Kimati?

Exercise 7.1

1. Describe the steps to resolve a noisy fan in a computer system.
2. A computer monitor displays distorted or no image at all. What steps would you follow to identify and resolve the problem?
3. If a printer is not responding to print requests, explain the steps you would take to resolve the problem.
4. How would you resolve the issue if an external hard drive is not showing up on a computer?

Computer software troubleshooting is a systematic process that involves identifying, isolating, and resolving issues with computer software. Common software problems include:

(i) *Software bugs:* The software may have programming errors or defects that cause it to behave unexpectedly or crash.

(ii) *Compatibility issues:* The software may not be compatible with the operating system, hardware, or other software components.

(iii) *Configuration problems:* Incorrect settings or configurations can lead to software issues.

(iv) *Data corruption:* Corrupted or invalid data can cause software malfunctions.

(v) *Resource constraints:* Insufficient system resources, such as memory or disk space, can impact software performance.

To resolve software problems, follow the general steps described in software troubleshooting. However, it is also advised to do the following:

(i) *Update software:* Ensure that all software components, such as the operating system, drivers, and applications are up to date. Updating software regularly can resolve compatibility problems and security vulnerabilities.

(ii) *Disable or uninstall recently installed software:* If the issue began after installing a new software, consider disabling or uninstalling it. Incompatibilities with existing software can lead to problems.

(iii) *Scan for malware:* Conduct a thorough malware scan using dependable antivirus or anti-malware software. Malware can

cause various software issues, including system slowdowns and crashes.

(iv) *Inspect hardware:* Sometimes, software problems can result from faulty hardware components, such as RAM or storage drives. Perform hardware diagnostics if necessary.

(v) *Use safe mode:* Booting into safe mode (in case the OS supports it) can help determine if the problem is related to third-party applications or drivers.

(vi) *Reinstall software:* If troubleshooting steps don't resolve the issue, consider restoring the system to a previous working state using system restore points or reinstalling the problematic software.

Activity 7.2

Use the guideline of software troubleshooting advised to carry simple troubleshooting of software.

Questions

1. Did you find it difficult to troubleshoot software?
2. What circumstance will force you to uninstall a program or software installed on your computer?

Computer performance troubleshooting is the process of identifying and resolving problems that are causing a computer to run slowly or inefficiently. It involves diagnosing problems that may be causing a computer to run slowly or experience other performance-related issues. The steps involved in computer performance troubleshooting include:

(i) identifying symptoms;
(ii) checking hardware;
(iii) checking monitoring resource usage;
(iv) cleaning and maintenance;
(v) software updates;
(vi) malware and virus scans;
(vii) startup programs;
(viii) software optimisation;
(ix) hardware upgrades; and
(x) data backup.

Electrical troubleshooting is the process of identifying and resolving problems or faults in electrical systems, circuits, devices, or equipment. It involves diagnosing issues that may be causing electrical malfunctions, such as power outages, electrical shocks, equipment failures, or circuit overloads. The goal is to identify the root causes of these problems and fix them to ensure the safe and reliable operation of electrical systems.

Exercise 7.2

1. What are the reasons for conducting performance troubleshooting?
2. Why is it necessary to conduct electrical troubleshooting in computer systems?

3. What are the common hardware problems that can occur in a computer system?
4. What are the common software problems that can occur in a computer system?

Chapter Summary

Troubleshooting is the process of identifying, analysing, and resolving problems or issues that occur in a system, device, software, or equipment. The goal is to fix the identified problems and restore the system's functionality to ensure it operates as intended. Troubleshooting involves investigating various components, configurations, settings, and interactions within the system.

There are four areas to consider when doing computer troubleshooting. These areas are hardware, software, performance, and electrical troubleshooting.

Common hardware problems include booting failure, application slowness, stuck applications and frozen computers. Software troubleshooting involves systematic diagnosis of the problem. It extends to gathering information and implementing solutions to restore the software to its intended functionality.

Performance troubleshooting involves diagnosing problems that may be causing a computer to run slowly or experience other problems. Electrical troubleshooting involves diagnosing problems that may be causing electrical malfunctions, such as power outages, electrical shocks, equipment failures, or circuit overloads.

Revision exercise 7

1. Your class teacher has adopted a program for computing final grades written by Form Two students. However, after using it for some time, the class teacher realised that the program produces outputs that are not consistent. What type of problem is this? How can it be resolved?
2. Your best friend has shared their favourite computer game with you. Having realised that the game requires more computer resources than your computer has, you consider upgrading your computer so that you can install and enjoy the game. Having installed the game, you started playing it, but there was an error, and the game did not start successfully. The input dives did not work properly. What do you think should be done to play the game successfully?
3. John's office computer is running very slowly, he wants you to help him. What steps would you take to resolve the issue?
4. Suppose you want to use your computer, but it doesn't boot up properly when you switch on. How would you diagnose and resolve the booting problem?

Chapter Eight

Problem solving

Introduction

In daily life, there are always problems that need to be solved. These problems may be simple or complex. For example, we often need to solve simple problems, such as a mathematical equation, or solve a more complex problem, such as analysing data and writing a report. These problems can be solved by hand using pen and paper or computer. Solving a problem by hand usually takes a lot of time and money. Solving a problem requires a systematic approach that involves understanding that problem, deciding on a strategy and laying down a set of steps to be followed to solve the problem (an algorithm). In this chapter, you will learn the concept of problem solving; and algorithm development and representation. The competencies developed will enable you to identify problems and develop algorithms for solving real-life problem.

Think

Problem solving without a systematic approach

Concept of problem solving

Read case studies 8.1 to 8.3 about mobile payment systems, precision agriculture, and traffic management systems in Tanzania, then answer the questions that follow.

Case Study 8.1: *Mobile payment systems in Tanzania*

A few decades ago, a large population in Tanzania lacked access to banking services. Financial transactions were difficult to conduct, which resulted in individuals and businesses facing insecure and inefficient financial services.

Telecommunication companies introduced mobile money transaction services to overcome the challenge of transfering, depositing, and withdrawing money through mobile phones (See Figure 8.1). These payment systems are transforming society in terms of money flow and are improving the standard of life.

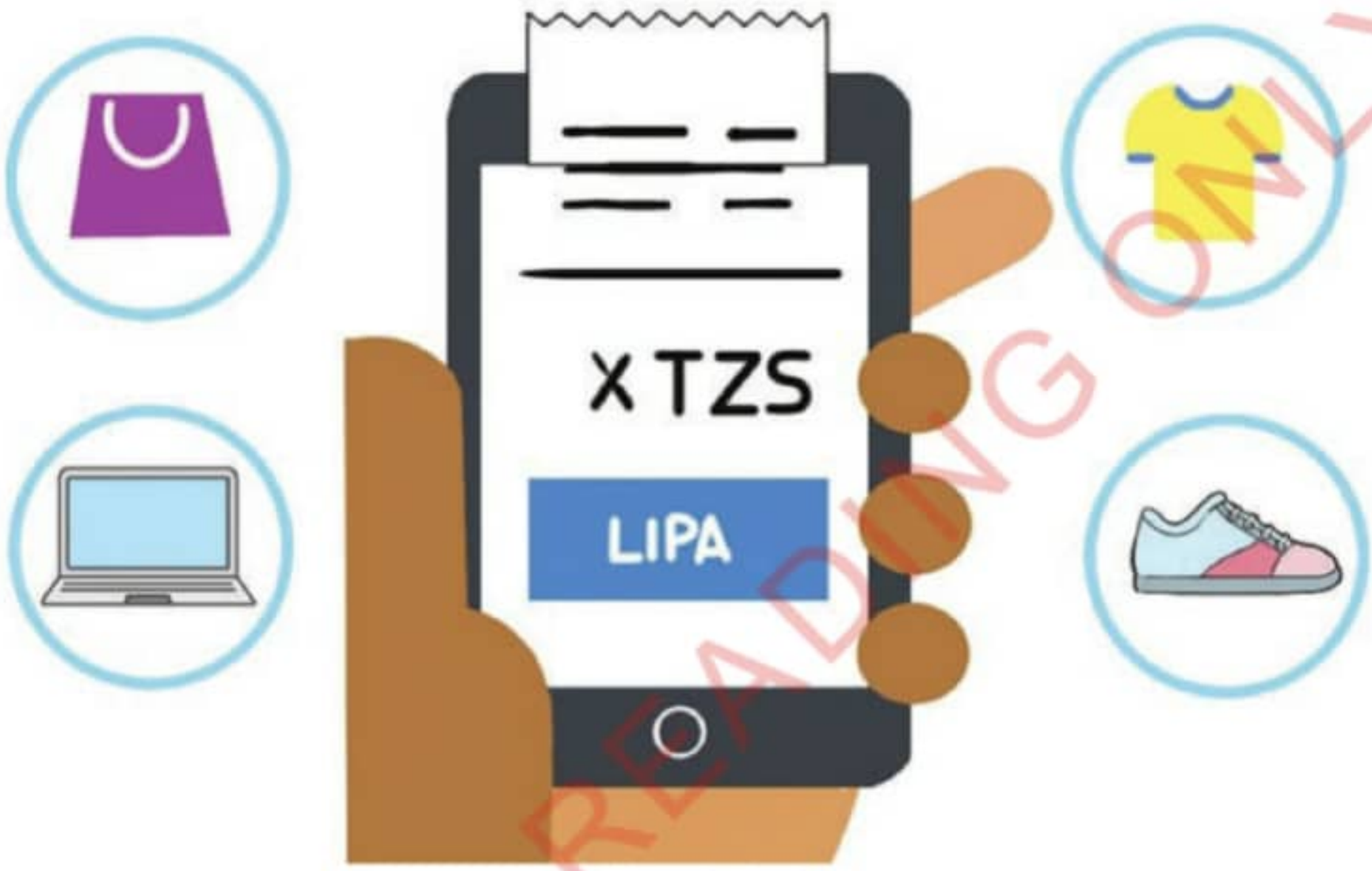


Figure 8.1: *Mobile payment systems*

Case Study 8.2: *Viewing examination results*

In past years, the National Examinations Council of Tanzania (NECTA) used to publish examination results in print form. The examination results were sent to secondary schools and other selected offices so that stakeholders, such as students and parents could see them. Students and parents had to wait very long to access the NECTA results.

The usage of digital technologies was suggested as a solution to the issue. Rather than waiting for hard-copy books, results can now be viewed online (see Figure 8.2). Additionally, results can be sent using SMS to stakeholders who do not have internet access.

S0240 ST. JOSEPH GIRLS' SEMINARY	S0241 KOWAK GIRLS'	S0245 PALLOTI GIRLS'
S0246 MAASAE GIRLS' LUTHERAN	S0247 BONICONSILI MABAMBA GIRLS'	S0248 MARIAN GIRLS'
S0249 LORETO GIRLS'	S0252 AL-KHEIR ISLAMIC GIRLS' SEMINARY	S0254 WALI-UL-ASR GIRLS' SEMINARY
S0255 ST. CHRISTINA GIRLS'	S0256 HURUMA GIRLS'	S0263 VISITATION GIRLS'
S0264 BARBRO-JOHANSSON	S0266 REGINAMUNDI GIRLS'	S0271 MANYUNYU
S0272 AL-IHSAN GIRLS'	S0275 GLENRONS GIRLS'	S0276 IFUNDA GIRLS'
S0279 EMMABERG GIRLS'	S0281 CHIEF IHUNYO	S0283 JOHN THE BAPTIST
S0284 RONECA GIRLS'	S0285 ST. THERESIA GIRLS'	S0291 GHOMME
S0298 FEZA GIRLS'	S0299 MKUGWA	S0302 ARUSHA
S0304 BUKOBA	S0305 BULUBA	S0306 DODOMA
S0307 DODOMA CENTRAL	S0308 ENABOISHU	S0309 FIDEL CASTRO
S0310 FOREST HILL	S0312 HIGHLANDS	S0313 IKIZU
S0314 KAZIMA	S0316 KIBASILA	S0317 KIBO
S0320 KIGOMA	S0321 KINONDONI	S0323 LAKE

Figure 8.2: *Viewing examination results online (Source: NECTA)*

The use of digital technology has shortened the time to view results and reduced many inconveniences that were previously faced. Furthermore, costs incurred by students and parents when travelling to access results have been significantly reduced.

Case Study 8.3: *Receiving and paying utility bills*

Figure 8.3: *Examples of government payment systems*

Utility bills, like those for water and electricity, used to be sent to consumers in print. Customers had to go to the relevant offices to pay the bills in cash after receiving them. The entire procedure was expensive and time-consuming.

The government introduced online payment systems to address this problem. For example, today's payment systems allow customers to receive water bills instantly. Such systems enable customers to use their mobile phones to pay the bills. In the case of electricity bills, customers no longer physically visit the TANESCO offices and agents; instead, they purchase electricity (tokens) online.

Questions

1. Do you think the suggested solution in each case study can solve the problem?
2. What could have been an alternative solution to the suggested solution?

Meaning of problem-solving

Case studies 8.1 to 8.3 shows real-life examples of problems and how alternative solutions were implemented. The art of studying, analysing, and formulating a methodology for solving a problem and finally applying the methodology to solve the problem is what is called problem solving. In all three cases, computer programs were developed to solve the problem. Therefore, the problem-solving ideas are common in any field. In this chapter, the focus is on problem solving using computers.

Importance of studying problem solving

Problem-solving is very important in the field of Computer Science. It is a foundational skill that underpins virtually every aspect of Computer Science and software development. The importance of problem-solving skills in developing a program is as follows:

(i) It helps in designing and optimising algorithms, ensuring they run quickly and use resources efficiently.

(ii) It helps in acquiring skills on how to break complex tasks into smaller, manageable components and solve them step by step.

Types of problems

There are so many problems in our daily lives, but all these problems can be grouped into two categories: problems that require algorithmic solutions and problems that requires heuristic solutions.

Problems that require algorithmic solutions

These are problems that can be solved with a series of actions. Their solution can be reached by identifying and completing

the actions in steps. Examples of such problems are finding an average of marks scored, sorting numbers, calculating utility bills, and finding the largest value out of many numbers. Computers are mainly built to deal with algorithmic solutions, which are often difficult or more time-consuming for humans. Problem solving, therefore, involves preparing instructions that must be followed to produce the best results. The act of preparing this solution is known as programming. The outcome of the completed computer-assisted answer of programming is a program. Therefore, a program is a set of instructions that make up the solution after they have been coded into a particular computer language.

Problems that require heuristic solutions

These are problems that cannot be reached through a direct set of steps. Solutions to such problems require reasoning built on knowledge and experience and a process of trial and error. Holistically, people are still processing most of the heuristic solutions. The field of computers that deals with heuristic types of problems is called artificial intelligence. Artificial intelligence enables a computer to do things like build its own knowledge bank and speak in a human language. In this case a computer's problem-solving abilities are like those of a human being.

Challenges of problem solving

Numerous problems can be solved. However, challenges in solving such problems arise due to:

(i) Insufficient knowledge and skills in how to solve problems.

(ii) Fear of making mistakes, which results in not making decisions.

(iii) Failure to complete all the steps of problem solving. For example, problem solvers may:

(a) If the problem is not defined correctly or may not generate a sufficient list of alternatives.

(b) Eliminate good alternatives or list the pros and cons too hastily.

(c) Not use a logical sequence of steps in their solution.

(d) Focus on details before the framework for the solution is in place.

(e) Incorrectly or haphazardly evaluate the solution.

(iv) Failure to dedicate time because the process is time consuming and needs a lot of concentration: hence, people tend not to attempt it.

Steps of problem solving

Good problem-solving skills can save a lot of time and resources. Effective problem-solvers are adept at dissecting an issue to understand its root cause, thus reducing the time spent on trial and error. This efficiency means projects

move faster, and the results are achieved in due time. There are six steps to solve both algorithmic and heuristic problems as shown in Figure 8.4.

