ISBN 978-99990-0-042-0

Federal Democratic Republic of Ethiopia Ministry of Education

INFORMATION TECHNOLOGY STUDENT TEXTBOOK GRADE 11

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INFORMATION TECHNOLOGY

STUDENT TEXTBOOK

GRADE 11

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FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF EDUCATION

HAWASSA UNIVERSITY

First Published August 2023 by the Federal Democratic Republic of Ethiopia, Ministry of Education, under the General Education Quality Improvement Program for Equity (GEQIP-E) supported by the World Bank, UK's Department for International Development/DFID-now merged with the Foreign, Common wealth and Development Office/FCDO, Finland Ministry for Foreign Affairs, the Royal Norwegian Embassy, United Nations Children's Fund/UNICEF), the Global Partnership for Education (GPE), and Danish Ministry of Foreign Affairs, through a Multi Donor Trust Fund.

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Printed by:
GRAVITY GROUP IND LLC
13th Industrial Area,
Sharjah, UNITED ARAB EMIRATES
Under Ministry of Education Contract no. MOE/GEQIP-E/LICB/G-01/23
ISBN: 978-99990-0-042-0

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UNIT 1

INFORMATION SYSTEMS AND ITS APPLICATIONS

Learning Outcomes

At the end of this unit, students will be able to:

- Define data, information, knowledge, and wisdom flow chain
- Differentiate the concepts of data, information, knowledge, and wisdom
- Explain the concept of information systems
- Identify the main components of an information system
- State the function of each component of an information system
- Describe the different application areas of information systems
- Recognize the value of information system through its application to solve societal problems
- Explain IT-based entrepreneurship

Unit Overview

This unit discusses concepts of data, information, knowledge, and wisdom as well as their relationships and differences. It also discusses information system and its components, and the application of information systems in areas such as e-banking, e-government and e-learning.

1.1. Data, Information, Knowledge, and Wisdom

Brainstorming 1.1

- Reflect on the value of information in our daily life.

1.1.1 Data

Data is raw facts that cannot give meaning on its own. It is a representation of what we see and perceive using things like letters and numbers. Facts such as 100, 250, age, and Ethiopia are considered as data. Each of them does not give meaning on its own. For example, 100 can be the weight of a person or the measurement of a distance. Likewise, the word Ethiopia can be a country name or a person's name. It does not tell us any meaning unless it is related to other data.

Data is recorded and stored using numbers, texts, and images. Some data can be represented better by numbers than texts. For example, age is better represented by numbers than texts. Likewise, words such as name are only represented by text. With the development of satellite technology, representation of data in the form of image has become very popular. Thus, one form of data representation is better than the other forms of representation, depending on the type of data and context.

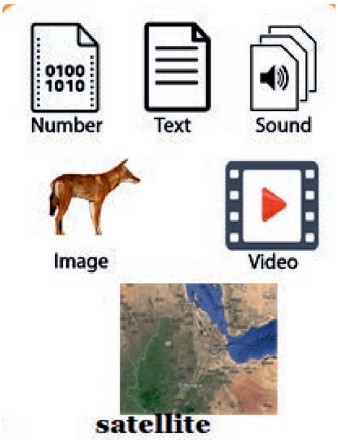


Figure 1.1: Different forms of data

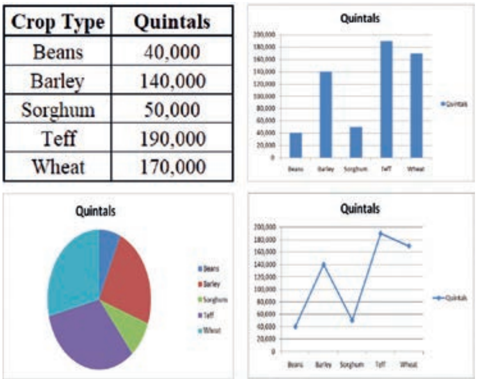
Activity 1.1

1. List and explain the different forms of data representations.
2. Reflect on why you need to collect and store data.

1.1.2 Information

Information is data processed in a meaningful way to the end users. Registering daily sales data may not give meaning. But when we aggregate daily sales data by weeks of the month, it becomes information as it shows whether the sales are increasing or decreasing. By asking relevant questions about ‘who’, ‘what’, ‘when’, ‘where’, etc., we can derive valuable information from the data and make it more useful for users. Therefore, **information** is a processed data that is used to answer certain questions.

Like data, information can be also represented in different forms. It can be represented in the form of a table, line graph, bar graph or formulas (see Figure 1.2).



Crop Type	Quintals
Beans	40,000
Barley	140,000
Sorghum	50,000
Teff	190,000
Wheat	170,000

Figure 1.2: Different forms of information representation

Notes

- Quintal or Qts, shown in Figure 1.2, is weight measurement which is equivalent to 100 kilograms

Activity 1.2

1. Explain the use of information.
2. Discuss the different ways in which data is converted into information.

1.1.3 Knowledge

Knowledge is an understanding which is acquired by further processing and integrating different sets of information. It includes both understanding and skill. For example, when you tell a child how to ride a bicycle, you are giving information. This helps the child to understand how to ride a bicycle. When a child applies the information in riding a bicycle, the child acquires the skills necessary to properly ride a bicycle (see Figure 1.3). Then the information becomes knowledge. Therefore, knowledge is acquired by integrating information from different sources such as reading books, engaging in different activities, discussing with other people, and observing when something happens. Knowledge is the capability to think and act to solve a problem or accomplish a given task. For example, the ability to read this textbook or maintain a computer is knowledge. Knowledge is more of a personal possession that you retrieve and apply when you need it.

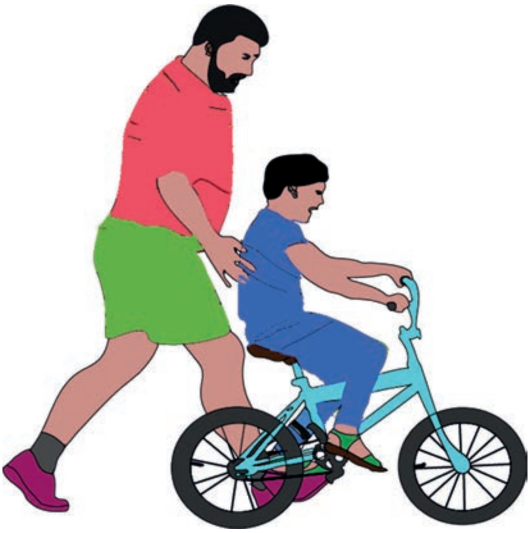


Figure 1.3: Example of knowledge acquisition

1.1.4 Wisdom

Wisdom is the ability to make wise decisions and judgments using one's knowledge. It is the highest level of human understanding. It is associated with good judgment and actions that contribute to living well (see Figure 1.4).

Figure 1.4: Wisdom

Wisdom is like love, intelligence, and politeness in that it is a good thing to have. The more we have it, the better we become.

1.1.5 The Difference between Data, Information, Knowledge, and Wisdom

Data, information, knowledge, and wisdom can be hierarchically arranged where data is placed at the bottom and wisdom is placed at the top of the pyramid. As you move up in the pyramid, the value you get increases. The more data is enriched with meaning and context, the more knowledge and insights we get from it. The top of the pyramid is where we have turned the knowledge and insights into wisdom which is the highest level of human intelligence (see Figure 1.5).

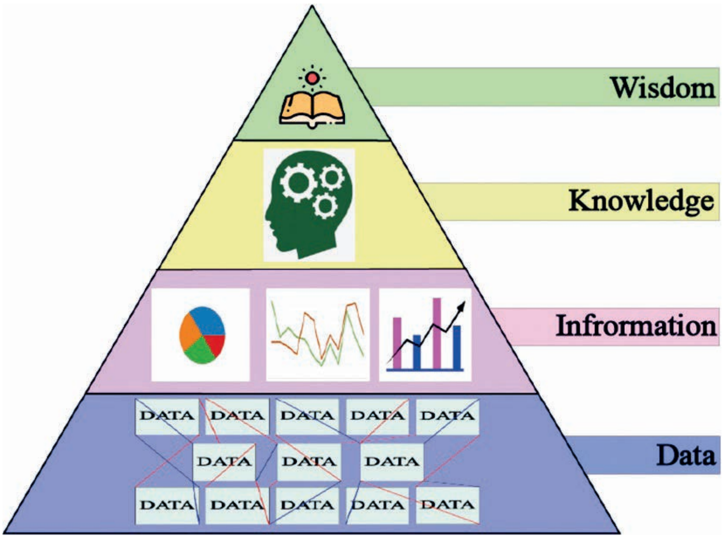


Figure 1.5: Data, Information, Knowledge and Wisdom

The difference between data, information, knowledge, and wisdom can be further explained as follows:

Data is anything represented as numbers, texts, and images. For example, 010101 or +251********* are data.

Information may be viewed as data put into context**.** It is an organized form of data to provide meaning. For example, when we say that +251********* is a person's phone number, the data becomes information. Information is a set of data that has already been processed, analysed, and structured in a meaningful way to become useful.

Knowledge refers to understanding patterns, rules, or other mechanisms that serve as a guide for our future actions. It emerges from further processing and integration of information. It is more complex than information. It is more of a personal possession. Knowledge shapes and guides our actions.

Wisdom is the ability to think and act using knowledge. It is the highest level in human intelligence. Wisdom includes intuitive thinking, logical thinking, creative thinking, and collective thinking.

Activity 1.3

- Give examples that illustrate the difference between data, information, knowledge, and wisdom.

1.2. Introduction to Information Systems

1.2.1 Information systems

An **information system (IS)** is a set of interrelated components working together to collect, process, store, and disseminate information to potential users (see Figure 1.6). An information system generates different types of information or reports that are used by employees in the organization to accomplish different organizational tasks. For example, managers use information to make decisions such as determining the selling price of a product. Information systems have now become an integral part of organizations. They are used to capture data and generate summarized reports for decision making. For example, a school information system captures student data about different types of assessments such as quizzes, assignments and final examinations. All these assessment data are summarized to show a student's overall performance. Each subject's mark is used to calculate the average mark of students and rank them accordingly. This information is important for schools to effectively organize their regular activities.

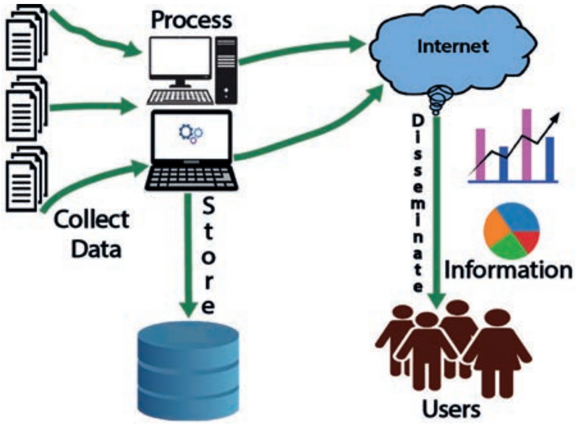


Figure 1.6: Model of Information System

Activity 1.4

1. Discuss the data captured by your school's information system.
2. Discuss the information that is generated by your school's information system and for what purpose it is used.

1.2.2 Components of IS

Information systems can be viewed as having five major components: hardware, software, data/information, people, and procedure. The functions of each component are explained below.

- **Hardware**

Hardware includes digital devices that are required to perform core information system functions such as data storage, data processing, and communication (see Figure 1.7).

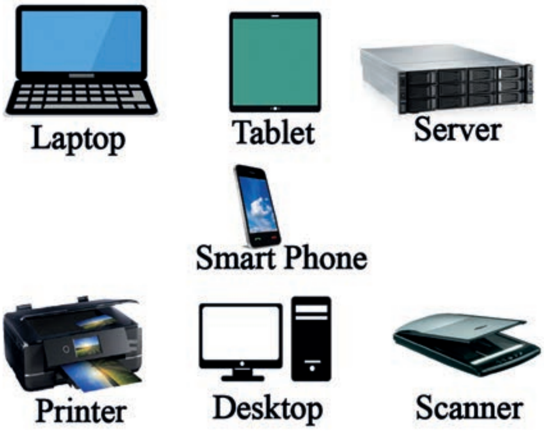


Figure 1.7: Hardware components of Information Systems

Communication among disparate parts of an information systems is facilitated through telecommunication networks that include wired and wireless networks.