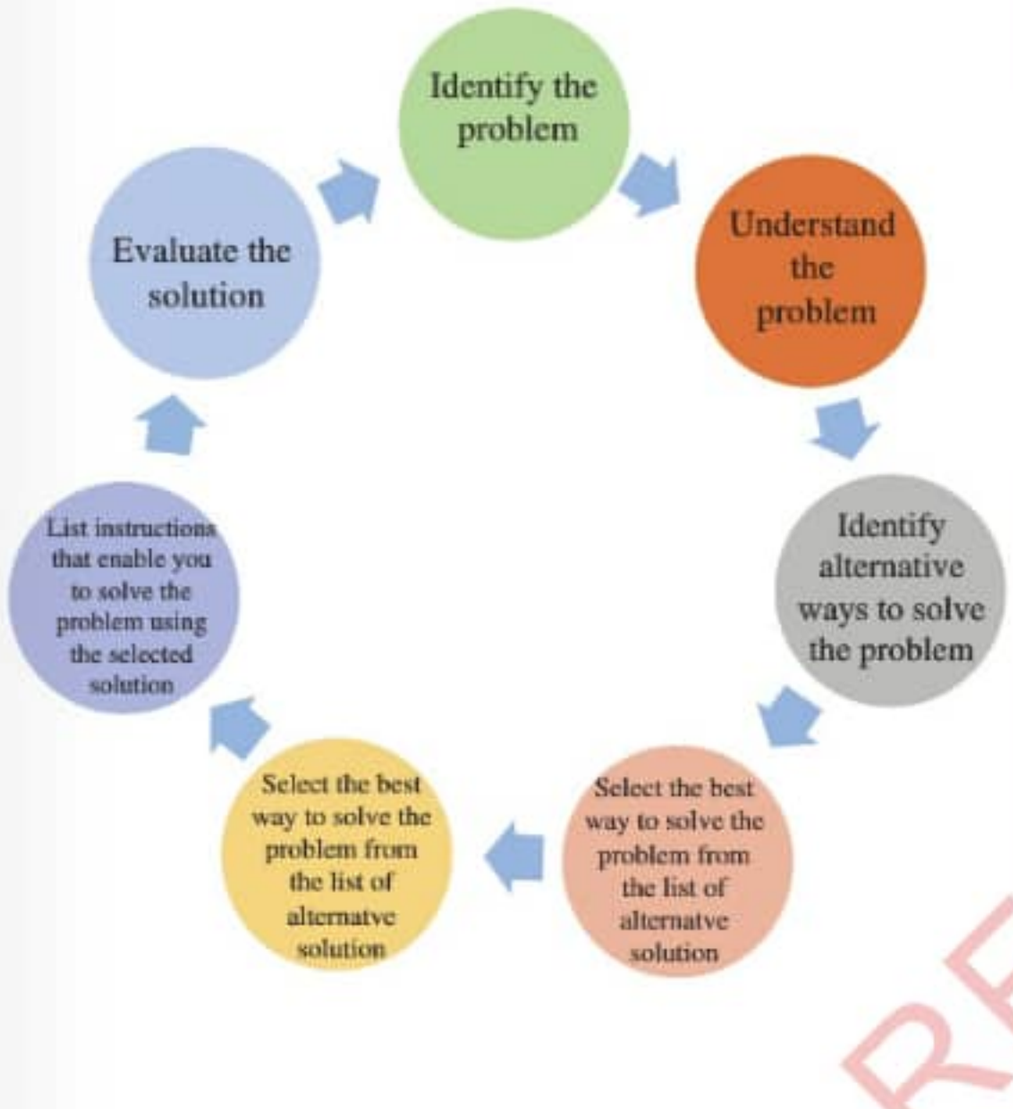


Figure 8.4: *Steps to solve to solve a problem*

It is important to note that problem-solving is a continuous process. Once a solution is implemented, another problem usually arises, and the cycle starts again.

Step 1: *Identify the problem*

This step involves identifying the problem before you start solving it. It involves recognising that a problem exists and understanding what it is. Generally, if you don't know what the problem is, it is impossible to solve it. Therefore, you should ask yourself, what am I going to solve?

Step 2: *Understand the problem*

This involves understanding the problem in detail, including its causes, effects, and potential solutions. You must ask yourself several questions to understand what you intend to solve. By analysing the problem, you can understand what is involved in the problem before you can continue toward the solution. Also, it helps to figure out the knowledge base on the problem as well as the outputs and inputs you intend for the solution. Knowing the knowledge base is very important since you cannot use any instructions outside this base.

Step 3: *Identify alternative ways to solve the problem*

A particular problem may have more than one way to solve it. This step gives a way to analyse different ways and possible solutions to a given problem. Therefore, you need to generate possible solutions. This involves brainstorming ideas and strategies to solve the problem. The list of alternative solutions should be as exhaustive as possible.

Step 4: *Select the best way to solve the problem from the list of alternative solutions*

After the analysing a list of alternative ways to solve a problem, you need to select the best alternative. This involves assessing the feasibility, effectiveness, and efficiency of each solution. You should ask yourself, what have I done

already in the proposed solution? What do I think the solution should be doing? You need to identify and evaluate the advantages and disadvantages of each possible solution before selecting the best one. To do this, you need to select criteria for the evaluation. These criteria will serve as the guidelines for evaluating each solution.

Step 5: *List instructions that enable you to solve the problem using the selected solution*

At this point, you can now decide on the resources needed to use in solving the problem. First, break the problem into subproblems to allow for a more organised and focused approach to problem-solving. Second, prepare instructions for solving the problem. Instructions for solving a problem are listed in a sequence of steps. In the case of algorithmic problems, it is time to write the algorithm for the problem. The details of the algorithm will follow in the next section. Remember, each subproblem is handled independently and when completed, they are combined to solve the whole problem.

Step 6: *Evaluate the solution*

To evaluate or test a solution means to check its result to see if it is correct. It means to see if the solution satisfies the needs of the people who experience that problem. You should ask yourself, if the solution effectively solved the problem. Does it satisfy the client? For example, when a person needs a shirt, buying her a t-shirt may be a correct solution, but it may not be a very satisfactory one. If the result is either incorrect or unsatisfactory, then the problem solver must review the list of instructions to see that they are correct or start the process all over again.

Activity 8.1

Use a library or internet search to explore real-world challenges and their proposed solutions following the steps outlined in this section. Document your findings together with the references of the sources of your information.

Questions

Which stage was more challenging compared to others?

Exercise 8.1

1. What is the importance of studying problem-solving concepts in day-to-day activities?
2. Identify a sample problem and describe how to find a solution for that problem.
3. How can you apply problem-solving skills in other areas apart from Computer Science?

Algorithms

This section introduces you to the concept of algorithms. Before proceeding, read Scenario 8.1 on everyday activities and then answer the questions that follow.

Scenario 8.1

Performing everyday activities

Every day, Kode performs activities by following steps. Examples of activities he performs include getting ready for body exercise, preparing breakfast, riding a bicycle, wearing shoes, and washing utensils. To complete each activity, he follows a sequence of steps. Examples of steps he uses to ride a bicycle are to:

(a) Remove the bicycle from the stand;

(b) Sit on the seat of the bicycle;

(c) Start peddling;

(d) Use breaks whenever needed; and

(e) Stop on reaching the destination.

Questions

1. Explain what will happen if Kode skips step (c) in the scenario.
2. What is the importance of following all the steps without skipping any?

Meaning of algorithms

An algorithm is a set of steps leading to the solution of a given problem. It is a method of representing the systematic and logical procedure for solving a problem. The steps in scenario 8.1 are an example of an algorithm for the smooth riding of bicycle. Thus, from the scenario, a set of procedures is required to be performed for a given task. The steps to solve a problem like those performed by Kode form an algorithm. Before developing an algorithm for solving a given problem, think of what the output will be when such an algorithm is implemented. Other examples of algorithms include finding the shortest route between your home and a school, steps of cooking tea, and finding the greatest common multiple (GCD) of two numbers, such as 48 and 18.

Importance of an algorithm

The importance of the algorithm is as follows:

(i) It is essential to enhancing a computer program according to the available resources;

(ii) It enables you to solve a problem through a better approach;

(iii) It saves for the best program speed and desired minor memory consumption; and

(iv) It emphasises solving problems in a straightforward manner.

Characteristics of a suitable algorithm

(i) *Well-defined input:* An algorithm requires some input values. Such input values can be zero or more,

but only a finite number of inputs are required.

(ii) *Well defined output:* The algorithm must give an output (one or more) once executed. The output produced should have a specific relationship with the input.

(iii) *Unambiguity:* The algorithm's instructions should be clear, precise, and well communicated.

(iv) *Effectiveness:* Each instruction in an algorithm should be adequate. That is, an algorithm should be designed in such a way that it correctly achieves its purpose and does exactly it was intended to be done in a finite length of time.

(v) *Programming language independence:* The algorithm should not depend on a particular programming language for its implementation. That is, once presented, it should always provide the same result regardless of the programming language used to write the program.

(vi) *Finiteness:* An algorithm must be composed of a finite number of steps. That is, for all different cases, the written algorithm should provide the result within a finite number of steps.

(vii) *Terminator:* The algorithm must terminate.

Qualities of a good algorithm

(i) *Memory utilisation:* The best algorithm is the one that will ensure that a program consumes the least memory.

(ii) *Efficiency:* The best algorithm enables a computer program to produce results while using less processing power in a short time.

(iii) *Cost-effective:* The best algorithm is the one that is simple, straightforward, and produced using minimal cost.

(iv) *Accuracy:* The best algorithm may provide more accurate results than other existing algorithms.

Recommendations for writing a suitable computer algorithm

The following are recommendations for writing a good algorithm:

(i) The instructions in the algorithms should be clear and precise to the programmer;

(ii) Write steps of algorithms in logical sequence;

(iii) Avoid infinite repetitions of instruction;

(iv) Phrases or words used should sound like typical natural language; and

(v) Make sure that the algorithms will finally terminate.

Uses of algorithm

An algorithm aims at increasing the reliability, accuracy, and efficiency of obtaining solutions. Algorithms are helpful for small and complicated problems.

Algorithm design principles

Some principles that guide the design of algorithms include:

(i) *Correctness:* Any valid input to the algorithm should produce the correct output and solve the intended problem without producing errors.

(ii) *Efficiency:* Algorithms should be efficient in terms of time and space. This means that the algorithm must work within a reasonable amount of time. Also, it should not employ large amounts of memory or resources.

(iii) *Input and Output:* Algorithms should have well-defined input and output specifying the expected input and output type to be produced.

(iv) *Determinism:* The algorithm should produce the same output for the same input and not something that un expected.

(v) *Finiteness:* Steps that are followed in algorithms must end. They should terminate and produce the desired output after several computations.

(vi) *Scalability:* Algorithms should be capable of handling larger problem sizes such that when input size increases, the performance should not decrease.

(vii) *Modularity:* Algorithms should be put into smaller subproblems to ensure the readability of code when implemented.

Exercise 8.2

1. Define algorithm using the understanding you have gained from this section.
2. Why designing efficient algorithms very important in solving a problem?
3. Explore the school environment and find out any problem that may require an algorithm to solve.

Construction of algorithms

In our daily lives, algorithms are used knowingly or unknowingly. Activities are performed using defined steps, making some decisions, selecting items, arranging things in a given order, and classifying things using a given criterion. All these are examples of algorithms. Other examples of algorithms in our daily lives include cooking, assembling something like a computer, and steps to power on a computer. Additional examples are sorting students' test or examination papers alphabetically and finding the shortest pathway to somewhere.

For example, you can write an algorithm to make a cup of tea as follows:

(i) Get a teabag, cup, kettle, water, sugar, and teaspoon;

(ii) Put the teabag in the cup;

(iii) Put some water in the kettle;

(iv) Boil the water in the kettle;

(v) Pour some boiled water into the cup;

(vi) Add a teaspoon of sugar to the cup; and

(vii) Stir the tea using a teaspoon until the sugar is dissolved.

Steps to construct an algorithm

(i) Collect detailed information on the problem

Identifying detailed information about the problem is a significant step in writing an algorithm. Before starting with an algorithm, you must first obtain detailed information about the problem you want to solve. This step will help enhance understanding of the problem and verify of the steps that will be used to solve the problem.

(ii) Analyse the problem

The precise analysis of the problem involves determining the nature of the inputs and outputs to the algorithm as well as the desired output.

(iii) Decide on the approach for solving the problem

In this stage, you need to develop a problem-solving approach to help construct the model that will solve the given problem. Build on experience and practice when selecting an excellent approach.

(iv) Review the approach and better alternatives

The best algorithm must comprise the best approach for solving a problem that reduces the effort required to create a program. It must also reduce the time required for a program to work (run). For that reason, when you think of a problem-solving approach, try to think about a better alternative for producing the best results. Review the approach to ensure that it solves the problem.

(v) Develop the entire organisation of the algorithm

Outline the steps required to solve the problem.

(vi) Refine the algorithm

After developing an algorithm, try to refine it in terms of efficiency and clarity.

Activity 8.2

(a) Identify two problem activities that require algorithms in your environment. Give reasons to support your choice.

(b) Write down the algorithm for each problem activity in (a) following the steps outlined in this section.

Questions

1. Suppose you did not write the algorithm for the problem in Activities 8.2. What do you think would happen?
2. Suggest ways to improve the algorithms you have developed in Activity 8.2.
3. Where else can you apply this kind of algorithm?

Exercise 8.3

1. Ndiyune has been given an unsorted list of numbers and his goal is to develop an algorithm to arrange these numbers in ascending order.
   (a) Identify the problem that Ndiyune is supposed to tackle.
   (b) Create an algorithm to solve a problem identified in (a).
2. Mwalimu Masiku is planning to distribute a set of "peremende" to a group of children. Each child must receive the same number of "peremende". Mwalimu Masiku intends to distribute the maximum number of peremende possible.
   (a) Identify the problem that Mwalimu Masiku is supposed to solve.
   (b) Write an algorithm to find the maximum number of peremende that Mwalimu Masiku can distribute to each child, ensuring an equal distribution.

Representation of algorithms

Until now, algorithms have been represented as an outline of steps to solve a given problem. This approach suffices for algorithms to be carried out manually. Algorithms to be coded for computer-based solutions are normally represented in different ways. That representation makes it easy to translate the algorithm into a computer program. To address this need, the representation of algorithms is done using either flowcharts or pseudocode.

Flowcharts

A flowchart is a diagrammatic representation of an algorithm. A flowchart is constructed using different types of symbols, each representing a particular step or action taken in an algorithm. One advantage of flowcharts is that they are helpful in detailed representations of algorithms.

Advantages of flowcharts

(i) Practical analysis: The problems can be analysed more effectively using flowcharts.

(ii) Efficient coding: Flowcharts act as a guide or blueprint during the system analysis and program development phase. You can easily convert flowcharts into code in any programming language.

(iii) Proper documentation: Flowcharts serve as good program documentation and are required for various purposes.

Disadvantages of flowcharts

Although flowcharts are a convenient tool for representing algorithms, their use has few limitations.

(i) Alterations and modifications: Changes can become problematic since they usually require rewriting the entire flowchart, which costs money and other resources.

(ii) Loss of detail: The essentials of what is done can be easily lost in the technical details of how it is represented.

(iii) Complex logic: Flowcharts are not suited for representing complex algorithms.

Rules for drawing flowcharts

The following six rules should be followed when creating program flowcharts:

(i) Only the standard symbols shown in Table 8.1 should be used in program flowcharts.

(ii) There should be a logical flow of steps.

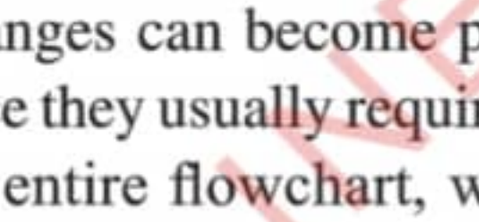
(iii) Each symbol used in a program flowchart should contain only one entry point and one exit point, except the decision symbol.

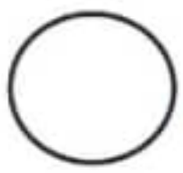
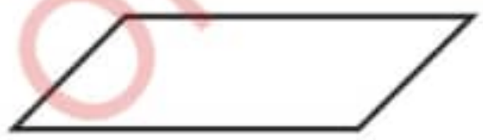
(iv) The operations shown within a symbol of a program flowchart should be expressed independently of a particular programming language.

(v) All decision branches should be labelled clearly.

(vi) All components of a flowchart should be connected through arrows.

Table 8.1: *Symbols used in flowcharts*

S/N	Symbol	Description
1.		Process symbol: Indicates the processing step. The description of a step is written inside the box. This indicates any type of internal operation inside the processor or memory

S/N	Symbol	Description
2.		Flowlines symbol: The arrow shows the direction of flow from one step or decision to another.
3.		Decision symbol: This is the symbol used in a flowchart to indicate a point at which a decision must be made and a branch to one or two more alternative points is possible. The decision symbol usually contains two exits; one labelled YES or TRUE and the other NO or FALSE. The decision is based on a question. The question is written inside the symbol.
4.		Delay or wait symbol: In flowcharts, the "wait" or "delay" symbol indicates a temporary pause or halt in the execution of a process. It represents a specified period where the flowchart stops before moving on to the next step or action.
5.		Connector symbol: Specifies a link to another page or another flowchart when a complex flowchart is to be drawn with various flow line directions. The same symbol on the other page indicates that the flow continues there.
6.		Input or output symbol: Used for both input (read) and output (write) to denote any function of an I/O device.
7.		Printed document: Specifies if the input or output from the process is in the form of the printed document
8		Terminal symbols: These are alternatives for start and end points. They always begin and end a flowchart. The start symbol can have only one flow line but no entering flowline. The stop symbol can have an entering flow line but no exit.

These are a few symbols that are commonly used, but you may come across other symbols depending on the complexity of the algorithm to be represented.

Activity 8.3

Use the library or internet search to explore the use and representation of these symbols in flowcharts.

Questions

1. In which circumstances are the symbols used? Explain.
2. How can the 'delay' or 'wait' symbol be effectively utilised in an algorithm to control the timing of specific actions or processes? Provide an example scenario where using this symbol would be useful, then draw a flowchart of that scenario.

Steps for drawing a flowchart

There are various steps in drawing a flow chart. The following are general steps:

(i) *Know the purpose of your flowchart*:

Clearly understand the algorithm you want to represent in the flowchart. Identify the start and end points, the major steps in between.

(ii) *Identify the steps*:

Break down the process into individual steps or actions. Each step should represent a specific task or decision.

(iii) *Collect information*:

Collect all the information and details needed to represent the algorithm accurately. This may include data inputs, decision points, actions, and outputs.

(iv) *Add shapes and symbols:*

Use common symbols, including:

(a) Rectangle for processes or actions,

(b) Diamond for decision points or conditional statements,

(c) Ellipse for the start or end of the process,

(d) Parallelogram for input or output of data, and

(e) Arrows connect symbols to show the flow of the process.

(v) *Determine the flow:*

Decide the sequence of actions and decisions in the process. Determine which symbols to use for each step and how they connect. Shapes are connected using lines and arrows.

(vi) *Add decision points:*

If there are decision points in the process where different paths can be taken based on certain conditions, add decision symbols (usually diamond-shaped) to represent these points.

(vii) *Include start and end points:*

Include a starting symbol (usually an oval shape) to represent the beginning of the process and an ending symbol (also an oval) to represent the conclusion of the process.

(viii) *Add connectors:*

Employ link points (small circles) to join different parts of the flowchart together, especially when the flowchart extends across multiple pages.

Example 1

Write an algorithm for calculating the sum of any two numbers entered by the user and then draw a flowchart for it.

Solution:

Algorithm for adding two numbers:

Step 1: Start by identifying two numbers, e.g., N1 and N2.

Step 2: Input or write the first number N1.

Step 3: Input or write the second number N2.

Step 4: Add the number N1 and number N2, i.e., N1+N2.

Step 5: Give the answer or output the sum, i.e., Sum= N1 + N2.

Step 6: End the process.

The following are steps for drawing the flowchart that will calculate the sum of any two numbers:

Step 1: Identify the inputs (two numbers, for example, N1 and N2),

Step 2: Define the processes or actions, that is, adding or calculating the sum of the two numbers.

Step 3: Identify the output. Output is the sum.

Step 4: Identify the standard symbols used in the problem.

Step 5: Draw a flowchart, as shown in Figure 8.5.

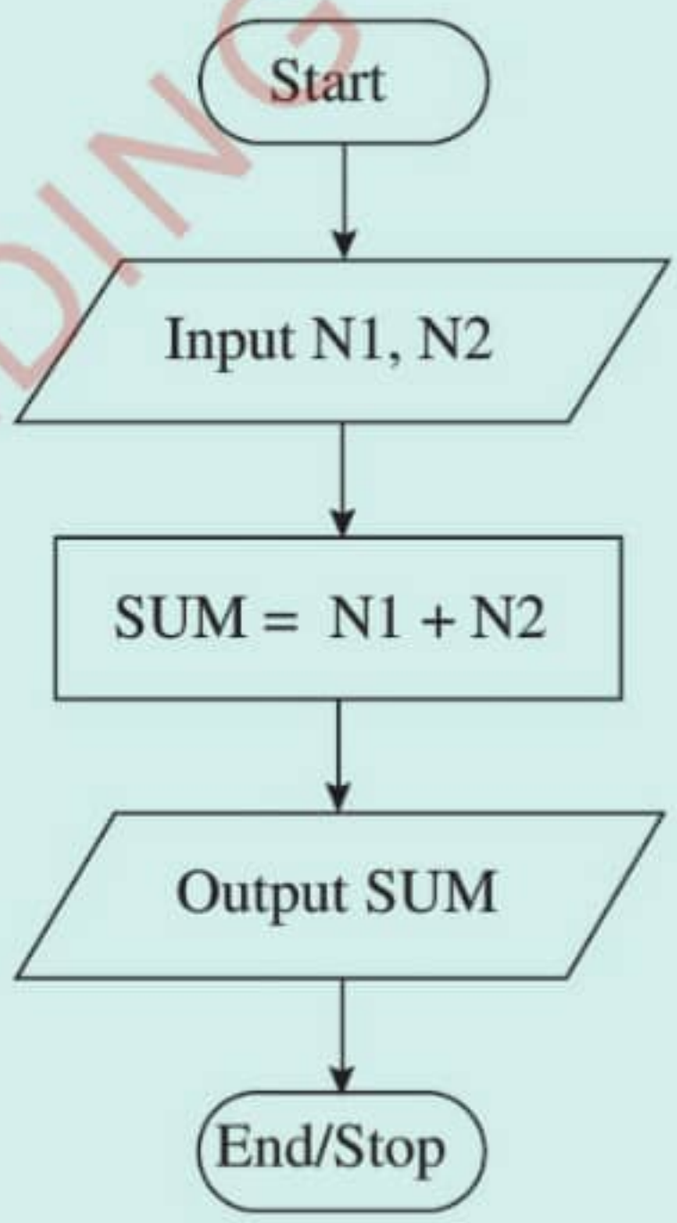


Figure 8.5: *Flow chart for the sum of two numbers*

Example 2

Suppose we want to write an algorithm to find the square of a number and represent it using a flowchart.

Before developing the algorithm, you should first identify the input, process, and output. In this case, input will be the number whose square is required.

The process will be to multiply the number by itself to get its square. The output will be the square of the number. The following is the algorithm to find the square of a number:

1. Get the number to be squared.
2. Multiply the number by itself.
3. Show the result.

The steps for representing this algorithm in a flowchart are:

Step 1: Identify input. Input here is a number that is entered, the 'Num'.

Step 2: Define the process or action. The action here is to multiply where you compute Num * Num, that is a product output for Square.

Step 3: Determine or identify output. The output here is to Print Square. The flowchart will appears as shown in Figure 8.6.

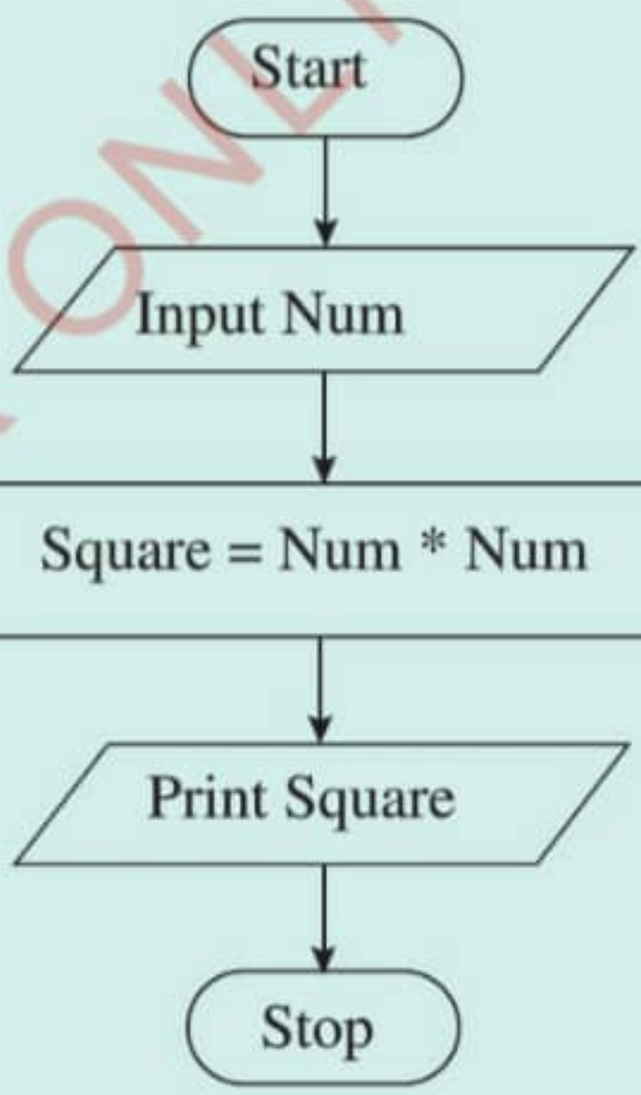


Figure 8.6: *Flow chart to compute the square of two number*

Activity 8.4

(a) Think about numerous activities in our daily lives that involve individuals selecting one course of action and presenting one of them using a flowchart.

(b) Choose one of the activities in (a) above

(c) Identify the inputs, process, and output elements.

(d) Identify the standard symbols for (c) above.

(e) Present it using a flowchart.

Questions

1. Did you find any challenges in identifying problem activities in your environment? Explain.
2. How did you know that it is an activity that has a problem to solve?

Exercise 8.4.

1. Describe the meaning of flowchart as used in the representation of the algorithm.
2. Do you think, to this point, you can tell someone that flowcharts are not useful in problem-solving? Explain.
3. Is it possible that all symbols for the flowchart outlined in this section

can be used in all types of problems that needs a solution?

4. Draw a flowchart to calculate the area of a circle.

Representation of algorithms using pseudocode

Pseudocode is the textural representation of an algorithm containing a detailed description of instructions. Pseudocode is a non-formal language that helps programmers to write algorithms. It is a type of structured English or Swahili used to specify an algorithm. It is neither compiled nor executed by a computer. There are no accurate formatting or syntax rules for writing pseudocodes.

The importance of pseudocode

Pseudocode is easy to read, understand, and modify. Pseudocode helps review the steps to confirm that the expected implementation will achieve the desired output.

Advantages of pseudocode

The following are the advantages of pseudocode:

(i) It can be easily modified, unlike flowcharts.

(ii) It can be read and understood easily.

(iii) It is easier to convert the pseudocode to a programming language than flowcharts.

(iv) It is helpful in structured design.

(v) It can be easily written using any word processor or text editor.

Disadvantages of pseudocode

The following are the disadvantages of pseudocode:

(i) It is more difficult for a beginner to follow the logic or write pseudocode than a flowchart.

(ii) There is no standard way of writing pseudocode. As a result, we can have different pseudocodes from one problem.

In pseudocode, keywords are used to indicate common input, processing operations, and output. They can be written entirely in uppercase or start with a capital letter. The commonly used keywords are described in Table 8.2.

Table 8.2: *Standard keywords used in pseudocode*

Item	Keyword	Description
1	START or BEGIN	This is used whenever you start your pseudocode.
2	INPUT, READ, or GET	These are keywords used for inputting data.
4	PRINT, DISPLAY, or SHOW	This will show your output to a screen or any output device.

Item	Keyword	Description
5	COMPUTE, CALCULATE or DETERMINE	This is used to calculate the results of an expression
6	SET	It is used to initialise values or assign a value to a variable
7	INCREMENT	It is used when you want to increase the value of a variable by one
8	DECREMENT	This keyword is meant to reduce the value of a variable by one.
9	END	Used to indicate the endpoint of the program or a process

Rules for writing pseudocode

(i) Only one statement should be written for each line, where each statement should represent a single action.

(ii) The input, output, and process statements must be clearly stated using standard keywords, such as READ, PRINT, WRITE, DISPLAY, and RETURN. For example,

```
START
        READ a, b, c
        c = a+b
        PRINT c
END
```

(iii) Each initial keyword should be capitalised. For example, pseudocodes are used to calculate the area of a triangle.

```
START
        READ base, height, area
        COMPUTE:
         area=0.5*base*height
        PRINT area
END
```

(iv) Show indentation for the pseudocode. For example, the pseudocodes used to find the minimum of the two numbers, can be indicated as follows.

```
BEGIN
        READ num1, num2
    If (num1<num2)
            SET Min=num1
    Else
            SET Min=num2
        PRINT Min
END
```

(v) Pseudocode should clearly show the start and end of executable statements and control structures.

(vi) The statements should be short, clear, and readable.

Example 3

Suppose you are given a task to find the average of two numbers entered by the user. Write pseudocode for this task and display the output on the screen.

Procedure:

(i) Think about what your input will be. For example, let the two numbers be X and Y.

(ii) Identify the processes. In this case, processes are add the X andY numbers and divide the sum by 2 to get the average.

(iii) Identify the outputs. In this case, the output is AVERAGE.

The pseudocode for calculating the sum and average will be as follows:

```
START
        PRINT "Enter two numbers."
        INPUT X, Y
        SUM = X+Y
        AVERAGE = SUM/2
        PRINT SUM
        PRINT AVERAGE
END
```

Comparison between flowcharts and pseudocode

Table 8.3 shows the comparison between flowcharts and pseudocode.

Table 8.3: *Comparison between flowchart and pseudocode*

S/n	Criteria	Pseudocode	Flowchart
1.	Representation	Textural representation of an algorithm	Graphical representation of an algorithm
2.	Level of details	It is flexible to accommodate many details	If many details are needed the flowchart becomes more complex
3.	Alteration	The pseudocode is flexible to alteration after it has been designed	It is difficult to modify once it has already been designed
4.	Format	There are no specific symbols to use, only textural description	Uses specific symbols to present the algorithm

Activity 8.5

Study the rules for writing algorithms and pseudocode, then do the following:

1. Write an algorithm to find the area of a circle of radius r. Then, represent it using pseudocode.
2. Write an algorithm to read three numbers and find their sum and then, represent it using pseudocodes.
3. Write an algorithm to convert temperature from Fahrenheit to Celsius and then represent it using pseudocode.

Questions

1. Did you face any challenges relating the rules to the formulars, operations, and processes? How did you manage to interpret the rules of an algorithm?
2. Which task among the three in Activity 8.5 is most challenging? Explain the challenges you faced compared to others and how you solved them.

Control structures in flowcharts and pseudocode

Control structures are essential components in programming that dictate how an execution of a program flows. They assist programmers in controlling the order in which instructions are executed, enabling them to make decisions and repeat actions as needed. There are three basic types of control structures that flowcharts and pseudocode operations employ. In drawing flowcharts, control structures can be used to represent control of the process flow in terms of sequence, selection, and iteration, as shown in Figure 8.7.

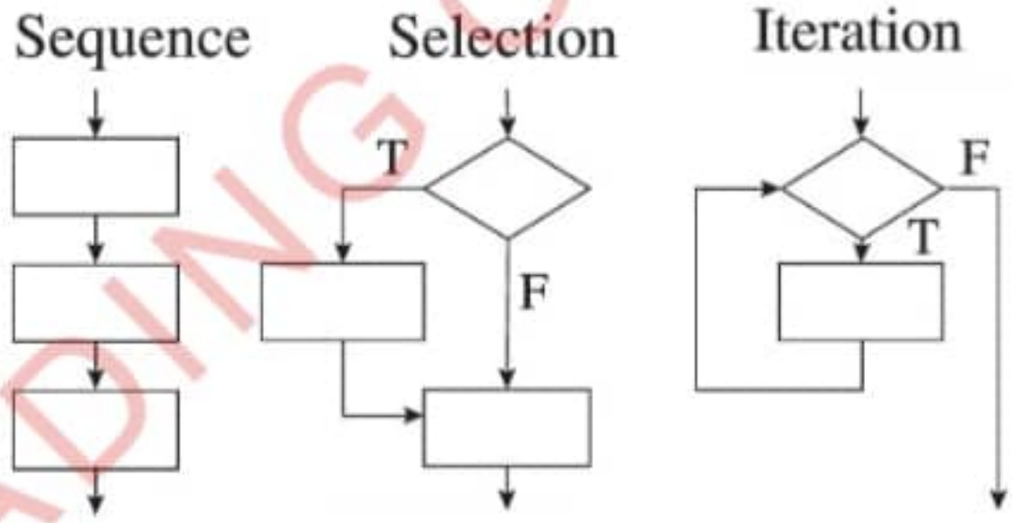


Figure 8.7: *Control structures*

Sequence control structure in flowcharts

The computer reads instructions from a program file line by line sequentially, starting from the first line. Examples from real life include adding numbers or any action with a series of steps before termination. Consider your dress before leaving for school. There are approximately four phases that make up a sequence structure: putting on underwear, putting on trousers or skirt, putting on socks, and putting on a pair of shoes.

The following example illustrates the flowchart using a sequential control structure for an algorithm to add two numbers, as shown in Figure 8.8.

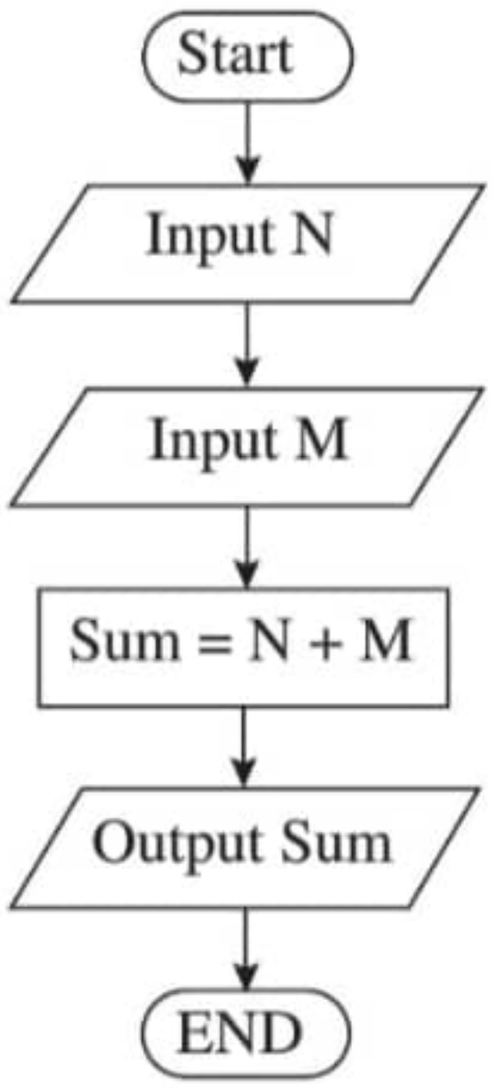


Figure 8.8: *Example of sequential control structure*

Selection control structure in flowcharts

The selection control structure is used to make decisions on an algorithm. A condition is a logical expression or statement that can be assessed as true or false. The ability to control flow of the algorithm by making decisions based on conditions is provided by selection control structures. It enables choosing between several paths of execution. Examples from real life include deciding what to wear based on the weather. You dress in a T-shirt and shorts when it is sunny, but you take an umbrella and a raincoat when it is raining.