- **Software**

Software is a set of instructions that commands the computer hardware to do something. It includes the operating system, the Database Management System (DBMS), application software, anti-virus software, and others that are required to be in place for the information system to operate properly.

- **Data and Information**

Organizations generate different types of data when they interact with their customers and suppliers. For example, data is generated when a digital device selling company sells its products such as computers and printers. The company must keep track of its daily sales data. Without such data, the company cannot properly execute its tasks and monitor its performance.

The various types of data that organizations collect on a regular basis must be stored in a computer database for later use. The data is used to prepare reports such as monthly sales reports that are used by managers for decision making. Therefore, data or information is a critical resource or asset that must be properly managed by the information system.

Links

See Section 1.1.1 of this unit for a more detailed explanation of data and information.

- **People**

Information systems require qualified or trained people with knowledge to operate the technologies and identify new data that must be captured and stored by the information system. Therefore, the technical people who have specialized knowledge of the information system are integral parts of the information system of an organization. They are responsible to create and manage an information system that is supportive to the organization's daily activities.

- **Procedure**

Procedure is another component of information systems. A procedure is a series of steps followed to achieve a desired outcome or goal. Procedures are the policies and methods to be followed in using, operating, and maintaining an information system. It is necessary for organizations to have clear procedures that clarify: what data should be captured by the information system; who should have access to the data; who should have the privilege to modify data; and many more. Procedures that are put in place to facilitate an effective use, operation, and maintenance of information systems will help organizations to get more benefits from their information systems.

Activity 1.5

- Explain the function of each component of an information system.

In the following section, we will discuss a human resource information system (HRIS) as an example of information system implementation in an organization. HRIS is a type of information system. HRIS has a database that stores data of employees. The kind of data kept in a database of typical HRIS include:

- Recruitment data such as applicant's Curriculum Vitae and the number of candidates.

- demographic data like employee ID, name, date of birth, gender, position, residence, cost center specifications, department, termination date, and so on.

- performance management data like performance records of employees. It refers to the feedback, ratings, and achievements of employees.

- learning management data like training and development.

- Compensation and benefits data like employee's salary structure and other benefits.

HRIS uses different technologies to store and process data into useful information. Server computer, desktop computer, laptop, and networks to interconnect different departments and branches are among the infrastructural resources used in a HRIS. Employee use the available computers to access data and generate information from the database (see Figure 1.8).

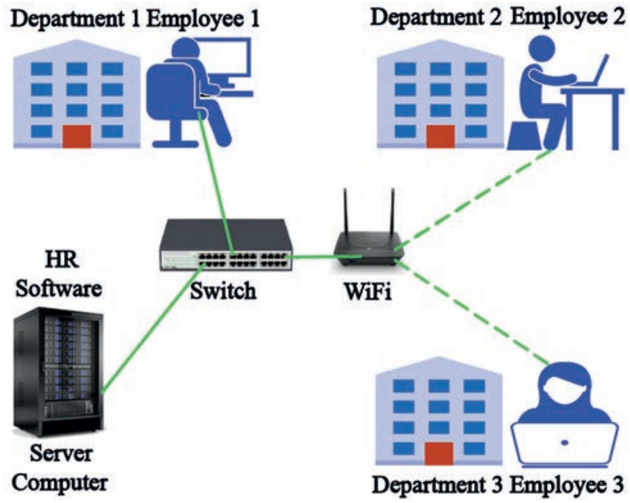


Figure 1.8: Human Resource Information System (HRIS)

Some of the software components of the HRIS would include:

- **Recruitment software.** This software is used to automate the posting of job offerings as well as the sorting of incoming applications. The software can post an organization’s job needs on a variety of websites. Applicants can also submit resumes without meeting with anyone in person.

- **Time and attendance software**: It is used to track employee attendance. This software helps the organization save money. Employees are paid based on the hours they work.

- **Performance management software**: It is used to manage performance appraisal data. It helps the organization to make evidence-based decisions to retain, promote, transfer, or terminate an employee.

- **Training and development software**: This software is used to manage training programs for employees. It is also used to automate training for online delivery.

Nowadays, information systems are no more considered only as means of generating information for managerial decision makings. Their role for the competitive power of organizations has become so high that they are considered as strategic assets of organizations.

1.3. Applications of Information System

Brainstorming 1.2

- Share ideas on information systems that are used to provide services in the business environment.

Information systems have now become the means through which different IT-enabled services are provided by organizations. These IT-enabled services are usually known as e-services. E-services are defined as the provision of public services using technology as a mode of service delivery. For example, banks provide banking services through mobile phone without the need to go to a bank branch. The different types of e-services are discussed below.

1.3.1 E-Government

Electronic government or e-Government is the use of information systems to provide electronic services to citizens with the purpose of increasing efficiency, transparency, and citizen participation. The appropriate application of e-Government allows for higher levels of effectiveness and efficiency in governmental tasks. It also improves efficiency of communication among different governmental offices. Different organizations establish an organizational portal to facilitate communication between the organizations and their customers. A **portal** is a web-based information system that collects information from different sources into a single user interface so that users can easily access the organization's electronic services. Figure 1.9 shows the portal of the Ethiopian Ministry of Health. The portal provides different health related services to citizens.

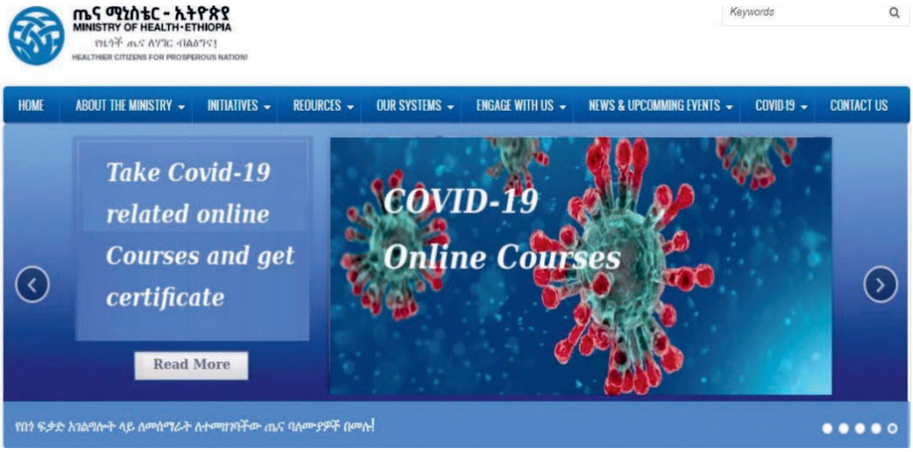

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Figure 1.9 Portal of the Ministry of Health (https://www.moh.gov.et/ejcc/en)

Citizens go to municipalities for business registrations, auto registry, payment of taxes, issuance of birth certificates, issuance and renewal of identification cards, etc. All forms of municipal services require citizens to go to the municipalities in person. All these services can, however, be automated and made accessible for citizens over the municipality's web portal.

Adoption of e-government solution brings several benefits. Some of the benefits are:

- Establishing trust between governments and citizens

- Facilitating sharing of information and ideas between government agencies and departments within an agency
- Allowing citizens to easily get government decisions and policies through institutional web portals
- Reducing cost of running government services as the services are delivered online
- Improving convenience of service delivery. Citizens can easily access government services through their mobile phones. For example, customers can pay their monthly electric bill through their mobile phones.

Activity 1.6

1. Explain the concept of e-government.
2. Discuss the benefits you get by using e-government services.

1.3.2 E-banking

In the traditional banking service, customers must go to the nearby banks to withdraw money, transfer money to families, and pay their utility bills. The traditional banking service is inconvenient and inefficient as it demands customers to go the bank in person and wait their turns to get a service. It also creates unnecessary burden on the bank.

Electronic banking is a form of technology-based banking service that avoids exchange of cash, checks, or other types of paper documents. In the banking sector, IT is mainly associated with services like Internet banking, Automated Teller Machine (ATM) and mobile banking. Like in other service sectors, IT has positively influenced the banking industry. Banks make their information systems accessible over the Internet so as to provide Internet banking services (see Figure 1.10). This allows customers to make payments online, transfer money from their account to other accounts and get other banking services from wherever they are.

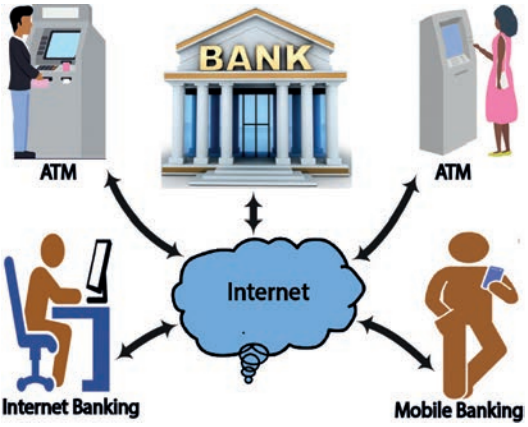

Figure 1.10: E-Banking

Some of the commonly known e-banking services include Automatic Teller Machine (ATM), Mobile Banking, Internet Banking, Credit cards, Debit Cards, Smart Cards, Electronic Funds Transfer (EFT) System, etc.

E-banking provides many benefits to banks as well as to customers. Some of the benefits include:

- The cost of operation per unit of services is lower for banks.
- Customers can withdraw cash any time using, for example, ATM service.
- Customers can make payments from wherever they are.
- Customers can easily check their account balance
- Customers can get immediate message about transactions related to their accounts.

Despite all of the several benefits that e-banking has, there are some challenges to it such as:

- Digital theft
- Exclusion of the digitally illiterate citizen from e-banking services
- Lack of access to IT infrastructure in remote areas
- Unaffordable cost to acquire IT devices like smart phones for low-income citizens

Activity 1.7

1. Explain the concept of e-banking.
2. Discuss e-banking services that you have used before or heard from your family members and list the benefits that you obtained from them.

1.3.3 E-learning

The face-to-face form of education is the dominant form of educational delivery but it has some limitations. It does not allow students to learn in their own pace, and class schedules are not flexible. E-learning is introduced as an alternative form of educational delivery.

E-learning is a form of learning delivered through the use of digital devices. A number of other terms are also used to describe e-learning. It is known by terms like *online learning*, *virtual learning*, *distributed learning*, *computer-based learning, etc*. Despite their subtle differences, these terms in general refer to the use of information and communication technologies for facilitating the teaching learning process. If e-learning is provided over the Internet, it is referred to as online learning

The main components of e-learning are the Internet, computers or mobile phones, digital learning resources, content developers (such as teachers and graphic editors), and learners (see Figure 1.13).

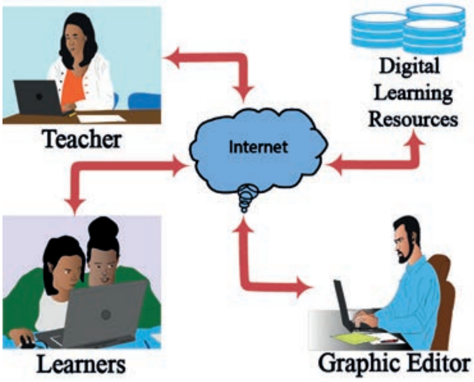

Figure 1.13: Components of E-Learning

Some of the benefits that e-learning offers to learners are:

- Flexibility in learning time: Learners can access and learn at any time, or any day.

- Implementation of student-centered learning: Learners can learn on their own pace.
- Access to a variety of educational resources from different schools or universities
- Rich multimedia learning resources: The multimedia e-learning content engages learners to be active learners.
- Reduced educational costs: there are no costs for travel and accommodation.