Under the selection control structure, one condition is evaluated first and then the program flows into one of the two or more paths. Once the conditional execution is finished, it will re-join before leaving the structure. Selection control structure uses 'IF…THEN' or 'IF…. THEN ...ELSE' or a CASE structure in pseudocodes and flowcharts.

IF … THEN

IF…THEN, the structure executes the process if the condition is true. If it is not true, it skips the process. The diamond-shaped box in flowcharts represents the decision or condition. The syntax for IF…THEN is:

IF (Condition) THEN

Statement

END IF;

The corresponding flowchart is represented as shown in Figure 8.9.

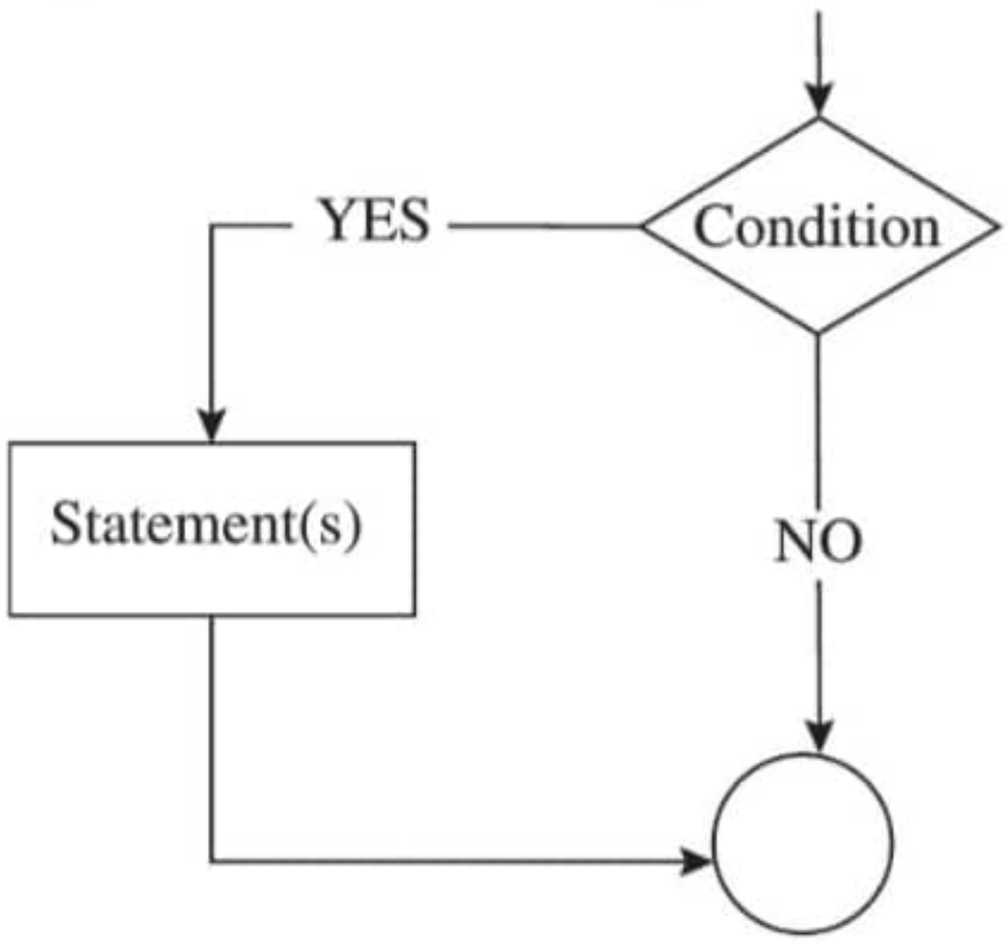


Figure 8.9: *Example of IF-THEN selection*

Example of IF…THEN selection control structure

Write an algorithm using a flowchart for the headmaster of Chato secondary

school who wants to reward students who attain an average mark above 80%. Figure 8.10 shows an example of a flow chart for rewarding students.

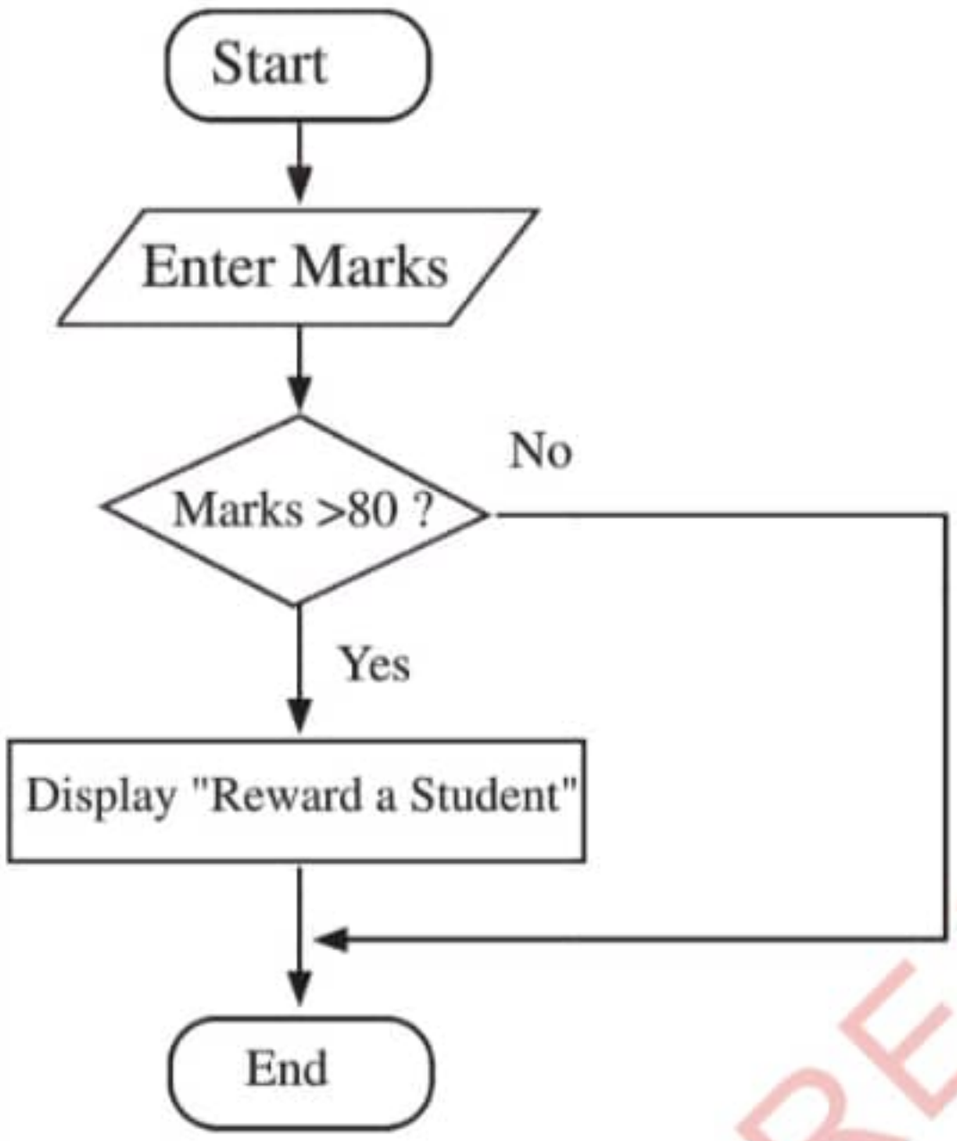


Figure 8.10: *Flow chart for rewarding students*

IF…THEN…. ELSE

In this structure, the condition is true, if it executes statement 1. If the condition is false, it will execute the second process (statement 2). In this case, process 1 or 2 will only be implemented depending on the given condition. The syntax of IF… THEN…ELSE is shown as follows:

IF (condition) THEN

Statement 1

ELSE

Statement 2

ENDIF;

The corresponding flowchart is represented as shown in Figure 8.11.

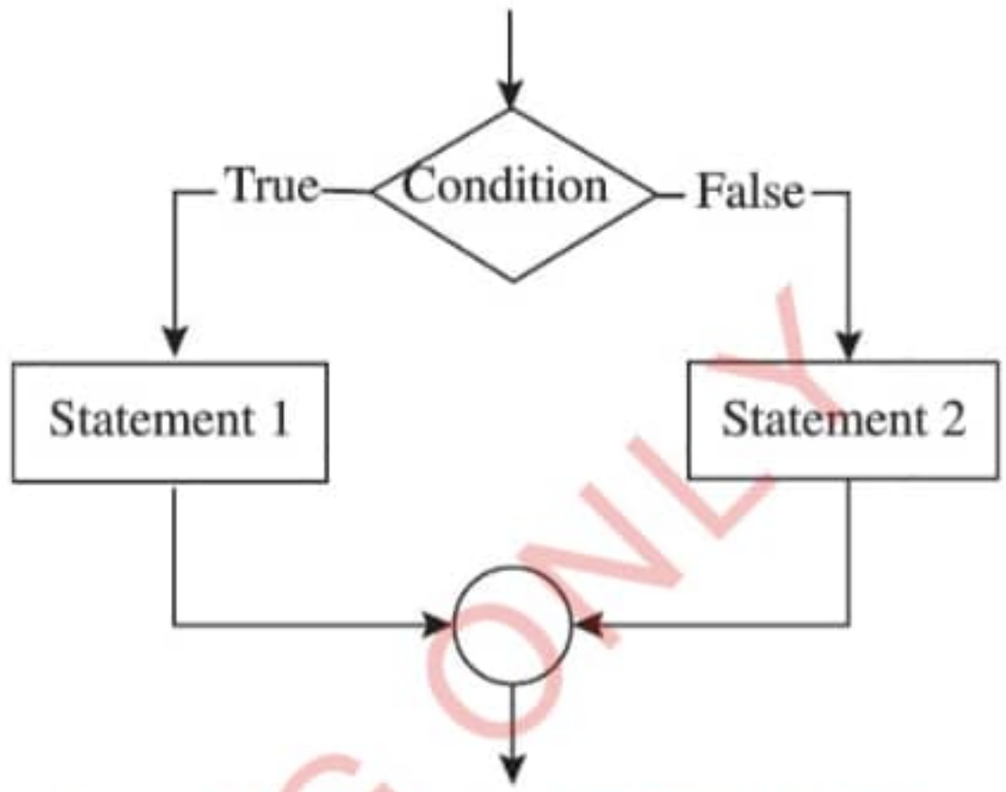


Figure 8.11: *Example of IF-THEN-ELSE selection*

When the IF-THEN-ELSE structure is encountered:

(i) The condition used to make the decision is tested.

(ii) If the condition is true, the statements between IF and THEN are executed. The ELSE part is skipped, and execution continues with the statement following ENDIF.

(iii) If the condition is false, the THEN part is skipped. Instead, the statements between ELSE and ENDIF (i.e., the ELSE part of the structure) are executed, and execution continues with the statement after ENDIF.

Example of IF-THEN-ELSE selection control structure

Write an algorithm using a flowchart that reads two scores of a student, determines the largest score, and print the largest score with the message that identifies it.

Algorithm: Determining the largest score

Step 1: Read the first score and assign it to be score1.

Step 2: Read the second score and assign it to be score2.

Step 3: If score1 is greater than score2, then display "The largest score is score1".

Step 4: Else, if score2 is greater than score1, then display "The largest score is score 2".

Step 5: End.

The flowchart of If-Then-Else is shown in Figure 8.12.

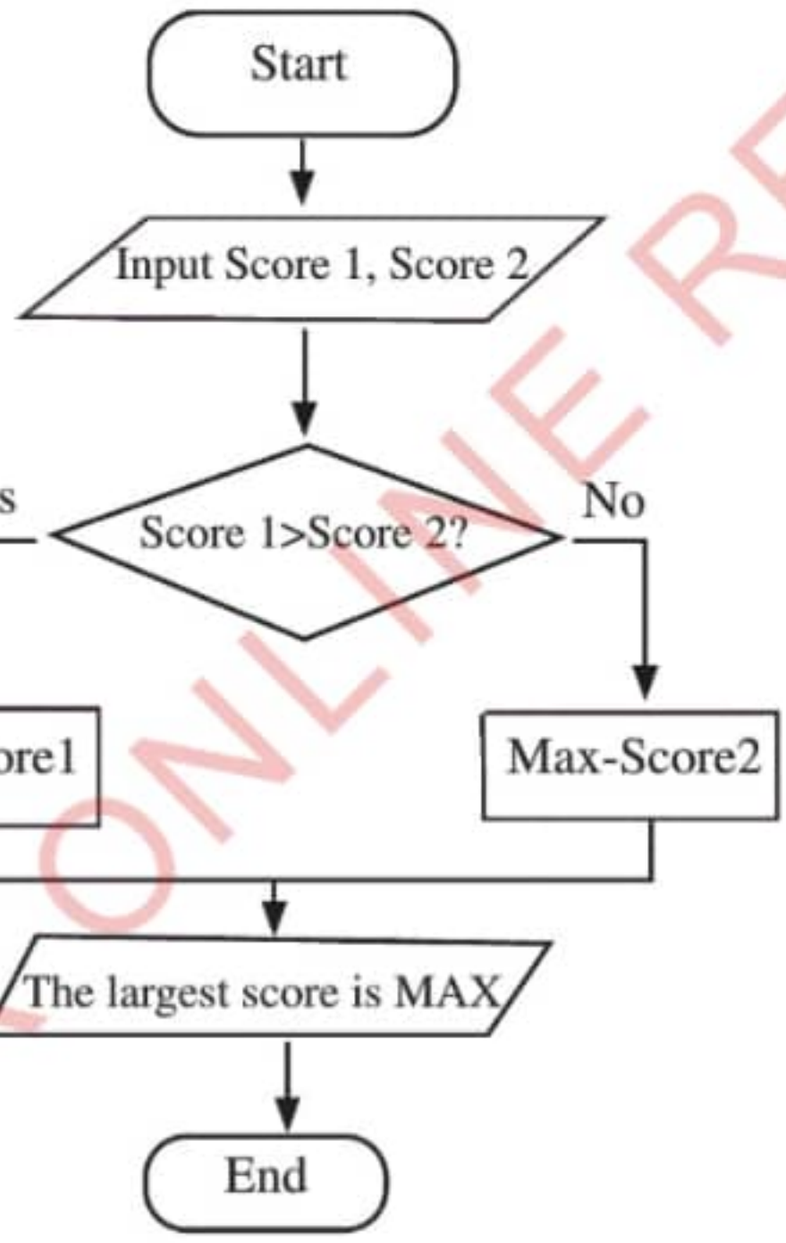


Figure 8.12: *Example of IF-THEN-ELSE selection*

IF…. THEN …. ELSE IF

You can introduce this IF statement if you want to select an action from several alternatives. This statement introduces the additional conditions. If condition1 is false, the *Else if* executes another condition. In this form of IF statement, more than one *Else if* can be used. All conditions in the statement are evaluated one after another from top to bottom. When one of them is true, then it will be executed. If all conditions are false, the sequence in *Else* clause is executed. The syntax for IF…THEN…ELSE IF is as follows:

```
IF (condition1) THEN
        sequence_of_statements1
ELSE IF (condition2) THEN
sequence_of_statements2
 ELSE
sequence_of_statements3
END IF;
```

The corresponding flowchart is represented as shown in Figure 8.13

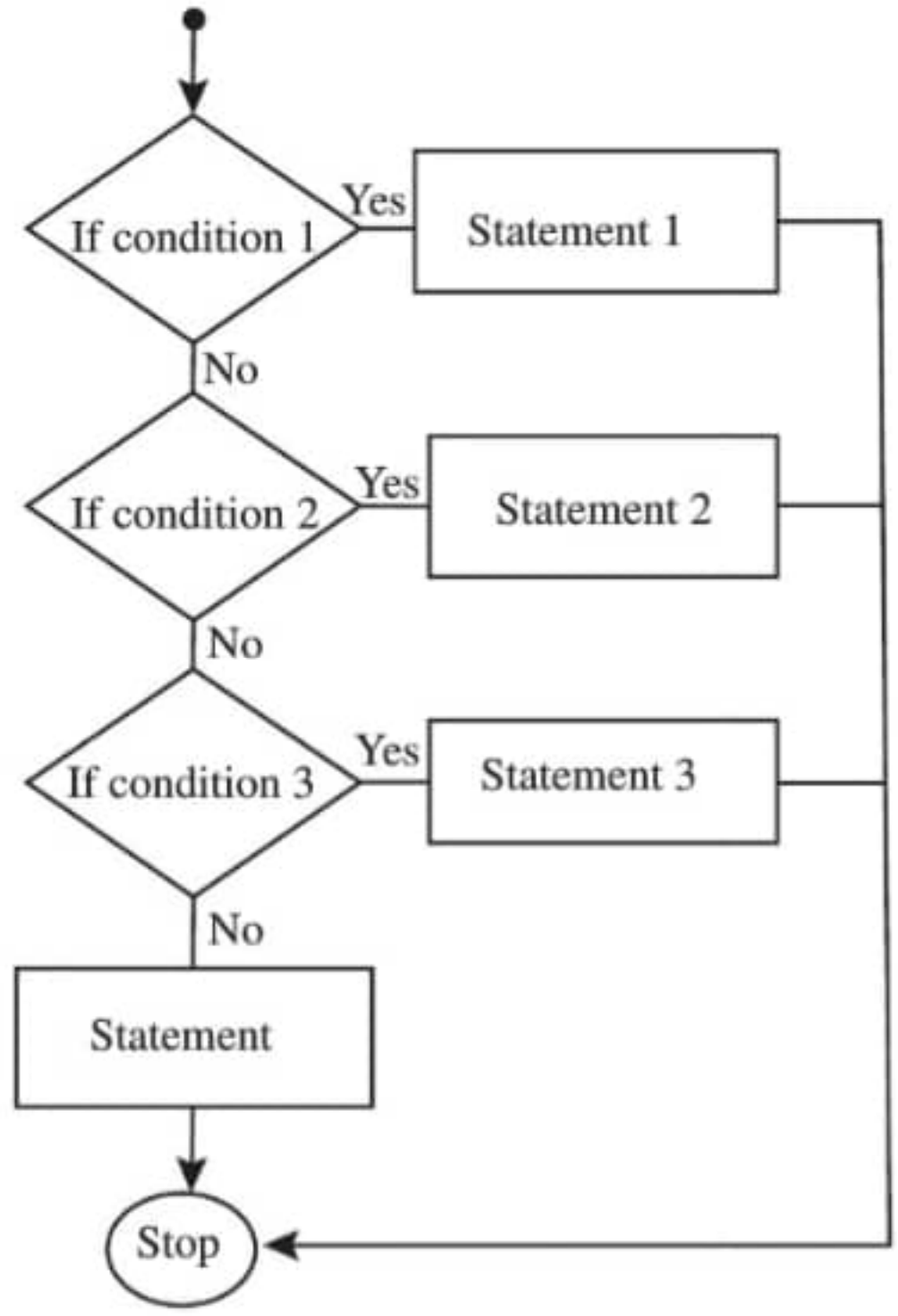


Figure 8.13: *Example of IF-THEN-ELSEIF selection*

Example of IF-THEN-ELSEIF selection control structure

Write an algorithm to determine the weather conditions of your environment using a flowchart diagram.