The main disadvantages of e-learning are:

- Physical isolation of students from teachers and other students
- Teachers have little control to monitor the progress of students' learning
- Technology related costs make access to e-leaning difficult for students of low-income families.

Activity 1.8

1. Explain the concept of e-learning.
2. Discuss the e-learning system you might have used before or heard about. What are the benefits of e-learning in facilitating your learning?

1.3.4 E-commerce

E-commerce (electronic commerce) is the buying and selling of goods and services over the Internet. E-commerce is fundamentally a website deployed over Internet to handle online transactions. Buyers go to the E-commerce website using their smartphones or computers when they make an order for a product or service over the Internet. Once the order is received by the merchant, the payment will be processed through the Bank. After the whole transaction is successfully completed, the order will be delivered to the buyer. In E-commerce transactions, many actors are involved including merchants, buyers or customers, banks and transporters. (See Figure 1.14).

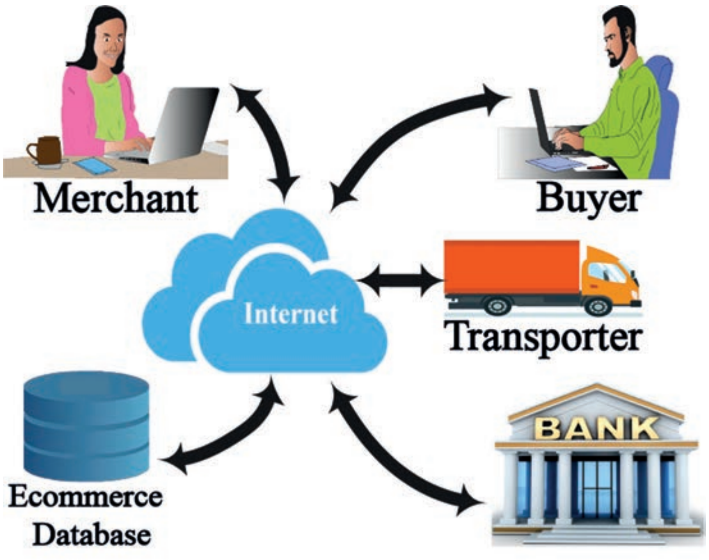

Figure 1.14: Components of E-Commerce

In Ethiopia, small businesses which sell different types of products online have mushroomed recently. The flexibility with which customers browse products and compare prices and buy the cheapest offerings contributed to the growth of such types of businesses. On the business owner's side, they do not need to have physical stores and hire salespersons. This allows them to attract more customers. It is, however, worth noting that e-commerce is at its infancy stage in Ethiopia. There is a need to develop the e-commerce infrastructure such as Internet access in all places, efficient transport system, appropriate regulations for E-commerce transactions, and many more. Figure 1.15 shows a sample local online e-commerce site.

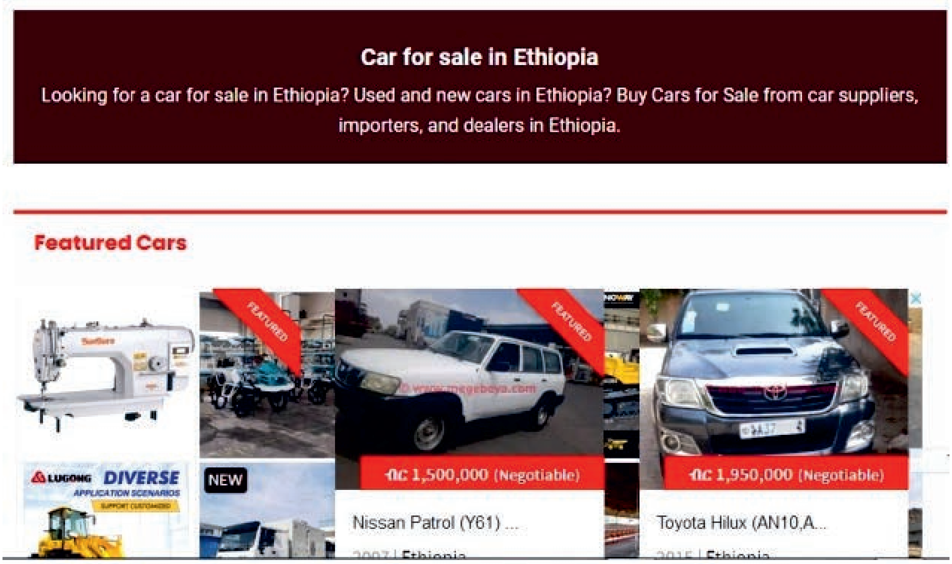

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Figure 1.15: E-commerce - online product selling

Some of the advantages of e-commerce include:

- Avoiding intermediaries: this mode of business allows customers to buy products directly from manufacturers at a cheaper price avoiding wholesalers and retailers.
- Convenience: customers can order products from where they are.
- Increased bargaining power for the customer: customers can easily browse the price of different merchants and choose the least price.
- Global reach: the Internet made it possible for the merchants to expand their customers outside their local area. This, however, also creates more competition as merchants now compete not only with local competitors but also with global ones.

Activity 1.9

1. Explain the concept of e-commerce.
2. Discuss your own experience of e-commerce, if you have any. What benefits do you get?

1.3.5 Telemedicine

Telemedicine refers to the practice of caring for patients remotely without the caregiver and the patient being in the same physical location. Telemedicine was originally introduced to treat patients who were in remote places, far away from local health facilities, or in areas with shortages of medical professionals. People who live in rural areas of Ethiopia do not have access to quality health services. In addition to creating access, telemedicine has now been used as an alternative mode of health service and as a tool for convenient medical care.

There are now different telemedicine companies that provide online treatment. A patient can simply come online and request a visit with one of the telemedicine company's doctors and get treatment. The patients pay the service fee online through their bank account (See Figure 1.16). This online medical consultation has already been implemented in Ethiopia. One can meet online doctors in Ethiopia by browsing the Internet.

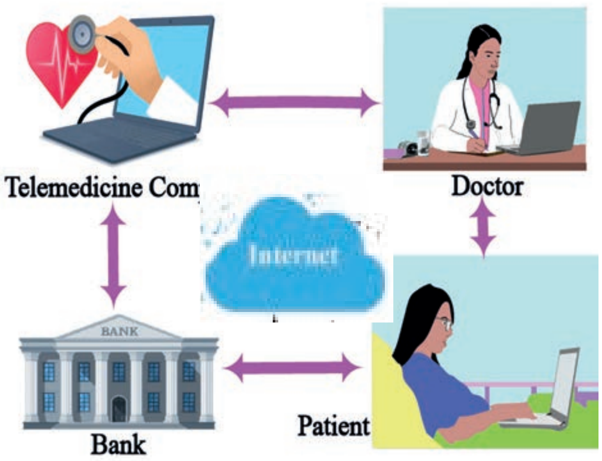


Figure 1.16: Telemedicine - mobile based service

There are now new mobile-based medical services. Patients are starting to use their mobile to monitor and track their health conditions. Simple home-use medical devices allow patients to gather needed medical information for doctors (see Figureure 1.17). These devices are used to measure the patient's body temperature, glucose levels, and blood pressure without the need to go to clinics. This encourages more and more patients to become proactive about using technology to manage their health.

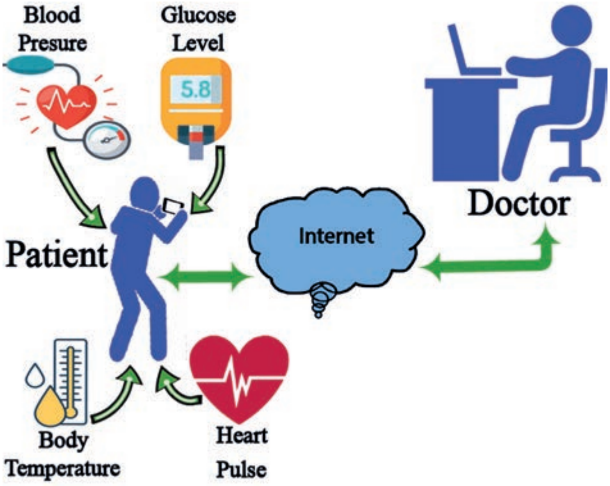


Figure 1.17: Telemedicine Mobile based Service

Some of the advantages of telemedicine for patients include:

- Overcoming geographical barriers to access health care services
- Reduced cost through avoidance of costs such as travel and hotel services.
- Access to specialized physicians by people who live in remote locations

Telemedicine, however, has some limitations. Telemedicine requires technical trainings and equipment, which may not be readily available in the rural areas of developing countries.

Activity 1.10

1. Explain the concept of telemedicine.
2. Reflect on the benefit of telemedicine in your daily life.

1.3.6 Teleconference

A teleconference is a meeting of two or more people who are separated by distance using electronic communication. It is a generic term for connecting people from different locations electronically. The two popular forms of teleconferencing are **audio conferencing** and **video conferencing**.

- **Audio conference**: it is a voice-only communication, sometimes called conference call, which connects people from remote locations via telephone lines (See Figure 1.18). For example, meetings can be conducted via audio conference.

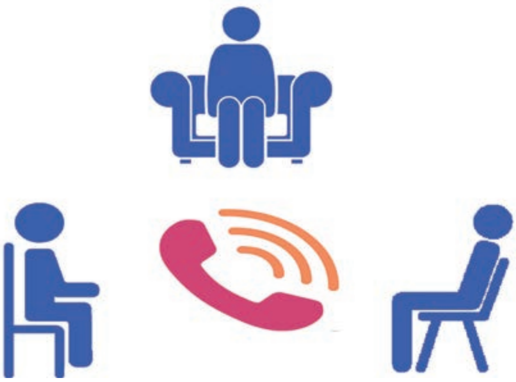


Figure 1.18: Teleconference -Audio conference

Activity 1.11

1. Explain the concept of teleconferencing.
2. Discuss the benefits of teleconferencing for students to do group assignments or project works.

- **Video conference**: it combines both voice communications and video images. It supports two-way video conferencing. Video conferencing creates a social presence that resembles face-to-face meetings. It enables participants to see the facial expressions and physical appearance of conference participants at remote sites (see Figure 1.19). Zoom, Google Meet, and Microsoft Teams are some examples of video conferencing software.

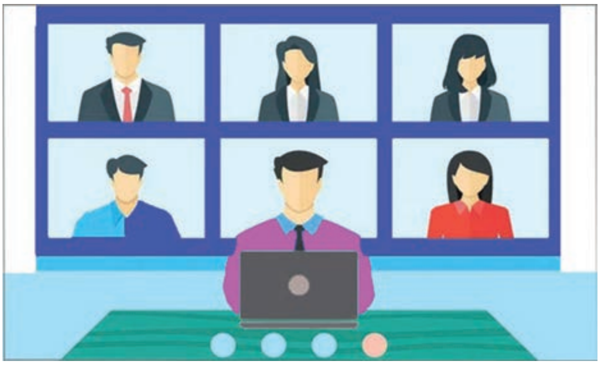


Figure 1.19: Teleconference -Video conference

Teleconference has many benefits for conference participants. It saves time and travel costs. Conference participants can attend the meeting from home or office. It reduces conference hosting costs. In addition, it can accommodate more people as it does not cost that much for each additional participant.

1.4. IT for Entrepreneurship

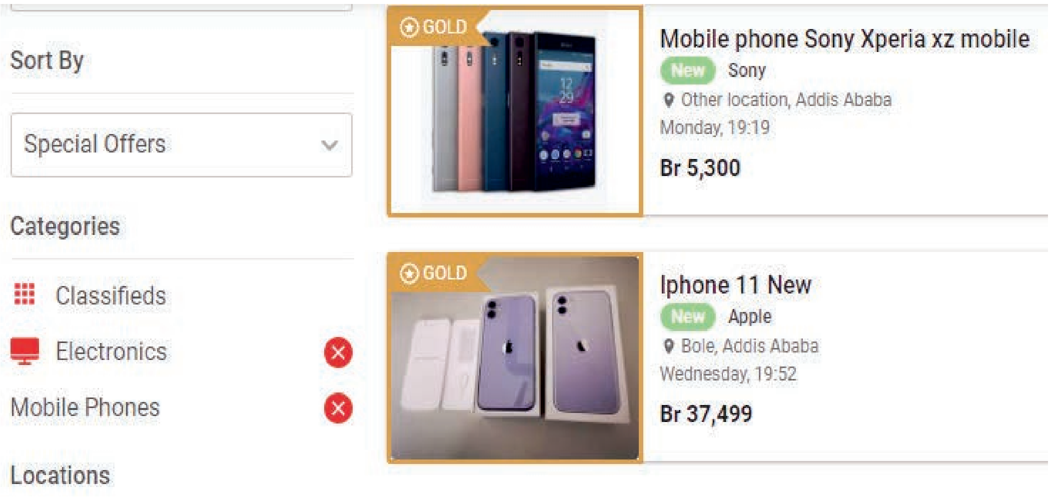
Entrepreneurship is defined as the process of designing, launching, and running a new business. An entrepreneur is an individual who creates a new business, bearing most of the risks and enjoying most of the rewards. The entrepreneur is commonly seen as an innovator, a source of new ideas, goods, services, and businesses.

Information technology (IT) is transforming the world of work. IT provides new opportunities for business people. IT enabled business is a business that uses IT as a platform to run a business. It includes business like online training, providing data entry and processing services, Internet Café service and online product sells. These types of businesses are providing new opportunities for job creation that could help tackle global unemployment. For instance, the development of the mobile-based applications has created new opportunities for small- and medium-sized enterprises (SMEs) in various parts of the world, especially in developing countries like India and Kenya.

In our country, IT has also created new employment opportunities. Youth unemployment is one of the global challenges we face today. IT can be exploited to solve such types of problems. Therefore, IT should be included in youth employment and entrepreneurship strategies for three key reasons:

- More jobs and businesses require IT skills
- IT is transforming the way young digital entrepreneurs do business
- There is an explosion of online learning opportunities and resources for job seekers and digital entrepreneurs

People who are competent in IT can create different types of IT-based businesses. They can have their own business as application developers, game developers, and service providers using various platforms including social network websites. In Ethiopia, IT-based services are flourishing such as Internet cafes and online sales. Figure 1.20 shows a sample online mobile sales business.



Mobile phone Sony Xperia xz mobile
Sony
Other location, Addis Ababa
Monday, 19:19
Br 5,300

Iphone 11 New
Apple
Bole, Addis Ababa
Wednesday, 19:52
Br 37,499

Figure 1.20 Online mobile sales

IT-based businesses do not require large capital to start as do traditional businesses. An innovative and entrepreneurial mind with little resource like a laptop can create incredible business ideas. The story of the founder of RIDE, Samrawit Fikru, is a good example in Ethiopia. Starting as an SMS-based service, RIDE today is a popular Internet-based taxi-hailing service that is used by thousands of pepole (See Figure 1.21). RIDE has made great contributions to job creation in addition to providing an alternative service to taxi users.

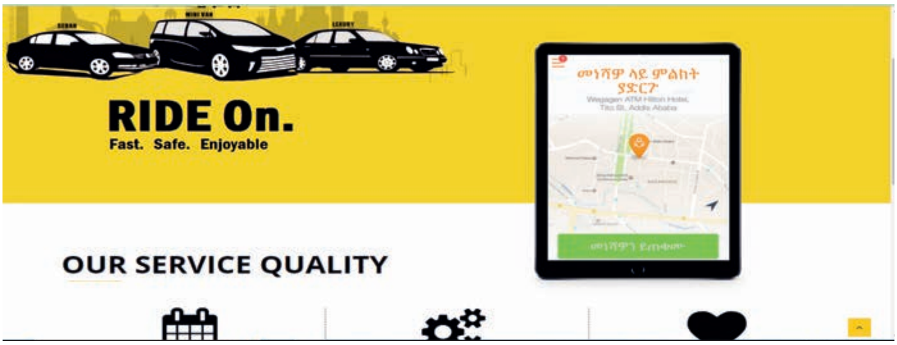


Fig 1.21: Ride taxi-hailing system

Activity 1.12

1. What is IT based business?
2. Discuss in a group to identify different types of IT-based businesses.

Unit Summary

In this unit, you have learnt about:

- basic concepts of data, information, knowledge and wisdom.
- the relationship between data, information. Knowledge, and wisdom
- concepts of information systems
- components of information systems
- application of information systems in the society such as E-government, E-banking, E-learning, E-commerce, Telemedicine, and Teleconference.
- advantages and the potential downsides of applications of information systems in different social and economic activities of the society
- the use of IT for entrepreneurship

Key Terms

Data is a collection of raw facts.

Database is a collection of related files that stores organized data

E-commerce (electronic commerce) is the buying and selling of goods and services over the Internet.

E-learning is a form of education that is delivered through digital devices.

E-banking is a form of banking in which funds are transferred through an exchange of electronic signals rather than through an exchange of cash, checks, or other types of paper documents.

Entrepreneurship is the process of designing, launching, and running a new business.

E-services are defined as the provision of public services using technology as a mode of service delivery.

Information is processed data in a meaningful way to potential users.

Information system is a set of integrated components for collecting, storing, processing data, and providing information.

Knowledge is an understanding which is acquired through the application of information into actions.

Procedure is a series of steps followed to achieve a desired outcome or goal.

Telemedicine is a practice of caring for patients remotely while the caregiver and the patient are in separate physical locations.

Teleconference is the meeting of three or more people who are separated by distance using electronic communication.

Wisdom is an ability to make wise decisions and judgments using one's knowledge. It is the highest level of human understanding.

Review Questions

Part I: Write True if the statment is correct and False if it is incorrect.

1. Data is the foundation for generating information and knowledge.
2. Information must be accurate and relevant to the purpose in order to be considered valuable.
3. Knowledge is data put into context.
4. As one goes from data to wisdom hierarchy, value increases.
5. “Think many times before you act”. This statement refers to information.
6. People are not important component of the information system.
7. E-commerce is a form of e-service that provides banking services.
8. E-learning is a form of education that is delivered through digital devices.
9. Telemedicine is a form of medical services which is provided through digital devices.
10. IT can be used to create IT-based businesses.

Part II: Choose the correct answer from the given alternatives.

1. A collection of facts without meaning to users is ___ .

   A. Knowledge B. Data
   C. Information D. Wisdom

2. The wise use of knowledge is known as_____.

   A. Knowledge B. Data
   C. Information D. Wisdom

3. ___ is acquired by integrating information with experience.

   A. Knowledge B. Data
   C. Facts D. Wisdom

4. One of the following is not the component of information systems.

   A. Hardware B. People
   C. Procedures D. None

5. Application of digital technologies to provide government services to the public is known as ___________.

   A. e-banking B. e- government
   C. e-learning D. e-commerce

6. _________refers to the practice of caring for patients remotely through electronic devices.

   A. e-banking B. e- government
   C. telemedicine D. e-commerce

7. Which one of the following is the benefit of ICT entrepreneurship:

   A. Create employment opportunities
   B. Generate income for the country
   C. Diversify the country's economic sector
   D. All

Part III: Discussion Questions.

1. How can e-government transform government services to the public?
2. Why have information systems become very important for present-day society?
3. How has e-learning changed the way we learn in school as well as in the office?

UNIT
2

EMERGING TECHNOLOGIES

Learning Outcomes

At the end of this unit, students will be able to:

- Explain Emerging Technologies
- Define Artificial Intelligence and state its branches
- Describe common Artificial Intelligence applications
- Differentiate the concepts of Augmented Reality and Virtual Reality
- Describe Data Science and its applications

Unit Overview

Emerging technology can be understood as a technology that is developing and evolving fast with a prominent socio-economic impact. There are several examples of emerging technologies that are covered in this unit such as artificial intelligence, virtual reality, augmented reality, and data science. The application areas of emerging technologies are also discussed in the unit.

2.1. Artificial Intelligence

Brainstorming 2.1

- To what extent emerging technologies can transform the work environment today?

Artificial Intelligence (AI) is a branch of computer science that deals with the design of systems that mimic human intelligence. AI systems are designed to have features that only humans are capable of such as reasoning and generalization. An example of reasoning is, "My friend is either at home or in her workplace. My friend is not in her workplace. Therefore, my friend is at home". Generalizing is about applying past experiences to current problems of similar nature. For example, "I know how to change a wheel on my bicycle and therefore I can use this knowledge to change the wheel on my friend's bicycle."

Even though the history of AI goes back to the 1940s, it was in the 1950s that the term was coined. AI has become so popular and a powerful tool today due mainly to significant growth in computer capacity and the availability of a large amount of data. AI algorithms are now extensively used in a wide range of areas including business, medicine, and entertainment.

2.1.1 Branches of AI

Though there is no hard and fast way of identifying the subfields of AI, the following groups can be considered as branches of AI.

a. Machine Learning

Machine Learning is the study of computer algorithms that enable the computer to learn from data and improve itself without being explicitly programmed. Machine learning algorithms learn from experience. Unlike conventional computer algorithms with explicit instructions that are followed by the computer to solve a problem, machine learning algorithms allow the computer to train on sample data inputs. A model that is built from the sample data will then be used to make predictions that are useful for decision-making. Fraud detection, recommendation systems, email spam detector, and speech recognition are some of the examples of applications of machine learning.

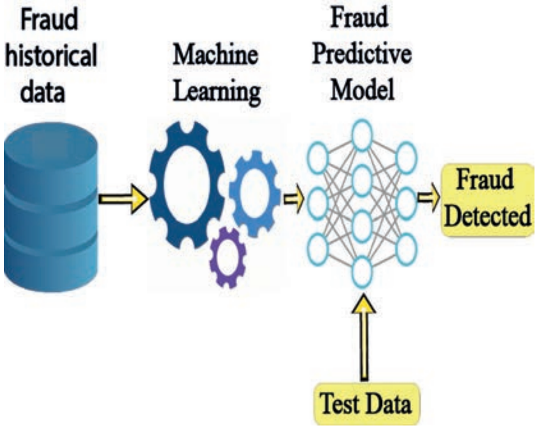


Figure 2.1 Fraud detection using machine learning

b. Robotics

Robotics is the study of machines called robots that substitute tasks that are traditionally done by human beings. Over the past few decades, robots have been used mainly in replacing human labor in routine and mundane activities such as those that are found in car manufacturing assembly lines (See Figure 2.2). Robots are also used in environments that are considered hazardous to human beings like handling radioactive wastes, underwater, and space explorations.

Figure 2.2 Robots in car manufacturing assembly line

Similarly, the application of robots in the household is also becoming common. Nowadays, robots are used at home to do chores, assist the elderly, monitor young children, and more. A robot vacuum cleaner, shown in Figure 2.3, is a well-known example of the application of robots in homes. A robot vacuum cleaner is a machine that sweeps carpets and cleans floors without human intervention.

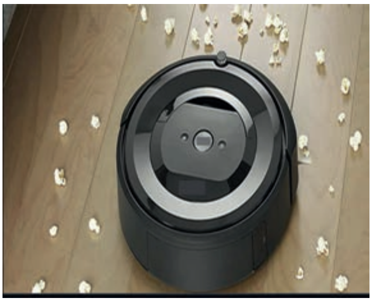


Figure 2.3 Robot vacuum cleaner

c. Natural Language Processing

Natural Language Processing (NLP) is a branch of AI that deals with enabling computers to understand written and spoken human language in the same way human beings do. Computers' understanding of natural language is what powers the services we get from a wide range of systems around us. Some of the major application areas of NLP are listed below (See also Figure 2.4).

- ***Spam Detection***: Email service providers, like Yahoo, analyze a text in an email to check if it is spam or not using NLP.
- ***Machine Translation***: translation of text from one language to another that systems, like Google Translate, do is supported by NLP.
- ***Virtual Assistant***: voice-operated virtual assistants such as Amazon's Alexa and Apple's Siri use NLP.
- ***Sentiment Analysis***: by extracting and analyzing users' data on social media, it is possible to learn users' opinions (which could be negative, positive, or neutral) about something using NLP.
- ***Fake News Identification***: identifying whether or not news is trustworthy and checking the reliability of its source can be done using NLP.
- ***Text Summarization***: summary of a large piece of document like academic articles can be automatically done using NLP.