Algorithm: Determining the weather conditions of your environment

(i) Read the current temperature.

(ii) If the temperature is less than 10 °C, then display "It is cold, wear a sweater."

(iii) Else, if the temperature is between 10 and 25 °C, then display "It is enjoyable day, wear comfortable clothes."

(iv) Else, if the temperature is above 25 °C, then display "It is hot outside, wear simple clothing and drink water."

(v) Else, display "Invalid temperature reading."

(vi) End.

The flowchart of If-Then-ElseIf is shown in Figure 8.14.

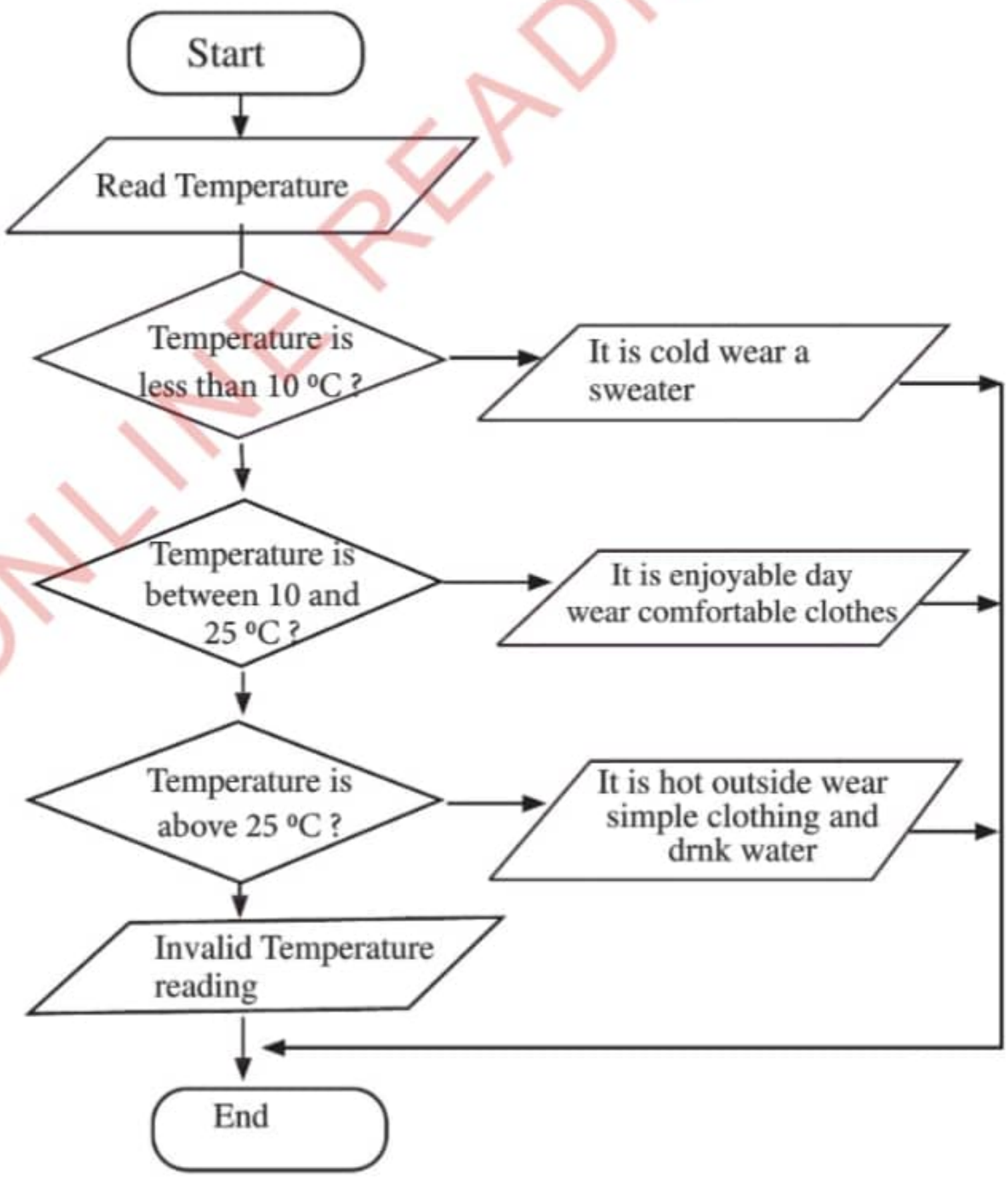


Figure 8.14: *Example of IF-THEN-ELSIF selection*

Activity 8.6

Use a library or internet search and study various real-life examples and the steps used to write their algorithm using selection control structures. Then do the following:

(a) Kakulu is planning a school trip. She needs to arrange students into groups for transportation. Write an algorithm to find the maximum number of buses needed and the number of students on each bus to ensure an even distribution. Kakulu wants each bus to carry the same number of students and fill the buses to the capacity they have and not more.

(b) Write an algorithm to find the largest value among three given numbers.

(c) Write an algorithm to find the result of equation $y = -x$ when $x<0$ and $y=x$ when $x\geq 0$.

Questions

1. In your search, did you explore the algorithm in everyday life relating to numbers only? What was the difference between algorithms for numbers and other algorithms you have explored?
2. Where can those algorithms you created in this activity be applied in everyday life?

Exercise 8.5

1. Write an algorithm for withdrawing money from your bank account using an ATM card.
2. Provide an example of an algorithm for a task of your choice (e.g., cleaning your room, washing your clothes, cooking a porridge for your young sister, preparing for your midterm test) and explain the step-by-step process.
3. Design an algorithm for planning your school's Parents' Day, considering factors such as time, budget, and available resources.
4. Write an algorithm to calculate the area of a square.

Iteration control structure in flowcharts

Iteration, also known as looping, means repeating steps or instructions over and over. Iteration is used when there is a need to execute a statement or block of statements several times. The repetition of loops is controlled with the help of a test condition. The statements in the loop are repetitive until the test condition becomes false. Examples from real life include:

(i) A cook in the kitchen may try different ingredients or adjust different steps of the cooking

Example of loop iteration control structure

Consider that you have a "Kibubu" and that you wish to save money on it. Write an algorithm that asks the user to input coins in Tanzania shillings (Tshs) repeatedly and then addsthe sum to the "Kibubu" until it exceeds or equals 6000 shillings. Construct this algorithm and draw a corresponding flowchart.

Algorithm:

(i) Start a loop with the condition that the Kibubu contains less than 6000.

(ii) Within the loop:

  (a) Prompt the user to input the amount of coins (in Tshs).

  (b) Add the input amount to **Kibubu**.

  (c) Check if **Kibubu** is still less than or equal to 6000.

  (d) If the condition is false, exit the loop.

(iii) End the loop.

(iv) Display a message to the user that their Kibubu now contains 6000 shillings or more.

(v) End.

The flowchart to implement the loop is presented as follows in Figure 8.16:

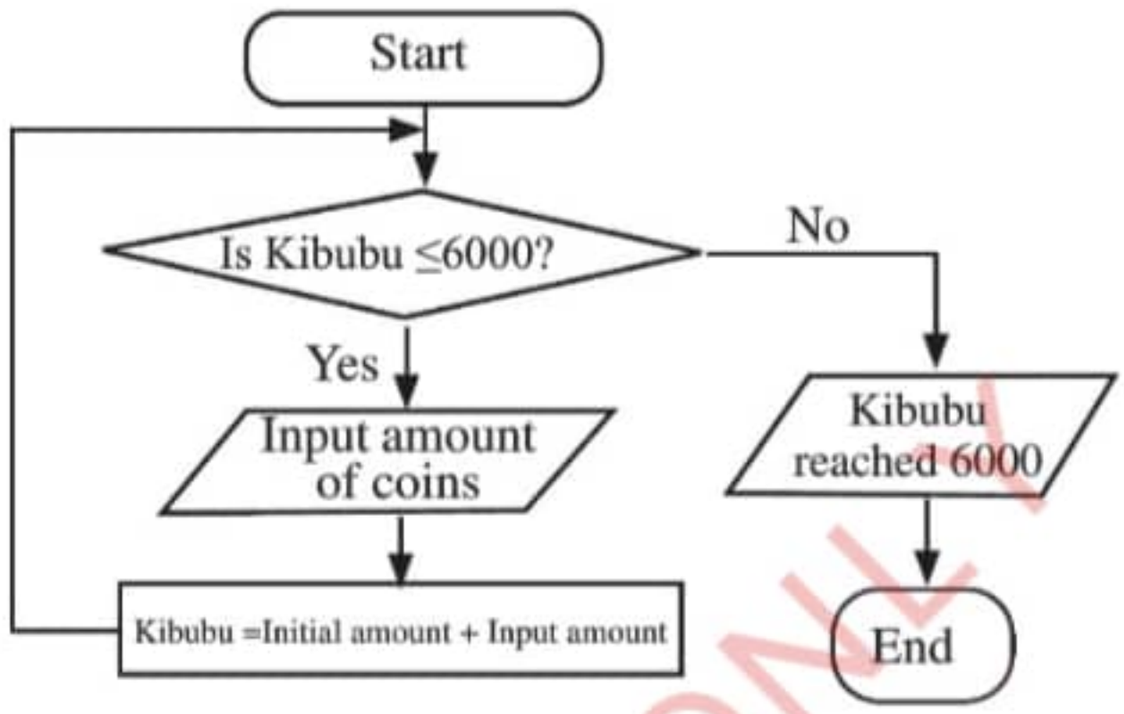


Figure 8.16: *Loop to display the amount in Kibubu*

Exercise 8.6

1. What is pseudocode?
2. Can you tell someone that presenting a problem in pseudocode is useful? Explain.
3. Write pseudocode to calculate the sum and average of numbers.
4. Write a pseudocode for converting temperature from Fahrenheit into Celsius. The inputs to the algorithm are temperature in Fahrenheit, and the expected output is temperature in Celsius.
5. Write an algorithm to find the largest of three numbers: a, b, and c.

Project work 8.1

Explore the problems or challenges being faced by your school. Through those challenges, identify a problem. Then, present your proposed solution using problem-solving skills you gained in this chapter. Discuss how your algorithm can be implemented in your school environment by referring to all problem-solving steps covered in this chapter.

Chapter Summary

Problem-solving is a cognitive process fundamental to human existence. It involves identifying challenges, developing algorithms, and implementing solutions. Effective problem-solving demands creativity, critical thinking, and determination. Importance of problem-solving skills are important in developing a solutions, as they help design a good algorithms, break the problems into a smaller subproblems and help in the effective implementation of a soulutions.

Steps for problem solving using a computer include:

(i) identify the problem,

(ii) understand the problem,

(iii) identify alternative ways to solve the problem,

(iv) select the best way to solve the problem from the list of alternative solutions,

(v) list instructions that enable you to solve the problem using the selected solution, and,

(vi) evaluate the solution.

An algorithm is a precise set of instructions or steps designed to solve a specific problem. Algorithms serve as the backbone of computer programs and problem-solving processes. They enable a systematic and efficient solutions, impacting fields from technology to science, underpinning our digital world. Algorithms have a definite beginning, an end, and a finite number of steps. A good algorithm is finite, programming language independent unambiguous; receives input and produces an output. Algorithms are represented using flowcharts and pseudocodes. A flowchart is a diagrammatic representation of algorithm using various symbols connected by arrows.

An algorithm, where all the steps are executed one after the other is said to run in sequence. Decision-making involves selecting one of the alternatives based on the outcome of a condition. An algorithm may have a particular set of steps repeated in a finite number of times. Such an algorithm is said to be iterative.

There can be more than one approaches to solving a problem, and hence we can have more than one algorithm for a particular situation.

The other way to represent algorithms when solving a problem is using pseudocode. A pseudocode is a detailed human description of instructions that a computer must follow in a particular order to solve a given problem. Some keywords used to write pseudocode include START or BEGIN, INPUT, READ or GET, PRINT, DISPLAY, or SHOW, COMPUTE, CALCULATE, or DETERMINE, SET, and END.

Revision exercise 8

1. Why are algorithms crucial in problem-solving and Computer Science.
2. Why are algorithms required to be finite?
3. What is the importance of clearly understanding the problem before constructing an algorithm?
4. Write an algorithm that accepts four numbers as input and find the largest and smallest of them by using pseudocode and flowchart.
5. Write an algorithm to find a greater number between two different numbers entered by the user in an algorithm.
6. Write a pseudocode that reads two numbers, divides one by another, and displays the quotient. If the divisor is zero, display an appropriate message.

Glossary

Advertisement	A notification or statement in a public medium promoting a product, service, event, or a job opportunity.
Agriculture	The practice of farming, including cultivation of the soil and the rearing of animals.
Algorithms	A procedure used for solving a problem or performing a computation.
Artificial intelligence	The simulation of human intelligence processes by machines, especially computer systems.
Autonomous	Being able to make decisions, and potentially take actions, without direct human control.
Autonomous vehicle	A vehicle capable of sensing its environment and operating without human involvement.
Big data	Data that contains greater variety of features, arriving in increasing volumes and with more velocity
Blockchain	A distributed ledger or database that duplicates and distributes transactions across the network of computers
Camera	A piece of device that is used for taking photographs, making films, or producing television images.
Climate	The long-term pattern of weather in a particular area.
Cloud computing	A virtualization-based technology used to create, configure, and customise applications via internet.
Collaborative learning	Learning that involves working as a group to solve a problem or understand an idea.
Cryptography	A technique of securing information and communications through use of codes.
Cybersecurity	The practice of protecting systems, networks, and programs from digital attacks.
Data	Facts and statistics collected for reference or analysis.
Database	An organised collection of data stored and accessed by electronic means using a database management system.
Data mining	The process of categorising large data sets to identify patterns and relationships that can help solve a problem
Debugging	The process of identifying, isolating, and resolving errors, bugs, or unexpected behaviours in a software program.

Defragmentation	The process of rearranging the data on a storage medium, such as a hard disk drive, for efficient storage and access.
Diagnostics	The process of determining the nature of a disease or disorder and distinguishing it from other possible conditions.
Digital	Describes systems that generate and process binary data.
Digital learning	Learning facilitated by technology that gives students some element of control over time, place, path and/or pace.
Directory	A container used to store files and other directories. It serves as a logical grouping of related content
E-commerce	The buying and selling of goods online.
E-Learning	The delivery of learning and training through digital resources.
E-mail	Messages generated and distributed by electronic means via a network.
Encryption	The conversion of data from a readable format into an unreadable format.
Engineering	The science of solving technical problems and developing new technology and infrastructure.
Folder	*A space that stores files, other folders, and shortcuts on a computer*
Gaming	Playing electronic games, whether through consoles, computers, mobile phones or another medium altogether.
Genomics	The study of genes and their functions, and related techniques.
Greenhouse	A glassed small house that traps radiation and keeps warm for better green plants growth.
Interactive learning	A technique that students actively engage in the learning process, often using technology.
Internet	A vast network that connects computers all over the world.
Internet of things	A network of physical objects connected to the Internet for the purpose of exchanging data.
Interrupt	A signal emitted by a device attached to a computer or from a program within the computer
Modelling	An act of creating a physical representation of an objects that shows what it looks like or how it works.
Network	The connection of at least two computer systems, either by a cable or a wireless for them to communicate and share resources.

Open banking	The practice of securely sharing financial data between banks and third-party service providers.
Personalised learning	An educational approach aims at customises learning along student's strengths, needs, skills, and interests.
Portfolio	The gathered educational evidence for the purpose of monitoring the learning progress.
Program	A set of instructions or a sequence of code that is written to perform a specific task or accomplish a particular function.
Programming language	A formal system of rules and conventions used to instruct a computer or a computing device to perform specific tasks or operations.
Revolution	A point in time at which computers make a significant change to human civilization.
Ride-hailing	An action where a customer requests a personalised ride online, often using a smartphone app.
Robotics	The intersection of science, engineering and technology that produces robots.
Satellite	An object in space that orbits or circles around a bigger object.
Search Engines	A software program that helps people find the information online using keywords or phrases.
Sensor	A device that detects and responds to some type of input from the physical environment.
Simulation	The re-creation of a real-world process in a controlled environment.
Smartphone	A portable computer device that combines mobile telephone functions and personal computing functions into one unit.
Source code	The text-based representation of a computer program that is written by a programmer to define the logic and behaviour of a software application.
Supply chain	A network of individuals or company involved in the production and delivery of a product or service.
Technology	The application of scientific knowledge for practical purposes, especially in industry.
Virtual reality	A computer simulated environment which can be explored in 360 degrees.

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Mathematics
for Secondary Schools

Student's Book

Form One

THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF EDUCATION,
SCIENCE AND TECHNOLOGY

Certificate of Approval

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Dr Lyabwene M. Mtahabwa
Commissioner for Education

Tanzania Institute of Education

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Table of contents

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Dr Aneth A. Komba
Director General
Tanzania Institute of Education

Preface

This textbook, *Mathematics for Secondary Schools*, is written specifically for Form One students in the United Republic of Tanzania. The book is prepared in accordance with the 2023 Mathematics Syllabus for Ordinary Secondary Education, Form I-IV, issued by the Ministry of Education, Science and Technology. It is a revised edition of Basic Mathematics for Secondary Schools Student's Book for Form One that was published in 2019 in accordance with the 2005 syllabus issued by the then, Ministry of Education and Vocational Training (MoEVT).

The book consists of six (6) chapters, namely: Concept of Mathematics, Numbers, Approximations, Ratios and proportions, Algebra, and Coordinate geometry. In addition to the contents, each chapter contains activities, illustrations, projects, and exercises. You are encouraged to do all the activities, projects and attempt all questions in the exercises. This will enhance your understanding and development of the intended competencies for this level.

Additional learning resources are available in the TIE library at https://ol.tie.go.tz or ol.tie.go.tz

Tanzania Institute of Education

Concept of Mathematics

Introduction

Mathematics is all around us. Almost everything we do involves Mathematics. It is applied in various fields such as science, engineering, technology, social studies, economics and many others. Numerous devices such as mobile phones, computers, television sets, and satellites are designed and manufactured on the basis of mathematical knowledge. In this chapter, you will learn about the meaning of Mathematics, branches of Mathematics, relationship between Mathematics and other subjects, and the importance of studying Mathematics. The competencies developed will enable you to apply Mathematics knowledge and skills to solve daily life problems in different fields such as Agriculture, Entrepreneurship, Botany, Zoology, Music, History, Business, and many other fields.

Meaning of Mathematics

The word 'Mathematics' comes from the Greek word '*mathema*', meaning 'which is learnt' or 'science, knowledge or learning'. Numbers, measurements, shapes of physical objects, and equations form a small part of it. Mathematics can be thought of as the science of the structures, orders, patterns, and relations that have evolved from elementary practices of counting, measuring, and describing the shapes of objects. It can also be thought of as a language of science because by using mathematical reasoning, one can develop an understanding and be able to predict nature. Mathematics has the ability to provide precise expression for every concept that can be formulated using mathematical symbols and structures. The knowledge and skills of Mathematics play a crucial role in understanding the concepts of other subjects, both in sciences and arts.

Branches of Mathematics

Mathematics can be categorized into different branches such as Arithmetic, Algebra, and Geometry.

Arithmetic

Arithmetic is a branch of Mathematics that deals with properties and manipulations of numbers. Manipulation of numbers is achieved through the use of basic mathematical operations namely: addition, subtraction, multiplication, and division.

Algebra

Algebra is a branch of Mathematics in which arithmetic operations are applied to symbols rather than specific numbers. The symbols or letters in algebra are called variables which represent quantities with no fixed values.

Geometry

The word geometry was derived from the Greek word 'Geo', which means 'earth' and 'metry', which means 'measurement'. Therefore, Geometry is a branch of Mathematics which deals with the study of the sizes, shapes, positions, angles, and dimensions of different physical objects. Moreover, properties of points, lines, planes, similarities, congruence, and shapes of different regular objects are also studied in Geometry.

Relationship between Mathematics and other subjects

Every aspect of our life makes use of Mathematics in one way or another. Mathematics plays a major role as a tool for effective understanding of other subjects. Numerous concepts in other subjects and fields are described precisely using Mathematics. Learning Mathematics can also benefit students through developing their problem solving and critical thinking skills. Note that, Mathematics formulas which are used to represent and describe concepts and scenarios in other fields are commonly referred to as mathematical models.

Activity 1.1: Discovering the use of Mathematics in daily lives

1. Recall your daily activities, identify and record applications of Mathematics in such activities.
2. Use a table or any method of your choice to represent the identified activities and its mathematical skills obtained in step 1.
3. Explain the mathematical aspects you have observed in step 2.

Mathematics and Agriculture

Agriculture is closely related to Mathematics. For instance, when farmers want to buy seeds, they need to understand the ratio of seeds that is sufficient per piece of land.

Similarly, the determination of the number of bags of fertilizers needed per acre requires some calculations. In these two examples, Mathematics enables farmers to avoid the wastage of financial resources by purchasing only the required amount of inputs. Mathematics is also used in Agriculture to determine suitable amount of water to be used in irrigation and the spacing between seedlings. Similarly, Mathematics is used to determine the investment, expenditure, and savings in cultivating a specific crop, dividing a piece of land, calculating the cost of labour, and so forth.

Mathematics and Biology

There is a direct relationship between Mathematics and Biology. For example, normal animal weights, rate of respiration, nutritive values of food, and transpiration are a few quantities in Biology that can be calculated using mathematical concepts. Mathematics can also be used to estimate the number of blood cells present in the body, measurement of blood pressure, and counting sex chromosomes, among many others.

Mathematics and Chemistry

Mathematics is widely applied in Chemistry to represent and solve various problems. Some Chemistry activities involve measurement of masses, volumes, lengths, temperatures and densities of matter. Mathematics is also used to measure the constituents of mixtures, balancing chemical equations, among many other applications.

Mathematics and Physics

Physics involves the study of laws, principles, and theorems which governs how matter works. Most of the quantities in Physics are expressed mathematically through formulas. In order to understand how to apply the formulas to solve some physics challenges, knowledge of Mathematics is needed. All the quantities in physics are expressed in numbers and units which have to be manipulated using the concepts and skills of Mathematics. For example, to determine the speed of a moving object, one has to find a ratio between the distance covered and the time taken.

Mathematics and Information and Communications Technology

Mathematics plays a big role in the field of Information and Communications Technology (ICT). Computer programs, applications, software, and computer languages make use of mathematical concepts. A common example of the application of numbers is in defining colours in web development languages. For instance, the HTML (hypertext markup language) and CSS (cascading style sheets) uses colour notations such as #000000 which represent Black, #008000 for Green and #800000 for Maroon. Furthermore, the digits 0 and 1 are commonly used in computing systems in computers.

Mathematics and Business Studies

Mathematics is widely applied in daily life activities related to Business Studies. For example, if one wants to determine profit or loss in business, a difference between the selling and buying prices is to be calculated. If the buying price is less than the selling price, the business makes profit. If the buying price is higher than the selling price, the business makes loss. Mathematics is also applied in other areas such as in loan borrowing, determining prices of items, among many other applications.

Mathematics and Geography

Geographers require mathematical calculations to find the distance from one place to another, finding gradients, altitudes of hills and mountains. Through mathematical calculations, geographical locations of different places are determined using latitudes and longitudes, and real-life objects such as buildings are represented on a map through the use of scales.

Mathematics and History

Mathematics helps in describing various historical activities such as duration of events and expressing historical events which happened at different points in time. For example, a simple mathematical operation is used to determine duration of historical events such as World Wars, colonial periods and time spent by leaders in positions, determining dates and ages of fossils by using some mathematical principles such as carbon-14 among many other applications.

Mathematics and Literature

Mastering basic concepts of arithmetic can enable a person to understand better and manage literary works. A kind of writing which can draw attention to readers depend on several factors such as number of words per sentence, the number of sentences per paragraph, and the number of paragraphs per page. For example, 20 words in a sentence are considered as average. Thus, in analysing writing style, one need to find an average number of words in each sentence, which requires Mathematics concepts.

Mathematics and Music

The knowledge of Mathematics plays a vital role in music. For instance, playing one note in piano has a different sound as when three harmonic notes are played together. Music notes are distinguished mathematically by their different values.

A semibreve has four beats, a minim has two beats, crotchet has one beat, quaver has $\frac{1}{2}$ a bit, semi quaver has $\frac{1}{4}$ a bit, and so on. Reading and playing music represented by notes in a music sheet depends on the mathematical ability to understand these values.

Mathematics in Sports and Games

Mathematics is important in all forms of sports and games. For example, in many sports and games, winners are those who have accumulated highest number of points. Furthermore, in most of the sports and games, there are specific number of players in the playing ground. For instance, a football team has 11 players while a netball team has 7 players. Moreover, players in some games such as football are given names in terms of numbers. In football, a goalkeeper is normally assigned number 1. In addition, all playing grounds are prepared with specific standards of measurements.

Activity 1.2: Exploring the use of Mathematics in other fields

Explore various resources such as books and internet to discover examples of mathematical concepts and skills that are used in 3 subjects other than those discussed in this chapter.

Importance of Mathematics

Learning Mathematics and using mathematical skills in daily life enhances problem solving, critical thinking, effective time management among many other importances.

Financial Management

Financial management requires mathematical skills during the preparation of budgets. Calculations are done to ensure the budget prepared correlates with the funds collected.

Problem-solving skills

Problem-solving is one of the most important skills in life. Mathematics is one of the most effective ways to increase analytical and logical thinking, which helps us to become better problem solvers.

Time management

Time management is a key to success for everyone. Therefore, time must be carefully managed. Mathematics helps to determine the time spent on every activity so as to maximize its efficiency.

Activity 1.3: Exploring the importance of Mathematics

Use different sources such as books and internet to explore the importance of Mathematics in daily life.

Exercise 1.1

1. What is Mathematics?
2. Explain five mathematical skills that are useful in your daily life activities.
3. Choose any five subjects of your choice other than Mathematics and explain with vivid examples how each of them is connected to Mathematics.
4. Write an essay arguing whether or not learning Mathematics is important in our lives.

Chapter Two

Numbers

Introduction

Numbers play a vital role in everyday life. Different activities are performed with the help of numbers. Numbers are used to quantify and measure quantities. For instance, length, mass, time, volume, and population are some of the quantities represented by numbers. In this chapter, you will learn about rational, irrational, and real numbers. You will also learn about repeating decimals, inequalities and absolute values of real numbers. The competencies developed will enable you to perform daily life activities such as counting things, managing money, distributing items, and interpreting numbers based on contexts, and many other applications.

Concept of numbers

Numbers are classified into different categories. Some categories of numbers that you have already learned include whole numbers, natural numbers, fractions, integers, and decimals. Other major categories of numbers include rational, irrational, and real numbers. Activity 2.1 enables you to identify categories of numbers from daily life activities.

Activity 2.1: Categorising numbers

1. Use different measuring tools such as tape measure, ruler, weighing balance, and measuring cylinders to measure lengths, masses, and volumes of different objects, respectively.
2. Record the measurements in task 1 and categorise them based on your understanding of categories of numbers.

Rational numbers

A rational number is any number that can be written in the form of $\frac{a}{b}$, where a and b are integers, and $b \neq 0$. The condition $b \neq 0$ is essential because division by zero is not defined. The set of rational numbers is denoted by the symbol $\mathbb{Q}$.

Fractions, integers, whole numbers, terminating and non-terminating decimals form the set of rational numbers. For instance,

$-\frac{34}{3}, -\frac{20}{3}, -3, -\frac{4}{7}, -\frac{5}{6}, \frac{1}{2}, \frac{1}{3}, \frac{4}{4}, \frac{9}{5}, \frac{100}{5}, 0, \frac{30}{1}, 0.45, 0.\dot{3}, 0.\dot{2}\dot{3}$, and $1.56\dot{7}$ are rational numbers.

Representation of rational numbers on a number line

Rational numbers can be represented on a number line. Positive rational numbers are represented on the right of zero (the origin) and the negative rational numbers on the left of the origin. The number line helps us to determine other rational numbers between any two rational numbers by increasing the number of divisions. Activity 2.2 enables you to locate numbers on a number line.

Activity 2.2: Locating numbers on a number line

1. Prepare a number line (2 to 3 metres long) using sticks and masking tapes or any other materials of your choice.
2. Cut manila cards in small sizes and write on them different types of numbers such as whole, integers, and fractions.
3. Give the cards to others to post each of the numbers on appropriate position on the number line.
4. While sticking the cards, explain to others why you think the positions are appropriate.

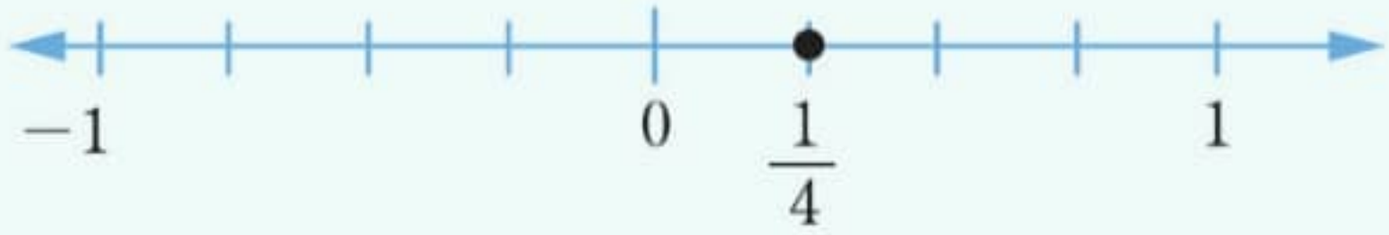
The representation of any positive rational number $\frac{a}{b}$ is done by dividing the unit interval into 'b' equal parts. The 'a' of these parts are taken along the number line to reach the point corresponding to $\frac{a}{b}$ on the right of zero if the number is positive and to the left of zero if the number is negative.

Example 2.1

Represent $\frac{1}{4}$ on a number line.

Solution

In order to represent $\frac{1}{4}$ on a number line, take one unit from 0 towards the right side and then divide that unit into 4 equal parts. Take one part out of the 4 parts to complete a part representing $\frac{1}{4}$. Therefore, $\frac{1}{4}$ on a number line is represented as shown in the following number line.



Example 2.2

Represent -2.4 on a number line.

Solution

$$-2.4 = -2\frac{4}{10}$$

$$= -2\frac{2}{5}$$

To represent -2.4 on a number line, take 2 units from 0 towards the left side and then divide the third unit into 5 equal parts. Take 2 parts out of the 5 parts to complete a part representing -2.4. Therefore, -2.4 on a number line is represented as shown in the following number line.

Example 2.3

Represent $\frac{13}{5}$ and $-\frac{13}{5}$ on the same number line.

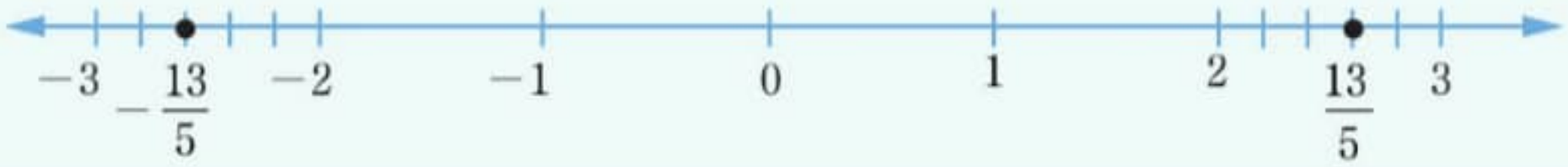
Solution

Convert $\frac{13}{5}$ into a mixed number. That is, $\frac{13}{5}$ $2\frac{3}{5}$

$$= 2 + \frac{3}{5}.$$

To draw a number line, take 2 units from 0 towards the right side and then divide the third unit into 5 equal parts. Add the 2 units and the 3 parts out of the 5 parts to complete $\frac{13}{5}$. Also, convert $-\frac{13}{5}$ into a mixed number, that is, $-2\frac{3}{5}$.

Repeat the same procedure from 0 to the negative side of the number line to represent $-\frac{13}{5}$. Therefore, $\frac{13}{5}$ and $-\frac{13}{5}$ on a number line are represented as shown in the following number line.