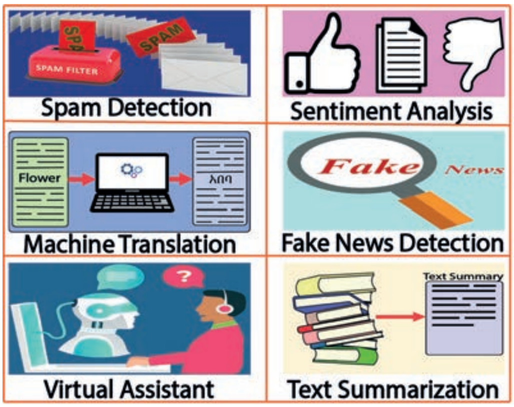

SPAM
SPAM
SPAM FILTER
Spam Detection
Sentiment Analysis
Flower
አበባ
Machine Translation
Fake
News
Fake News Detection
?
Virtual Assistant
Text Summary
Text Summarization

Figure 2.4 Applications of natural language processing

d. Expert Systems

Expert systems are computer programs that emulate human experts. They are designed to solve problems that are normally solved by human experts. Expert systems are one of the earliest attempts to put the field of artificial intelligence to the test. Some of the fields that benefit from expert systems include medical diagnosis, petroleum engineering, and financial investing.

An expert system consists of three components: User Interface, Knowledge Base, and Inference Engine.

User Interface: this is part of the expert system that users use to interact with the expert system. It accepts queries from the user and forwards them to the inference engine. It is also the means through which users see the recommendation that the expert system provides.

Knowledge Base: this is the repository of knowledge of experts in the domain area. The knowledge is organized in the form of if-then-else rules. The knowledge contained is of both factual and heuristic (experiential or common-sense rule) types. The completeness, accuracy, and precision of the knowledge captured in the knowledge base are central to the performance of expert systems.

Inference Engine: this is the brain of the expert system that produces the answer by referencing the knowledge base.

One of the earliest and most well-known examples of expert systems is MYCIN. MYCIN is an expert system that emulates infectious disease experts. It identifies bacteria that cause infections and recommends antibiotics.

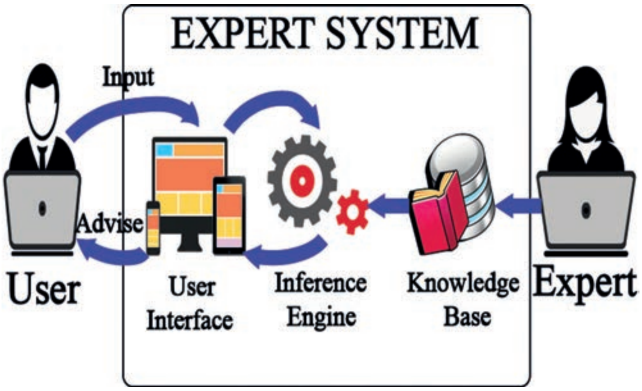


Figure 2.5 Expert system

Activity 2.1

- List the areas where expert systems can be applied.

2.1.2 Application of AI

Nowadays, the power of AI is being exploited to efficiently solve problems in a wide range of areas. The following are some examples of applications of AI.

i. Online Shopping

AI algorithms are used to dive into and process the massive user data available in various systems to extract personalized data about shoppers. The data is then used to present users with items that they are more likely interested in, which makes the whole shopping experience efficient and enjoyable.

Figure 2.6 Online shopping

ii. Autonomous Cars

By collecting data from sources such as GPS, vehicle radar, and cameras, autonomous cars can function without the help of a human agent. Although fully automated autonomous cars are not yet on the streets, autopilot features are already implemented in cars produced by companies like Tesla. The trend and development in the area indicate that the era of fully automated cars is not far away. Multiple reports indicate that autonomous cars have great potential for improving road safety. Autonomous cars are believed to significantly reduce the number of road accidents due to their features such as the ability to exchange safety-critical information with one another, the 360-degree view of the surrounding, the power to flag hazards on the road ahead, and many more.

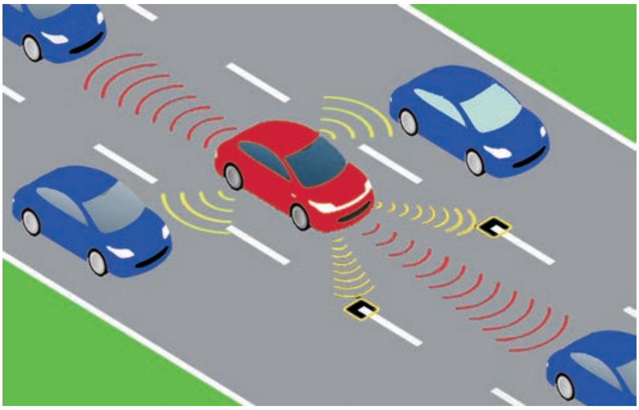


Figure 2.7 Autonomous car

iii. Social Media

The size of data available on social media makes it practically impossible to process the data using human beings. This is why AI has become a fundamental part of how social networks operate today. Social media companies, like Facebook, apply AI in various areas such as advertising, delivery of personalized content, facial recognition, and many more.

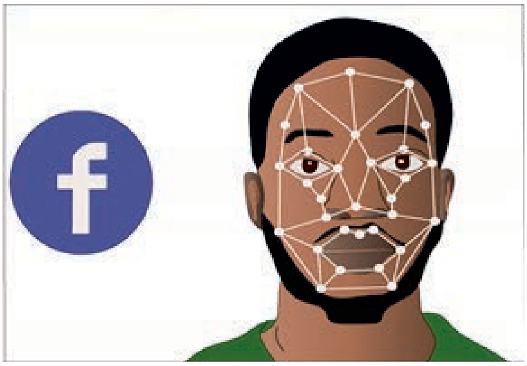


Figure 2.8 Facial recognition using AI

iv. Surveillance

Surveillance systems can benefit significantly from AI. For example, AI systems can automatically detect suspicious behavior in real-time. This can be implemented in places like supermarkets, military and security stations, or any place with restricted access.

Figure 2.9 AI application in surveillance

v. Agriculture

Global phenomena like climate change, food security, and population growth are making the application of innovative approaches in the area of agriculture more important than ever. AI systems are at the core of such type of innovative approaches. Examples of applications of AI in agriculture include precision farming, detection of pests, monitoring the health of soils and crops, and the like. AI-based agricultural advisory systems can be built that farmers use to be climate-ready and adjust their farming activities accordingly.

Sunlight
Temperature
Moisture
Humidity
Life Cycle
Battery
My Plants

Figure 2.10 AI based agriculture Precision Farming

vi. Customer Service

Due to advancements in multiple areas of AI such as Natural Language Processing (NLP), chatbots are nowadays used to provide customer support. A chatbot is a system that simulates human conversation through text or voice commands. It is a fast and cheaper way for companies to provide support and assistance to their customers.

Figure 2.11 Chatbot

vii. Healthcare

Healthcare is one of the areas with immense potential for the application of AI. Disease diagnosis, drug development, and hospital care are some of the examples of applications of AI in the healthcare sector. More examples of the assistance that AI offers in healthcare for complex activities like surgery are discussed in Section 2.2

Figure 2.12 AI application in surgery

viii. Space Exploration

Space exploration is characterized by the processing of a massive amount of data. AI and Machine Learning, which is one of the branches of AI, are used to process data that assists space exploration activities. Operations like space mission planning, data collection, navigation, and maneuvering are supported by AI. NASA, for example, uses a robot known as Robonaut to work on the International Space Station. Robonaut uses many of the tools that an astronaut uses and can perform tasks that are normally done by human beings.

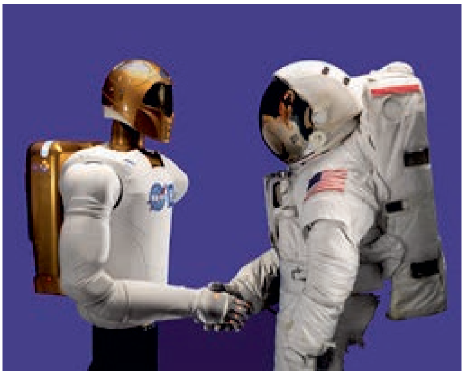


Figure 2.13 Robonaut and an astronaut

ix. Smart Homes

AI systems are abundant in what is known as smart homes. The AI systems assist in home security, household chores, alerting of smokes, and many more.

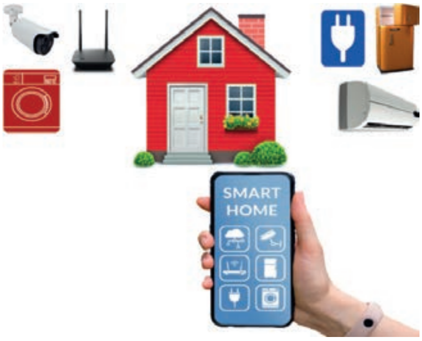


Figure 2.14 Smart home

x. Banks

Credit cards and other forms of fraud prevalent in the banking industry can be prevented using fraud prevention AI. AI systems are used to trace the pattern in credit card transactions and detect frauds.

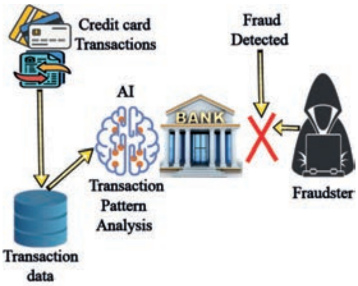

Credit card Transactions
Fraud Detected
AI
BANK
Transaction Pattern Analysis
Fraudster
Transaction data

Figure 2.15 Application of AI in banks

xi. Search Engine

Search engines use AI systems such as NLP to better understand user search queries. They also use AI in ranking algorithms, which determine in what order responses are presented to users in reply to their search query.

Google
Rankbrain

Figure 2.16 Google Rankbrain: Google's application of AI

Activity 2.2

1. Discuss how AI systems can help social networking companies improve their services.
2. Search and discuss in group on more examples of the application of AI outside those covered in the textbook. Discuss the features and debate for or against AI systems.
3. Join with a partner and let one of you take the role of supporting autonomous cars, one against. Then discuss and debate whether they are a good idea, or not, and why.

2.2. Augmented Reality and Virtual Reality

2.2.1 Augmented Reality

Augmented Reality (AR) is a technology that enhances the real world by overlaying computer-generated digital data on real-world objects. By blending the real world with computer-generated information, AR creates an engaging and dynamic user experience.

The hardware of AR includes a processor, sensors, input devices, and a display. Mobile devices do have all four components to run AR applications. Depending on the application, however, the display could be tablets, smartphones, head-mounted displays (HMD), or smart glasses. Such displays are used to locate objects of focus as well as show the computer-generated overlaid information.

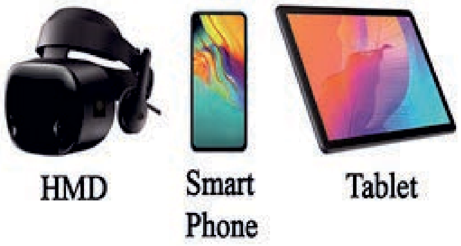


Figure 2.17 Augmented reality devices

AR works by first capturing the picture of the real-world object through a camera. Then relevant information about the image like measurement of the object, as well as other objects that are present in the image and their relative distance from the object in focus, will be processed by the software. Virtual information will be finally generated and overlaid on the object.

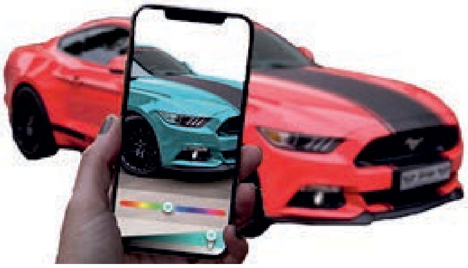


Figure 2.18 Example of augmented reality

Activity 2.3

- Share examples of AR applications that you have used. Describe their features including potential areas of improvement.