Exercise 2.1

1. Represent each of the following rational numbers on a number line.

   (a) 5 (c) $\frac{1}{5}$ (e) $\frac{3}{4}$ (g) 0

   (b) $\frac{7}{3}$ (d) 4.5 (f) $\frac{3}{2}$ (h) $3\frac{3}{4}$

2. Show the position of each of the following rational numbers on a number line.

   (a) $2\frac{2}{3}$ (c) $\frac{16}{8}$ (e) $\frac{25}{6}$ (g) $\frac{5}{5}$

   (b) $\frac{6}{1}$ (d) $\frac{0}{3}$ (f) $\frac{25}{50}$ (h) $\frac{50}{25}$

3. Represent each of the following numbers on a number line.

   (a) 3 (b) $-\frac{5}{2}$ (c) −3

4. (a) Write all negative and positive rational numbers from the following list of numbers.

   −5, 0, 12, −3.416520..., 2.85, 7.14, 12.64646464, $\frac{11}{5}$, $-\frac{3}{5}$, $-2\frac{1}{3}$.

(b) Which numbers from (a) are not rational numbers? Justify your answer.

5. Write each of the following rational numbers in the form of $-$ in its simplest form.

(a) 0.004 (c) -27 (e) -0.03 (g) $-6\frac{1}{8}$

(b) 4 (d) 5.6 (f) $4\frac{1}{4}$ (h) $-2\frac{2}{3}$

6. Represent each of the following rational numbers on a number line.

(a) -4 (e) $-\frac{5}{3}$

(b) -2.5 (f) $-0.9, -0.8, 0.3, 0.2, 0.7$

(c) 4 (g) $-\frac{3}{10}$

(d) 1.8 (h) $-\frac{3}{2}, -\frac{5}{4}, -\frac{1}{2}, \frac{1}{4}, \frac{1}{2}, \frac{3}{2}, \frac{5}{4}, -\frac{3}{4}$

7. Write 5 rational numbers which are equivalent to $\frac{7}{10}$.

8. Write true or false in each of the following questions.

(a) All whole numbers are rational numbers.

(b) All integers are rational numbers.

(c) The only rational numbers which are equal to their reciprocals are 1 and -1.

9. Write down the rational number whose numerator is (-2×3) and whose denominator is $(23-16)\times(9-4)$.

10. A monthly salary of a certain worker is Tshs 250,000. One-fifth of his salary is spent in buying car fuels, half of remaining salary is spent in buying food and half of the rest is spent in miscellaneous expenses.

(a) How much is his monthly savings?

(b) State whether the answer in part (a) is a rational number or not.

Repeating decimals

Decimal numbers are part of rational numbers and are common in our daily life activities. The quantities such as length, height, age, volume and mass can be presented in decimals. Activity 2.3 guides you in expressing various quantities in fractions into decimals.

Activity 2.3: Expressing measurements of quantities in decimals

1. Take some fruits or similar objects and divide them into two, three, four, five, six, and seven equal parts.
2. Convert each fraction in task 1 into decimals in many decimal places as possible. You can work manually or use a calculator.
3. Study carefully the decimal part of the fractions and write down their unique characteristics.

A repeating decimal, also known as recurring decimal is a decimal number with at least one digit in the decimal part that repeats consecutively in a regular order without an end. For example, 1.6666666… and 0.639639639639… are repeating decimals because 6 and 639 digits from the two decimal numbers, respectively, in the decimal part repeat themselves without an end. The three dots indicate that the repeating digits continue infinitely.

Repeating decimals can also be represented by using a dot or a bar that is placed on top of a repeating digit.

Example 2.4

Write each of the following repeating decimals by using a dot and a bar.

(a) 0.3333... (b) 0.639639639... (c) 0.474747474...

Solution

(a) 0.3333... is a repeating decimal which can be written as $0.\dot{3}$ or $0.\overline{3}$

(b) 0.639639639... can be written as $0.\dot{6}3\dot{9}$ or $0.\overline{639}$

(c) 0.474747474... can be written as $0.\dot{4}\dot{7}$ or $0.\overline{47}$

In Example 2.4, the digits with a dot or a bar are repeating infinitely. In (b) and (c), it can be observed that if a group of digits is repeating, a dot should be put over the first and the last repeating digits.

Decimals are either terminating or non-terminating. Terminating decimals have a definite number of digits after the decimal point while non-terminating decimals have an endless number of digits after the decimal point. Thus, repeating decimals are non-terminating with one or more repeating digits in the decimal part.

Examples of terminating decimals are 0.5, 1.4, and 7.9 while non-repeating decimals are 3.1415926..., 1.4142135…., and 2.2360679…

Converting repeating decimals into fractions

When working with problems involving repeating decimals, it is important to convert them into simple fractions to maintain accuracy and avoid errors. A repeating decimal can be converted into fraction using the following steps:

1. Choose any variable to represent the required fraction.
2. Multiply both sides of the equation by a multiple of 10 depending on the number of repeating decimals. For example, $0.\dot{8}$ and $0.21\dot{3}$ have only one repeating digit which means they are multiplied by 10. Decimal numbers $0.\dot{1}\dot{1}$ and $1.2\dot{1}\dot{4}$ have two repeating digits, thus they are multiplied by 100, and $0.\dot{8}3\dot{5}$ will be multiplied by 1,000 since it has 3 repeating digits.
3. Subtract the equation in step 1 from the equation in step 2.
4. From the equation obtained in step 3, solve for the chosen variable and simplify where necessary.

Example 2.5

Convert each of the following decimals into fractions.

(a) $0.\dot{3}$ (b) $0.\dot{8}\dot{3}$ (c) $0.\dot{8}3\dot{5}$ (d) $0.8\dot{3}$

Solution

(a) Let $x = 0.\dot{3}$ (i)

Multiply by 10 both sides of equation (i) to obtain,

$10x = 3.\dot{3}$ (ii)

Subtract equation (i) from equation (ii) as follows:

$10x - x = 3.\dot{3} - 0.\dot{3}$

Thus, $9x = 3$

$$x = \frac{1}{3}$$

Therefore, $0.\dot{3}$ into fraction is $\frac{1}{3}$.

(b) $0.\dot{8}\dot{3}$

Let $= .0.\dot{8}\dot{3}$ (i)

Multiply by 100 both sides of equation (i) to obtain

$100x = 83.\dot{8}\dot{3}$ (ii)

Subtract equation (i) from equation (ii) as follows:

$$100x - x = 83.\dot{8}\dot{3} - 0.\dot{8}\dot{3}$$

$$99x = 83$$

$$x = \frac{83}{99}$$

Therefore, $0.\dot{8}\dot{3}$ into fraction is $\frac{83}{99}$.

(c) $0.\dot{8}3\dot{5}$

Let $x = 0.\dot{8}3\dot{5}$ (i)

Multiply by 1 000 both sides of equation (i) to get,

$1000x = 835.\dot{8}3\dot{5}$ (ii)

Subtract equation (i) from equation (ii) and solve for x as follows:

$$1000x - x = 835.\dot{8}3\dot{5} - 0.\dot{8}3\dot{5}$$

$$999x = 835$$

$$x = \frac{835}{999}$$

Therefore, $0.\dot{8}3\dot{5}$ into a fraction is $\frac{835}{999}$.

(d) $0.8\dot{3}$

Let $x = 0.8\dot{3}$ (i)

Multiply by 10 both sides of equation (i) to get,

$10x = 8.3\dot{3}$ (ii)

Subtract equation (i) from equation (ii) and solve for x as follows:

$$10x - x = 8.3\dot{3} - 0.8\dot{3}$$

$$9x = 7.5$$

$$x = \frac{7.5}{9}$$

$$= \frac{5}{6}$$

Therefore, $0.8\dot{3}$ into fraction is $\frac{5}{6}$.

Example 2.6

Convert each of the following decimals into fractions.

(a) $9.\dot{2}$ (b) $5.\dot{2}\dot{3}$ (c) $2.\dot{1}0\dot{5}$

Solution

(a) $9.\dot{2}$

Let $x = 9.\dot{2}$ (i)

Multiply by 10 both sides of equation (i) to get,

$10x = 92.\dot{2}$ (ii)

Subtract equation (i) from equation (ii) and solve for x as follows:

$10x - x = 92.\dot{2} - 9.\dot{2}$

$9x = 83$

$x = \frac{83}{9}$

Therefore, $9.\dot{2}$ into fraction is $\frac{83}{9}$.

(b) $5.\dot{2}\dot{3}$

Let $x = 5.\dot{2}\dot{3}$ (i)

Multiply by 100 both sides of equation (i) to get

$100x = 523.\dot{2}\dot{3}$ (ii)

Subtract equation (i) from equation (ii) and solve for x as follows:

$100x - x = 523.\dot{2}\dot{3} - 5.\dot{2}\dot{3}$

$99x = 518$

$x = \frac{518}{99}$

Therefore, $5.\dot{2}\dot{3}$ into fraction is $\frac{518}{99}$.

(c) $2.\dot{1}0\dot{5}$

Let $x = 2.\dot{1}0\dot{5}$ (i)

Multiply by 1,000 both sides of equation (i) to get

$1000x = 2105.\dot{1}0\dot{5}$ (ii)

Subtract equation (i) from equation (ii) and solve for x as follows:

$$1000x - x = 2105.\dot{1}0\dot{5} - 2.\dot{1}0\dot{5}$$

$$999x = 2103$$

$$x = \frac{2103}{999}$$

$$= \frac{701}{333}$$

Therefore, $2.\dot{1}0\dot{5}$ into fraction is $\frac{701}{333}$.

Exercise 2.2

1. Convert each of the following decimals into fractions.

   (a) $0.\dot{1}$ (c) $80.\dot{2}1\dot{7}$ (e) $13.0\dot{1}\dot{5}$ (g) $0.\dot{7}2\dot{3}$

   (b) $0.\dot{8}$ (d) $3.1\dot{1}\dot{2}$ (f) $0.3\dot{4}$ (h) $2.\dot{4}$

2. Which of the following rational numbers are repeating decimals?

   (a) $\frac{1}{9}$ (b) $\frac{22}{7}$ (c) $3\frac{2}{3}$ (d) $\frac{20}{11}$

3. If $x = 2.\dot{6}$ and $y = 2.8\dot{3}$, find the value of $\frac{x}{y}$.

4. If $x = 0.\dot{3}$ and $y = 0.\dot{6}$, verify that $y^2 = x^2 + x$.

5. Evaluate the following giving your answer as a fraction in its simplest form.

   (a) $0.\dot{2} + 0.\dot{5}\dot{1}$ (b) $1.6\dot{7} + 2.\dot{1}$ (c) $0.6\dot{6} - 0.4\dot{1}$

6. Show that $0.\dot{4}\dot{6} = \frac{46}{99}$.

7. Evaluate the following and give your answer in fractions.

   $$1.2\dot{5}\dot{6} + 0.\dot{7} - 0.15$$

8. The fraction, $a\frac{b}{c}$ is equivalent to $5.\dot{1}6\dot{5}$. Find the values of a, b, and c.

9. What is the sum of the numerator and denominator of $0.\dot{2}\dot{7}$ when converted into fraction?

10. Why learning the concept of recurring decimals is important in your daily life?

Converting fractions into repeating decimals

A fraction can be converted into a decimal by performing a long division. In this process, some fractions will be equivalent to either terminating or non-terminating decimals. If the resulting decimal is a non-terminating with recurring decimals, the repeating digits are indicated by the repeating decimal's notation.

Example 2.7

Convert the following fractions into decimals.

(a) $\frac{1}{3}$ (b) $\frac{2}{3}$ (c) $\frac{5}{33}$ (d) $\frac{17387}{909}$

Solution

(a) Divide 1 by 3 using long division as follows and check your answer by a calculator.

$$
\begin{array}{r}
0.3333\ldots \\
3\overline{)\,1} \\
-\ 0 \\
\hline
\quad 10 \\
-\ \ 9 \\
\hline
\quad\ \ 10 \\
-\ \ 9 \\
\hline
\quad\ \ 10 \\
-\ \ 9 \\
\hline
\quad\ \ 10 \\
-\ \ 9 \\
\hline
\quad\ \ 1 \\
\vdots
\end{array}
$$

Therefore, $\frac{1}{3} = 0.\dot{3}$.

(b) Divide 2 by 3 using long division as follows and check your answer by a calculator.

$$
\begin{array}{r}
0.6666\ldots \\
3\overline{)\,2} \\
-\ 0 \\
\hline
\quad 20 \\
-18 \\
\hline
\quad\ \ 20 \\
-\ 18 \\
\hline
\quad\ \ 20 \\
-18 \\
\hline
\quad\ \ 20 \\
-18 \\
\hline
\quad\ \ 2 \\
\vdots
\end{array}
$$

Therefore, $\frac{2}{3} = 0.\dot{6}$.

(c) Divide 5 by 33 by long division or by a calculator to get 0.151515151515…. Note that in the answer, 1 and 5 repeats as you proceed to divide. Therefore, $\frac{5}{33} = 0.\dot{1}\dot{5}$ or $0.\overline{15}$.

(d) Divide $\frac{17\,387}{909}$ by long division or by a calculator to obtain

19.127612761276…

Note that in the answer, the digits 1, 2, 7, and 6 repeats as you proceed to divide.

Therefore, $\frac{17\,387}{909} = 19.\dot{1}27\dot{6}$ or $19.\overline{1276}$.

Example 2.8

1. Convert each of the following mixed fractions into decimals.

(a) $1\frac{5}{9}$ (b) $1\frac{37}{45}$ (c) $9\frac{1}{6}$

Solution

(a) Given $1\frac{5}{9}$.

Converting the mixed fraction into improper fraction gives, $1\frac{5}{9} = \frac{14}{9}$

Dividing 14 by 9 using the long division method gives $1.\dot{5}$.

Therefore, $1\frac{5}{9} = 1.\dot{5}$.

(b) Given $1\frac{37}{45}$.

Converting the mixed fraction into improper fraction gives, $1\frac{37}{45} = \frac{82}{45}$

Dividing 82 by 45 using the long division method gives $1.8\dot{2}$.

Therefore, $1\frac{37}{45} = 1.8\dot{2}$.

(c) Given $9\frac{1}{6}$.

Converting the mixed fraction into improper fraction gives, $9\frac{1}{6} = \frac{55}{6}$.

Divide 55 by 6 using the long division method to get $9.1\dot{6}$.

Therefore, $9\frac{1}{6} = 9.1\dot{6}$.

Example 2.9

A wire is divided into two pieces of lengths $2\frac{1}{3}$ cm and $2\frac{1}{2}$ cm. Find the total length of the wire in decimals.

Solution

Given the lengths of the two pieces of wire as $2\frac{1}{3}$ cm and $2\frac{1}{2}$ cm. Add the mixed fractions as follows:

$$2\frac{1}{3}+2\frac{1}{2}=\frac{7}{3}+\frac{5}{2}$$

$$=\frac{29}{6}$$

Divide 29 by 6 using the long division method to obtain $4.8\dot{3}$.

Therefore, the total length of the wire is $4.8\dot{3}$ cm.

Exercise 2.3

1. Convert each of the following fractions into decimals.

   (a) $\frac{6}{7}$ (c) $\frac{8}{11}$ (e) $\frac{25}{13}$

   (b) $\frac{11}{6}$ (d) $\frac{102}{90}$ (f) $\frac{21}{13}$

2. Which of the following rational numbers are repeating decimals?

   (a) $\frac{1}{9}$ (b) $\frac{22}{7}$ (c) $3\frac{2}{3}$ (d) $\frac{20}{11}$

3. Which is greater between $0.\dot{1}\dot{2}$ and $\frac{1}{3}$?

4. Write the following numbers in ascending order: $\frac{11}{23}$, $0.4\dot{7}\dot{2}$, and $\frac{5}{11}$.

5. Show that $\frac{23}{9}=2.55555\ldots$

6. Mwajuma has $\frac{1}{3}$ of a chocolate bar. She decides to share it equally among her 5 friends. How much chocolate will each friend get? Write your answer in fraction and decimal.

7. John wants to divide a 1 metre-long ribbon so that he can share it equally with his two friends. How much in metres will each get? Express your answer in decimals.
8. If $m = 0.\dot{2}$ and $n = 0.\dot{0}\dot{4}$, show that $m^2 = n(m+1)$.
9. A car travels 2/3 of the total distance to its destination at a speed of 30 km/h, and then travels the remaining distance at a speed of 40 km/h. If the car took 4 hours for the whole journey, what is the total distance of the journey? Express your answer as a repeating decimal.
10. The base of a lid of bucket has an area of $\frac{25}{484}\pi$ m^2. Find its diameter in decimal.

Irrational numbers

Irrational numbers are special numbers in our life. A widely known and used irrational number is Pi (π) which appears in formulas for determining circumferences, areas, and volumes of circular shapes. Activity 2.4 allows you to use your experience in decimals to learn about irrational numbers.

Activity 2.4: Differentiating types of decimal numbers

1. Identify 10 different fractions which can be converted into terminating or repeating decimals.
2. Use a calculator to find answers to the square roots of at most 10 numbers that have no perfect squares and write your answers with at least 10 decimal places.
3. Compare the answers in tasks 1 and 2 and write down the differences observed.

An irrational number is a number which can be written as a non-terminating and non-repeating decimal. Also, these numbers cannot be expressed in the form of $\frac{a}{b}$, where a and b are integers and $b \neq 0$. The set of irrational numbers is denoted by $\mathbb{Q}'$. Irrational numbers cannot be represented exactly on a number line. However, they can always be approximated to rational numbers.

Example 2.10

Write any 6 irrational numbers.

Solution

The following is a list of some irrational numbers.

(i) $\sqrt{2} = 1.414213562373\cdots$ (iv) $-\sqrt{5} = -2.236067977499\ldots$

(ii) $e = 2.718281828459\cdots$ (v) $\sqrt{11} = 3.316624790355\cdots$

(iii) $\pi = 3.141592653589\cdots$ (vi) $-\sqrt{21} = -4.582575694956\ldots$

From these examples, it can be observed that the digits after the decimal point continue infinitely without repeating.

Note:

The numbers such as π, e, $e\pi$, 2π, $e+\pi$, and other similar numbers are also called transidentals.

Example 2.11

Given the list of numbers

$-6,\ -5\frac{3}{5},\ -\sqrt{4},\ -\frac{3}{5},\ -\frac{3}{8},\ 0,\ \frac{4}{5},\ 1,\ 1\frac{2}{3},\ \sqrt{8},\ 3.01,\ \pi,\ 8.47.$ Identify all irrational numbers in the list.

Solution

The irrational numbers are $\sqrt{8}$ and π.

Exercise 2.4

1. Determine whether the following are rational or irrational numbers. Justify your answers.

   $\sqrt{11},\ 0.65,\ \sqrt{12},\ \frac{\pi}{2},\ 1.101001000100001\cdots,\ \sqrt{9},\ 3+\sqrt{7},\ 3\sqrt{3}-\sqrt{5},\ -\sqrt{7}$

2. Find an irrational number such that $x^2 = 7$.

3. Given the numbers $-5,\ -3.5,\ 0,\ \frac{3}{4},\ \sqrt{3},\ \sqrt{5},\ 9,\ -4.3\dot{2}\dot{5},\ \pi,\ \frac{\sqrt{2}}{2}$. List the numbers which are:

   (a) Whole numbers (c) Rational numbers

   (b) Integers (d) Irrational numbers

4. State whether the following statements are true or false. Justify your answers.
   (a) Every irrational number is a real number.
   (b) All non-terminating decimals are irrational numbers.
   (c) The square roots of all positive numbers are irrational numbers.
   (d) The sum of two irrational numbers gives an irrational number.
5. Ramadhani is planning to build a circular pond whose base area is 100 square metres. Express the radius of the base of the pond as an irrational number.
6. Identify irrational numbers from the following list of numbers:

$$\sqrt{9},\ 0.54,\ \frac{91}{13},\ 1.25\dot{6},\ \frac{\sqrt{2}}{2},\ \frac{1}{11}.$$

7. (a) What is an irrational number?
   (b) Explain the fact that the sum of two or more irrational numbers gives an irrational number.
8. Provide an example for each of the following statements.
   (a) The product of rational and irrational number is an irrational number.
   (b) The product of two irrational numbers is an irrational number.
9. Write five irrational numbers with denominators as irrational numbers.
10. In the following list of numbers, identify a list which does not contain irrational numbers.
    (a) $0.1,\ \frac{2}{7},\ 5.33333\ldots$
    (b) $\sqrt{16},\ \sqrt{1},\ \sqrt{9},\ 3.844231028\ldots$
    (c) $\sqrt{4},\ 4\frac{2}{9},\ 0.6,\ 7$
    (d) $-\frac{28}{9},\ 0,\ \sqrt{25},\ 3.45$

Real numbers

Real numbers are the numbers which include both rational and irrational numbers. A set of real numbers is denoted by $\mathbb{R}$. Thus, all sets of numbers such as natural numbers, whole numbers, integers, rational numbers and irrational numbers are all real numbers. Natural numbers are the smallest set of numbers followed by whole numbers and integers which are all rational numbers. Rational and irrational numbers are opposite sets of numbers and are what makes the largest set of real numbers as shown in Figure 2.1.

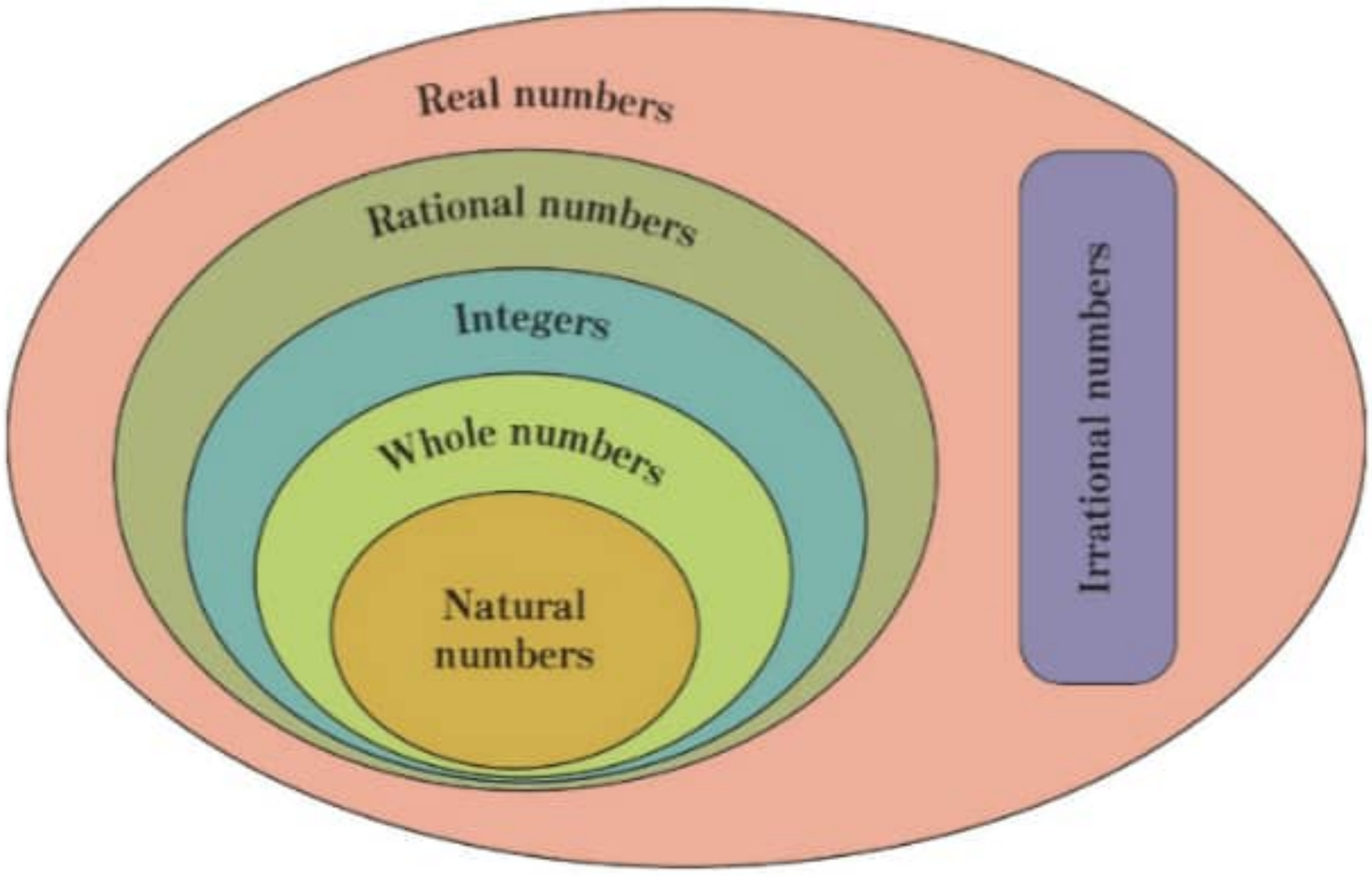


Figure 2.1: *Categories of real numbers*

If a and b are two real numbers, then either $a = b$, a is less than b or a is greater than b. For example, if:

(i) $a = 3$ and $b = 7$, then a is less than b or b is greater than a, that is, 3 is less than 7 or 7 is greater than 3.

(ii) $a = \frac{12}{3}$ and $b = 4$, then, $a = b$ that is, $\frac{12}{3} = 4$.

(iii) $a = -3$ and $b = -5$, then a is greater than b, that is -3 is greater than -5 or b is less than a, that is, -5 is less than -3.

(iv) $a = -4$ and $b = 2$ then a is less than b, that is -4 is less than 2 or b is greater than a, that is, 2 is greater than -4.

Examples of positive real numbers are 1, 2, 3, $\frac{2}{3}$, $\sqrt{7}$, 1.67, and 1.020020002 … and examples of negative real numbers are:

$-1, -2, -3, -\frac{3}{2}, -\sqrt{7}, -1.067, -1.020020002\ldots$

Note:

1. 0 is also a real number which is neither positive nor negative.
2. Every real number corresponds to a single point on the number line.
3. Every point on the number line corresponds to a certain real number.

Inequalities in real numbers

In daily life, people are faced with problems related to comparing quantities of the same item for the purpose of making decisions. Consider the following examples:

(i) In some places, the speed of the car is limited to a certain maximum value due to the large number of pedestrians.
(ii) Event organisers can set a maximum number of attendees for the event.
(iii) Most banks limit the withdrawal amount to a certain minimum and maximum amount per day in automated teller machines.
(iv) In schools, a minimum pass mark is set for students to be awarded certificates of completion of education.

Activity 2.5 guides you in comparing quantities in real life.

Activity 2.5: Comparing quantities in real life

1. Measure the lengths, widths, and heights of different objects of your choice.
2. Compare the measured values of a pair of objects in task 1.

In Mathematics, an inequality is a statement that compares or relates two values or expressions. The common terms involved in comparing the values or expressions are "less than", "greater than", "greater than or equal to", "less than or equal to", or "not equal to". For instance, the following statements are examples of inequalities:

(i) -5 is less than 0.
(ii) John's age is greater than Jane's age.
(iii) x is less than or equal to 9.
(iv) y is greater than or equal to 0.
(v) 2.5 is not equal to 1.2.

The mathematical statements can be written using symbols which represent inequalities as shown in the following table.

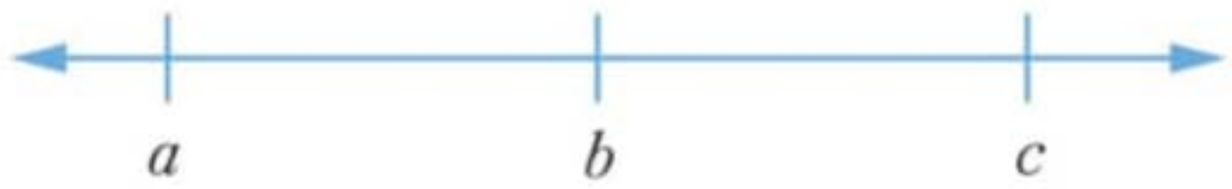
Word	Inequality symbols	Example
Less than	$<$	$-5 < 0$
Greater than	$>$	John's age $>$ Jane's age
Less than or equal	$\leq$	$x \leq 9$
Greater than or equal	$\geq$	$y \geq 0$
Not equal to	$\neq$	$2.5 \neq 1.2$

In general, mathematical statements which use $\neq$, $>$, $<$, $\geq$, or $\leq$ are called inequalities.

Note:

1. The sharp end of $>$ and $<$ always points to a smaller number.
2. The symbols $\leq$ and $\geq$ are sometimes referred to as at most and at least, respectively.
3. If the inequality is divided or multiplied both sides by a negative number, the direction of the inequality sign changes.

Suppose a, b, and c are real numbers which are represented on the number line shown in the following number line:



Generally, on a number line, a number to the right side of another number is always greater than a number to its left side. Thus, from the number line,
b is greater than a, which can also be written as $b > a$.
c is greater than b, which can also be written as $c > b$.
The vice versa is also true, that is, a number which is on the left side of another number on a number line is always less than the number on its right side. That is, $a < b$ and $b < c$.

Example 2.12

Study the following number line and use inequality symbols to answer the questions that follow.

(a) Write all real numbers which are greater than zero.
(b) Write all real numbers which do not exceed 2.
(c) Write all real numbers between –3 and 4.

Solution

(a) Let x be any real number that is greater than 0. The symbol $>$ is used to represent the solution. There are infinity real numbers which are greater than zero. Therefore, $x > 0$.

(b) Let x be any real number which does not exceed 2. Numbers on the left side of 2 on a number line are always less than 2. Also, 2 is included as it satisfies the given condition. Thus, the less than or equal inequality symbol should be used to present the solution. Therefore, $x \leq 2$.

(c) Let x be a real number between -3 and 4. This means that $-3 < x$ and $x < 4$. Combining the two inequalities gives, $-3 < x < 4$.

Example 2.13

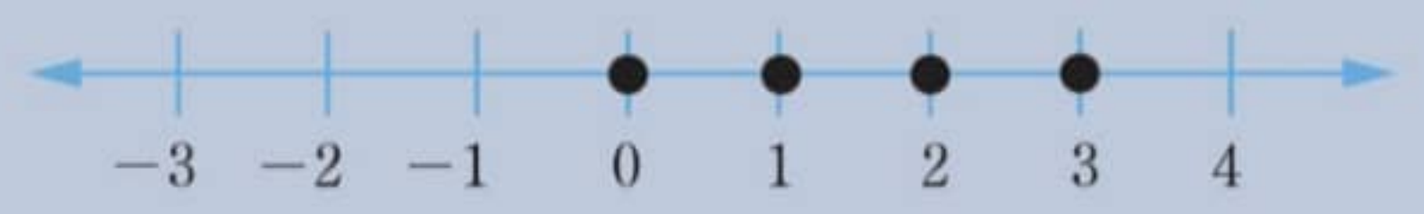
If x is an integer, locate each of the following on a number line.

(a) -1 is less than x and x is less than 4.

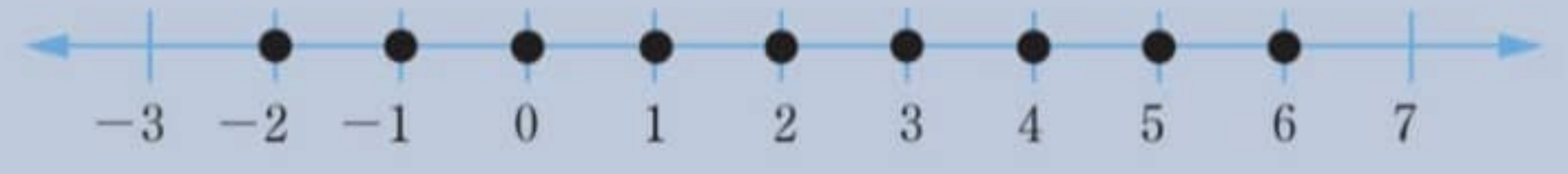
(b) -2 is less than or equal to x and x is less than or equal to 6.

Solution

(a) The statement is equivalent to $-1 < x < 4$, where x is an integer. On a number line, it is represented as follows:



(b) The statement is equivalent to $-2 \leq x \leq 6$, where x is an integer. On a number line, it is represented as follows:



Example 2.14

Use a number line to compare each of the following pair of numbers.

(a) 0.54 and 0.33

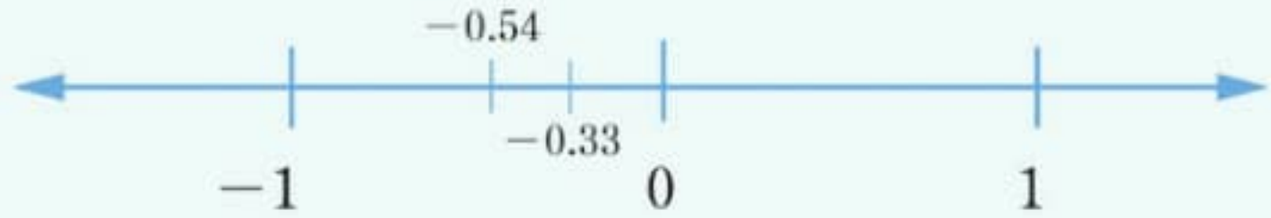
(b) -0.54 and -0.33

Solution

(a) 0.54 and 0.33 are represented in the following number line.

From the number line, 0.33 is on the left side of 0.54, which implies that it is less than 0.54. Therefore, $0.33 < 0.54$ or $0.54 > 0.33$.

(b) –0.54 and –0.33 are located on a number line as follows:



From the number line, -0.33 is on the right side of -0.54, hence -0.33 is greater than -0.54. Therefore, $-0.33 > -0.54$ or $-0.54 < -0.33$.

Example 2.15

Compare the following numbers by using the inequality symbols < and >

(a) 0.432 and 0.437

(b) -0.127 and 0.001

(c) 3.7244 and 3.724

(d) $-\sqrt{7}$ and $\sqrt{5}$

Solution

(a) $0.432 < 0.437$ or $0.437 > 0.432$

(b) $-0.127 < 0.001$ or $0.001 > -0.127$

(c) $3.7244 > 3.724$ or $3.724 < 3.7244$

(d) $\sqrt{5} > -\sqrt{7}$ or $-\sqrt{7} < \sqrt{5}$

Exercise 2.5

1. Write true or false in each of the following inequalities.

(a) $3 < 30$ (d) $6 \geq 2$ (g) $-8 \geq -4$ (j) $8 = -8$

(b) $5 > -2$ (e) $-3 < -2$ (h) $-4 < -5$

(c) $3 < -30$ (f) $2 > -4$ (i) $5 < 10$