2.2.2 Virtual Reality

Virtual reality (VR) is a technology that creates a three-dimensional computer-generated simulated environment. A person can interact with VR using electronic devices such as goggles, headsets, gloves, or bodysuits. VR attempts to create an illusory environment that can be presented to our senses with artificial information, making our minds believe that it is (almost) a reality. Unlike AR, VR creates a completely immersive experience for the user.

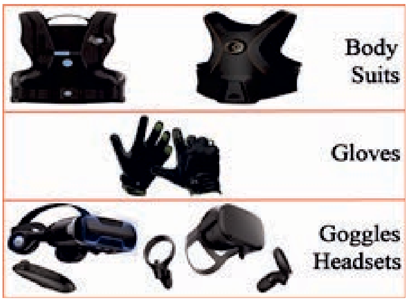


Figure 2.19 Virtual reality devices

Using sensors of various types, a VR environment responds to the user's movements and adjusts views and perspectives in real-time. VR also enables users to touch and manipulate virtual objects by way of data gloves equipped with force-feedback devices. This is how a VR creates the illusion of being in a real environment.

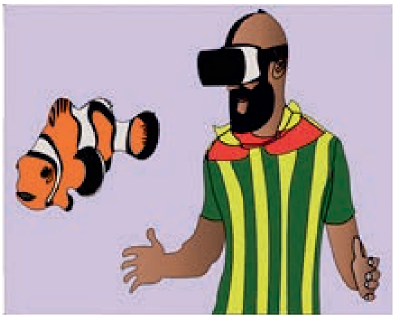


Figure 2.20 Example of virtual reality

Activity 2.4

1. Give examples of how different types of training can be provided using VR.
2. Prepare a presentation on how your school benefit from VR.

2.2.3 The Difference between VR and AR

AR and VR are both known for their enriched and interactive experiences with rich 3-D visuals. However, there are some differences between the two. The following table summarizes the major differences between the two technologies.

Table 2.1 The difference between Virtual Reality and Augmented Reality

Augmented Reality	Virtual Reality
AR works in a real-world setting. It is partially immersive.	VR operates in a completely virtual world. It is fully immersive.
AR users can control their presence in the real world.	VR users are under the control of the system.
AR can run on familiar devices such as smartphones.	VR requires a headset device to use it.
AR works in an environment where the real and virtual worlds blend.	VR works only in a fictional/simulated reality.

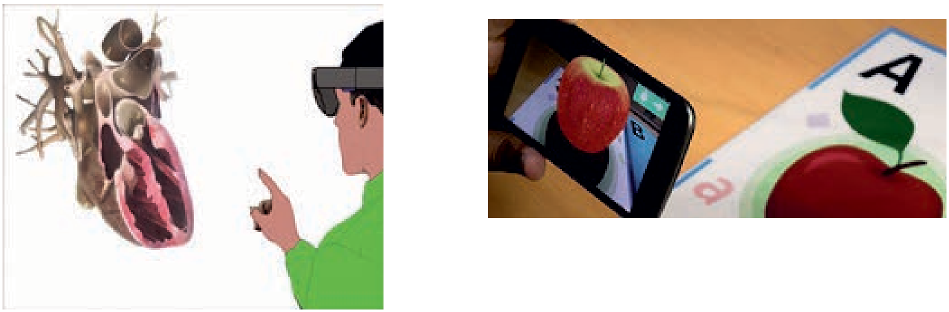
2.2.4 Application of VR and AR

The potential areas of application of AR and VR are very wide. The interactive nature of these technologies, however, makes them more attractive to areas such as education, healthcare, and entertainment. The following are examples of the application of AR and VR within the three areas.

- ***Education***: AR and VR have a wide array of uses in education and enable to learn-on-the go using real-time instructions. They also make learning interactive and fun. Among the reasons why such technologies are very useful in education include:
    - They allow students to travel in time and space and see historical events in a very interactive manner.
    - AR allows students to learn various things more concretely. For example, students can see the different organ systems visually and interactively.
    - The complexity of some concepts can be reduced when presented in a three-dimensional interactive manner.
    - They are a good alternative in an environment where resources are scarce such as laboratory equipment.
    - Learning will be made possible from anywhere using relatively

more accessible devices like smartphones.

- Students can get connected interactively with students from different parts of the world. This helps to instill desirable values like empathy and collaboration in students.

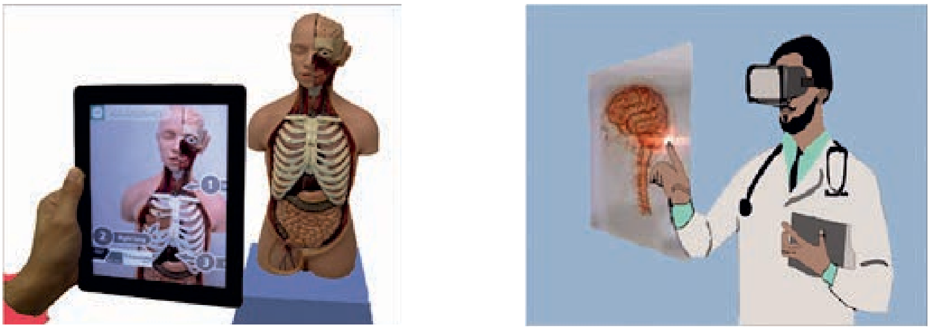


A

B

Figure 2.21 Example of augmented reality (A) and virtual reality (B) in education

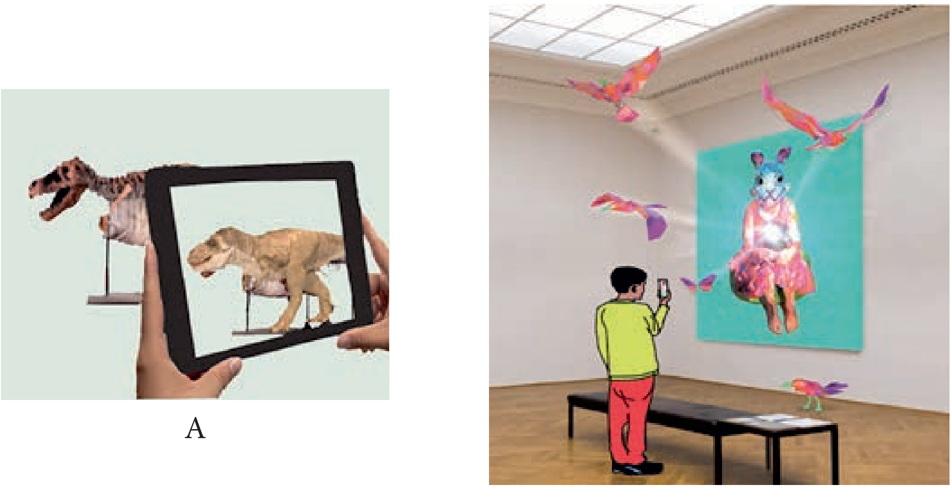
- ***Healthcare***: there are numerous AR and VR applications implemented in the medical industry. Some of the applications in use today include:
  - Physicians and medical students are trained and taught using AR/VR technologies. The technologies allow them to learn life-saving operations like surgery in a risk-free environment.
  - AR improves disease diagnosis in a manner that is less invasive and pain-free for the patient.
  - By helping surgeons visualize the patient's muscles, bones, and internal organs, AR supports a surgical procedure in a low-risk and much more accurate way.
  - Tele-surgery, which is conducted with the patient and the surgeon being in different locations, is supported by VR.
  - VR can be used to distract patients from stressful experiences caused by prolonged recuperation in hospitals. Such patients can use VR headsets to focus on entirely different things and make their medical treatment less stressful.



A B

Figure 2.22 Example of augmented reality (A) and virtual reality (B) in healthcare

- ***Entertainment***: this is another area where the use of AR and VR has become very popular. The following are some examples of the application of AR and VR in entertainment:
    - By adding computer-generated data on artifacts in art galleries and museums, AR creates a very interactive and enjoyable experience for visitors.
    - VR movie theatres equipped with individual armchairs that have extra gear, glasses, helmets, or tools for aroma injections can create a completely new and immersive experience for movie fans.
    - VR and AR components can be added to amusement parks to help visitors enjoy their visit more.
    - Different manufacturers are introducing numerous AR applications which present gamers with new ways to interact with the real world. The rise in the number of mobile gamers has also created a demand for augmented reality games.


A

B

Figure 2.23 Example of augmented reality (A) and virtual reality (B) in entertainment

Activity 2.5

1. Describe the difference between Augmented Reality and Virtual Reality.
2. Discuss among your class mates which technology, between AR and VR, is more practical in your particular context. Demonstrate or discuss the features and share what you like about them. Make also suggestions for improvements.

2.3. Data Science

The amount of data that is being generated by organizations from different sources is growing exponentially. In order to properly utilize such an enormous amount of data in a manner that ensures competitiveness, an appropriate type of approach or method on how to use data is required. Data science provides the tools and techniques that are used by organizations to take advantage of the vast amount of data that they own.

Data Science is a blend of tools, algorithms, and machine learning (ML) principles used to discover and extract hidden patterns. It is an interdisciplinary field that includes areas such as statistics, mathematics, and computer science. Data science employs various tools at different stages in finding valuable solutions. A professional who is charged with the responsibilities of the activities involved in data science is known as a data scientist. Data scientists use different types of algorithms to turn data into useful insights.

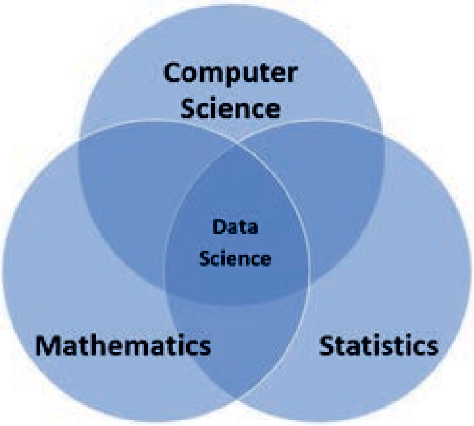

Computer Science
Data Science
Mathematics
Statistics

Figure 2.24 Data science disciplines

The concept of big data is strongly associated with data science. Big data refers to a huge volume of data that cannot be processed using traditional methods, and it is characterized by volume, variety, and velocity. For example, in 2020 Facebook generated 4 petabytes of data every day — that is a million gigabytes. Data science applies mathematical and statistical approaches and computer tools for processing big data.

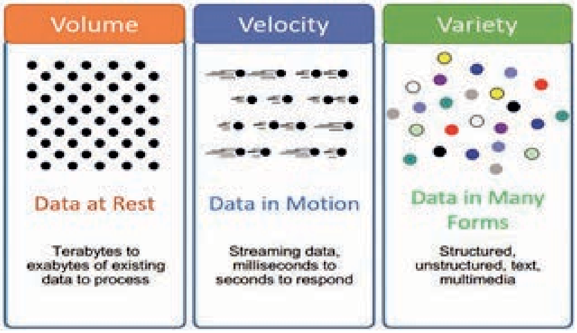

Volume
Velocity
Variety
Data at Rest
Data in Motion
Data in Many Forms
Terabytes to exabytes of existing data to process
Streaming data, milliseconds to seconds to respond
Structured, unstructured, text, multimedia

Figure 2.25 Characteristics of big data

The insights generated through data science tools and techniques apply to almost all fields. In manufacturing, for example, data science can be used to forecast product demand that will be used to determine the precise amount of raw material that needs to be ordered. The personalization of information on social media is achieved through the use of data science tools on the massive amount of data that social media companies collect from their users. Weather predictions in the agricultural sector, preventive medicine in health care, and risk management in business are but a few examples to mention about the areas where data science has improved results to a great extent.

The application of data science in sites like social networking sites involves the collection of large amounts of user data. But this sometimes creates tension with the issue of privacy, especially in countries where there are strong privacy regulations. *Data anonymization* and *data generalization* are some of the ways suggested for tackling issues of data protection and privacy. Data anonymization refers to removing personally identifiable information from data, while data generalization is about bunching data into broad categories such as age groups and geographical areas. As these approaches limit the level of insight that companies generate from data, privacy remains to be a contentious issue.

Activity 2.6

1. Discuss among your class mates on the exponential growth of data in today's business environment and its implications.
2. How much of your personal data are you willing to allow social media companies to use?

Unit Summary

In this unit, you have learnt about:

- what is meant by Emerging Technologies
- what Artificial Intelligence (AI) is
- the branches of AI
- the wide range of application areas of AI
- what Machine Learning is
- what robots are and their applications in various areas
- Natural Language Processing (NLP) and its applications
- what expert systems are and the three components of expert systems namely, user interface, knowledge base, and inference engine
- what Augmented Reality is
- what Virtual Reality is
- the difference between Augmented Reality and Virtual Reality
- the various application areas of Augmented Reality and Virtual Reality
- what Data Science is and the areas of applications

Key Terms

Artificial Intelligence is a branch of computer science concerned with the design of systems that mimic human intelligence

Augmented Reality (AR) is a technology that enhances the real world by overlaying a computer-generated digital data

Big Data is a data characterized by large size (volume), diverse sets of information (variety), and exponential growth rate (velocity)

Data Science is an interdisciplinary field with a blend of tools and algorithms that discovers and extracts hidden data

Emerging Technology is a fast-evolving and developing technology with a prominent socio-economic impact

Expert system is a computer program that emulates human experts

Internet of Things (IoT) is an interrelated Internet-connected objects that exchange data without human intervention

Machine Learning is a study of computer algorithms that enable the computer to learn from data and improve itself

Natural Language Processing (NLP) is a branch of AI that deals with enabling computers with understanding human language

Robotics is a study of machines called robots that substitute tasks that are traditionally done by human beings

Social Media is a medium that facilitates socializing through virtual networks

Virtual Reality (VR) is a technology that creates a three-dimensional computer-generated simulation environment

Review Questions

Part I: Write True if the statment is correct and False if it is incorrect.

1. Growth in computer power is one reason for the popularity of AI today.
2. It is practical to process the entire data of social media without the help of AI.
3. Virtual Reality is no different from Augmented Reality.
4. Data science has no challenge regarding privacy.
5. Big data is something that cannot be managed using traditional data processing approaches.

Part II: Match the items given under column B with associated items in column A

A	B
1. Application of NLP	a. Virtual Reality
2. Blend of virtual and real world	b. Sentiment Analysis
3. Bunching data into broad categories	c. Augmented Reality
4. MYCIN	d. Datata generalization
5. A fully immersive experience	e. Big data
	f. Expert Systems
	g. Data Science

Part III: Fill in the blank spaces

1. The process of de-identifying users from a data set is called __________.
2. One example of application of AI that can be implemented in a supermarket is _____________.
3. One example of an AI system that is used in customer service is _______.
4. A robot that NASA uses in the International Space Station is called ___.
5. The device used to capture input of an Augmented Reality is ___________.

Part IV: Discussion Questions.

1. Explain some of the ways in which AI contributes to the healthcare sector.
2. Discuss how AI can improve life in a smart home.
3. Explain ways in which AR and VR can make learning an interactive and fun experience.

UNIT 3

DATABASE MANAGEMENT

Learning Outcomes

At the end of this unit, students will be able to:

- Define database
- Explain data models
- Describe data management approaches
- Recognize database entities, attributes and relationships
- Develop data models with Entity Relationship Diagram (ERD)
- Create and manage databases using Microsoft Access

Unit Overview

Database management is a method used to organize data in a more effective way for easy management and use of data. In this unit you will learn the basics of database modelling and management. The unit covers concept of database, file-based and database approaches, relational data models, relational database, and database management with Microsoft Access.

3.1. Data Management Approaches

Brainstorming 3.1

- Discuss the types of data schools capture and how they manage it to run their day-to-day activities.

Data management is an integral part of our daily lives. Traditionally, data used to be managed manually using physical papers. As the size of data that organizations manage become larger and larger, computers have become instrumental for efficient management of data (see Figure. 3.1). The first computer-based data management is a file-based data management approach. The database approach was introduced later and addressed the inherent weaknesses of the file-based approach.

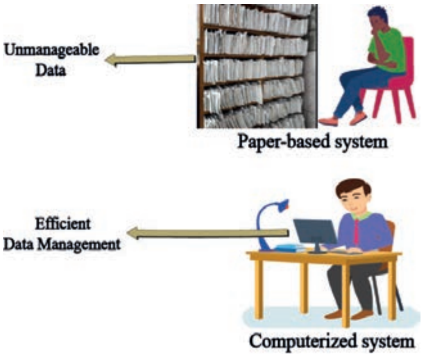

Unmanageable
Data
Paper-based system
Efficient
Data Management
Computerized system

Figure 3.1: Paper-based vs Computerized systems

3.1.1 File based data management

File-based data management is an approach in which data is stored in separate files without explicit relationships (see Figure. 3.2). Data in different files is managed by different application programs. Any change to data requires modification of the program that uses the data. Changes made on the program may also require change in the file structure. In file-based data management approach, each department creates and processes its own files separately. For example, procurement and finance departments create and manage their own files.

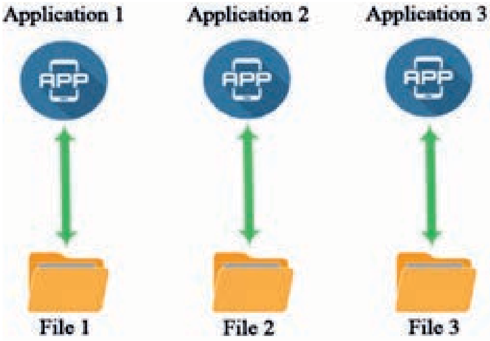

Application 1
Application 2
Application 3
APP
APP
APP
File 1
File 2
File 3

Figure 3.2: Architecture of the file-based data management

The file-based data management approach creates problems of data duplication and data inconsistency. For example, let us say employee data is stored both in human resource and finance departments. When human resource department modifies the employee records upon hiring new employees, it may not communicate the information to the finance department. As a result, different information about employees would be found in one organization. Such types of contradictions are caused by the fact that data in one file is not linked to data in other files of the same organization in the file-based approach. The isolation of data also makes retrieval of data of the entire organization a very difficult task. These problems led to the development of the database approach.

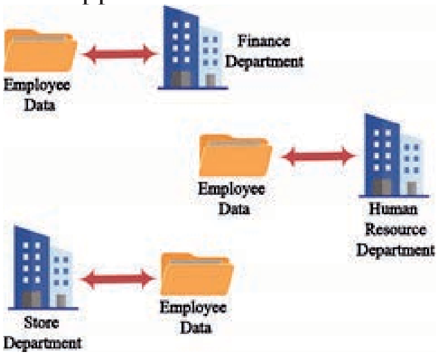


Figure 3.3: Data redundancy in different departments

Activity 3.1

1. Discuss the file-based data management approach.
2. Discuss the main limitations of the file-based approach to management of data in an organization

3.1.2 Database approach to data management

In the database approach to data management, data is managed by a database using a database management system (DBMS) software. A **database** is a collection of logically-related data. It stores all organization's data in one repository. A database is created to address the data requirements of different user groups and application programs in an organization.

Database is an essential resource to every organization. It is used to maintain internal records of organizations such as student records for schools, customer records and daily sales records for supermarkets, patient database for hospitals and the like (see Figure. 3.4). Data in the database are used to generate different information that are used in the daily business activities. For example, the salesman in a supermarket uses database to generate daily or monthly sales reports. Hospitals may generate report that shows the most frequent disease types in the last year.

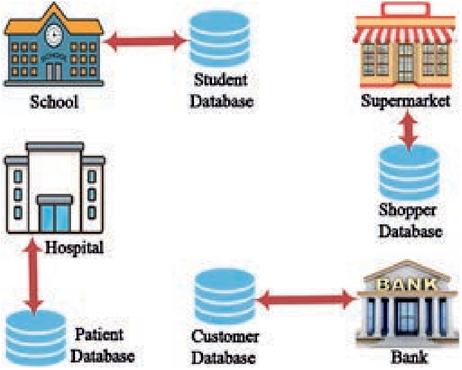

School
Student Database
Supermarket
Shopper Database
Hospital
Patient Database
Customer Database
BANK
Bank

Figure 3.4: Databases for different organizations

DBMS is software that manages databases. DBMS is used to add new data, modify data and delete data in the database. It is also used to retrieve data from the database. DBMS essentially serves as an interface between the database and end users or application programs. It ensures that data is easily accessed by potential users.

The database management process has three main components (see Figure 3.5). At the bottom is the **database** which stores the actual data. In the middle is a DBMS which manages the database. At the top of the DBMS are application programs that use the database. The application programs submit database query to the DBMS. Then, the DBMS retrieves data that matches the queries and replies retrieved data to the application programs.

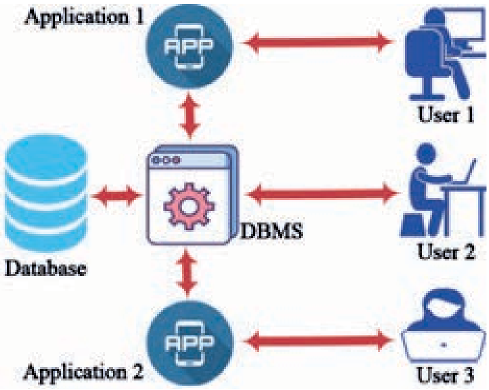

Application 1
APP
User 1
Database
DBMS
User 2
APP
Application 2
User 3

Figure 3.5: Database Architecture

The database approach to data management provides many advantages to the organization. Some of the advantages are:

- **Data independence**: A database is created to store all organization data and support all users of the organization. Each user or department does not need to manage its own isolated data.
- **Data sharing:** all organization's data is stored in one central database. DBMS allows this central database to be accessed by different users.
- **Avoiding data redundancy:** Isolated departmental files are stored in one central database. The DBMS can retrieve data from multiple tables so as to meet the requirement of different database users or application programs.
- **Improved data security**: Data in the database is accessed only by authorized users. Only users who are given data access right can access and modify data in the database.

Activity 3.2

1. What are the benefits of a database as compared to file-based data management approach?
2. Why do organizations need to store data in the database?
3. What is the purpose of the DBMS?

3.2. Data Model

Data model of a database is the blue print of the database. It is used as a guide to store data in a database. It shows database entities, attributes and the relationships between the entities. It also specifies what data to store in the database. For example, a school database stores data about students and teachers. It does not need to store data about patients or traffic accidents. These data do not have relevance to the school's day-to-day activities. Likewise, hospitals store data about patients and physicians.

3.2.1 Basic Concepts in Data Modelling

The basic concepts of entity, relationship and attribute are discussed below:

- *Entities* are basically people, places or events about which you want to store data. For example, banks may keep data about customers and bank account entities. Similarly, a library may have entities like book, *loan* and *borrower*. Entities are equivalent to tables when implemented in the database.

- *Attributes* are properties of an entity that are used to differentiate one entity from other entity. For example, customer entity may have customer id, name, sex and address as its attributes. On the other hand, book entity may have author name, book title and publication year as its attributes. The two entities have different attributes because they are different entities.

- A *relationship* is an association between entities. For example, customer has account in a bank. The verb 'has' indicates the relationship between customer and bank account entities.

The relationship between entities can take different forms:

- **One-to-one relationship**: An instance of an entity has only one instance in the other entity with which it is associated (see Figure 3.8). For example, a country and a capital city. A country is associated with one capital city, and a capital city is associated with only one country.

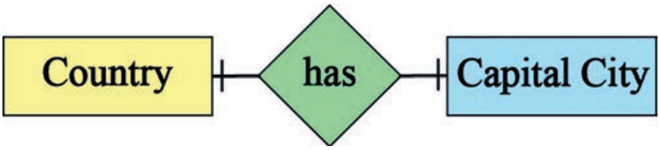


Figure 3.7: One-to-one relationship type

Notes

- **Instance** of an entity refers to a single occurrence of an entity. For example, "Addis Ababa" is an instance of the entity "City".

- **One-to-many relation**: An instance in one entity is associated with many instances in the other related entity (see Figure 3.8). For example, a department called ‘Computer Science’ is associated with multiple students.

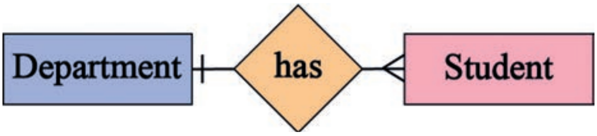


Figure 3.8: One-to-many relationship type

- **Many-to-many relationship**: Instances on both sides of the relationship are associated with multiple instances of the other entity (see Figure 3.9). For example, an employee may work in multiple projects. At the same time, a project may have multiple employees assigned to it.

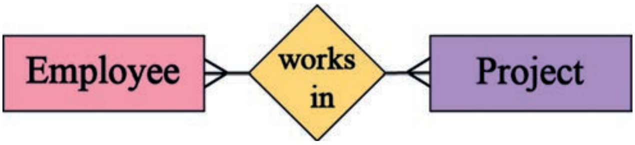


Figure 3.9: Many-to-many relationship type

Activity 3.3

- Explain the differences between entities, attributes, and relationships.

3.2.2 Entity Relationship Diagram

One of the popular representation tools for data model is Entity Relationship Diagram (ERD). ERD is used to visually represent a data model. It has three main components discussed in Section 3.2.1, namely entity, attribute and relationship.

Entities are represented as a rectangle and relationships as a line to show the association between entities. Attributes are represented as ellipses. The names of entities and attributes are placed inside the rectangle and the ellipse respectively. The names of relationships, on the other hand, are placed right on top of the line.

Figure 3.10 shows an example of ERD that shows the association between a student and book entities and their respective attributes.

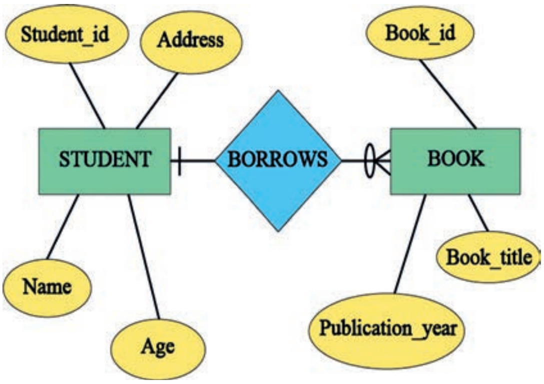


Figure 3.10 Entity Relationship Diagram

As Figure 3.10 shows, student entity has student_id, name, age and address attributes. On the other hand, book entity has book_id, book_title, publication_year attributes. The two entities are related by ‘borrows’ relationship.

Activity 3.4

1. Describe the purpose of ERD.

2. Assume that teachers are assigned to a class schedule in your school. The Teacher entity has teacher_id, name, sex, and specialization attributes. The Schedule entity has schedule_id, room, period, and section attributes. Construct an ERD based on the description given.

3.2.3 Relational Data Model

The relational data model represents data in terms of two-dimensional tables called ***relations***. A relation is nothing but a table of rows and columns. Each row, also called a *record* or *tuple*, contains a unique instance of data. These rows in the relation denote a real-world entity. The columns in a relation, also known as attributes or fields, are used to describe the properties of relations. Figure 3.11 shows an example of a student relation.

Student

Records *Attribute*

Student ID	Name	Sex	Grade	Address
ST001	Brook Assefa	M	12	Kebel 05
ST002	Chaltu Bayissa	F	11	Kebele 01
ST003	Ali Mohammed	M	10	Kebel 03
ST004	Tsion Gabissa	F	10	Kebele 01

Figure 3.11 Student relation

The **relational data model** provides conceptual tools to represent a data model of a relational database. A relational data model captures a collection of relations, their attributes, and their relationships. See Figure 3.12.

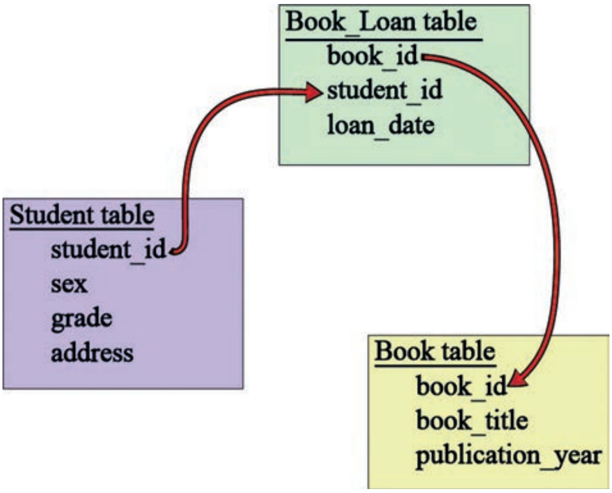

Book_Loan table
book_id
student_id
loan_date
Student table
student_id
sex
grade
address
Book table
book_id
book_title
publication_year

Figure 3.12 Relational data model

Notes

- Figure 3.12 shows that student relation has student_id, sex, grade and address attributes. On the other hand, Book_Loan relation has book_id, student_id and loan_date attributes. Student and Book_Loan relations are related via the student_id attribute that is paced in the Book_Loan_ relation. In the same way, Book relation is related with Book_Loan_ relation via the book_id attribute placed in the Book_Loan_ relation.

3.2.4 Relational Database

Relational database is a type of database that contains logically related set of tables. The rows in a table are called records, and the columns are called fields or attributes. Relational database is implemented using relational database management system (RDMS) software. The following three tables are used to show implementation of a relational database (see Figure 3.13).

Student

Primary key

Student ID	Name	Sex	Grade	Address
ST001	Brook Assefa	M	12	Kebele 05
ST002	Chaltu Bayissa	F	11	Kebel 13
ST003	Ali Mohammed	M	10	Kebele 05
ST004	Tsion Gabissa	F	10	Kebele 08

Book loan

Primary key ***Foreign key***

Book_Loan_No	Book ID	Student ID	Loan date
BL0001	**B001**	**ST001**	12/5/2021
BL0002	**B002**	**ST002**	10/6/2021
BL0003	**B003**	**ST001**	3/12/2021

Book

Primary key

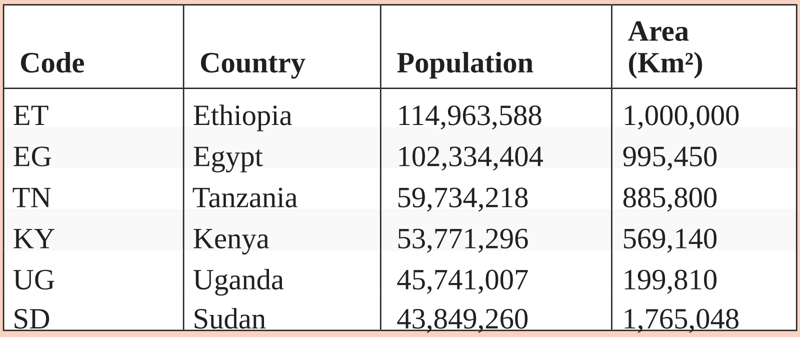
Book ID	Author	Title of book	Year
B001	Hana Bekle	Introduction to Physics	2004
B002	Dania Kedir	Organic Chemistry	2015
B003	Kebede Yohannes	Java Programming	2020

Figure 3.13 Relational database

Notes

- The above three tables in Figure 3.13 have a primary key. A **Primary Key** is a field which has a unique value for each record. For example, student_ID serves as a primary key for the Student table because no two students can have the same id.
- The relational database uses **Foreign Keys** as a navigational link to retrieve data from related tables. A foreign key is an attribute in a table that matches the primary key of another related table. Student_ID and Book_ID in Book_Loan_Table are foreign key. They are used to link Student table and Book table respectively to the Book_Loan table.

Activity 3.5



Code	**Country**	**Population**	**Area (Km²)**
ET	Ethiopia	114,963,588	1,000,000
EG	Egypt	102,334,404	995,450
TN	Tanzania	59,734,218	885,800
KY	Kenya	53,771,296	569,140
UG	Uganda	45,741,007	199,810
SD	Sudan	43,849,260	1,765,048

Source: https://www.worldometers.info

City	**Population**	**Code**
Addis Ababa	2,757,729	ET
Omdurman	1,200,000	SD
Cairo	7,734,614	EG
Gondar	153,914	ET
Jimma	128,306	ET
Kisumu	216,479	KY
Khartum	1,974,647	SD
Mombasa	799,668	KY
Nairobi	2,750,547	KY

Source: https://worldpopulationreview.com/continents/africa/cities

Answer the following questions based on the tables given above.

1. What are the entities in the above tables? Give a name for each table that represents the content of the data.
2. What is the attribute that is used to link the two tables?
3. How many fields does the first table have?
4. List the cities that are found in Kenya.
5. Create a new table that contains country name, city name and city population attributes.
6. Create an ERD diagram with the relationship type.

3.3. Creating Relational Database in Microsoft Access

This section explains how to create and manage a database on Microsoft (MS) Access. Relations or entities are represented as database tables. Attributes are represented as table fields. Figure 3.14 shows the required transformation between relations in the relational data model and MS Access database tables.

Student entity

Attribute name
student_id
student_name
Sex
Grade
Address

Student table

Field name	Data type
student_id	Text
student_name	Text
sex	Text
grade	Number
address	Text

Figure 3.14 Transformation of entity into Microsoft Access database table

The data type column indicates the type of data to be stored for the respective field. For example, student name field, as shown in Figure 314, has Text data type while grade is assigned Number as its data type.

3.3.1 Creating Microsoft Access Database

When you work on Microsoft Access, creating a database is the first step. In MS Access, a **database** is a container of database objects such as tables, forms, queries and reports. There are different versions of MS Access software to create and manage databases. In this textbook, you will learn how to create and manage database objects using MS Access 2010.

In order to create a database, follow the following steps:

1. Open MS Access Software
2. In the main Window, click on **Blank database**
3. Enter the database name in the File Name input box. (When giving a name to the database, it is highly recommended to use names that properly describe the data stored in the database.)
4. Click on the **Create** button.

After the database is created, another MS Access window is opened where database objects can be created. Before other database objects are created, a table object must be created. A table is a set of fields that store data about a certain entity.

We use the following tables in Figure 3.15 for the following practical activities in MS Access.

Student

Student_ID	Sname	Sex	Age	Grade_level
ST0001	Brook Assefa	M	17	11
ST0002	Chaltu Bayissa	F	18	12
ST0003	Giday Hagos	M	15	9
ST0004	Nejat Mohammed	F	17	11
ST0005	Hailu Mekonnen	M	16	9
ST0006	Kedir Ali	M	18	12

Teacher

Teacher_ID	tname	sex	age	specialization
T0001	Oljira Kuma	M	42	Biology
T0002	Hagos Kiros	F	35	Chemistry
T0003	Rediet Assefa	F	28	Mathematics
T0004	Ahmed Yusuf	M	27	Physics
T0005	Delebo Nurye	M	26	IT

Grade

Student ID	Teacher_ID	subject	grade
ST0001	**T0001**	Biology	75
ST0001	**T0002**	Chemistry	86
ST0002	**T0002**	Chemistry	70
ST0001	**T0003**	Mathematics	95
ST0001	**T0004**	Physics	65
ST0003	**T0002**	Chemistry	82
ST0002	**T0003**	Mathematics	78
ST0001	**T0005**	IT	90
ST0002	**T0001**	Biology	67

Figure 3.15 Sample Tables

3.3.2 Creating Table in Microsoft Access

When you create a new table, Microsoft Access asks you to define table fields. Table fields are entity attributes. One or more tables can be created in one database. Each table name must be unique. The tables must also have two or more fields. Field names must be unique in a table.

Follow the following steps to create a table in MS Access:

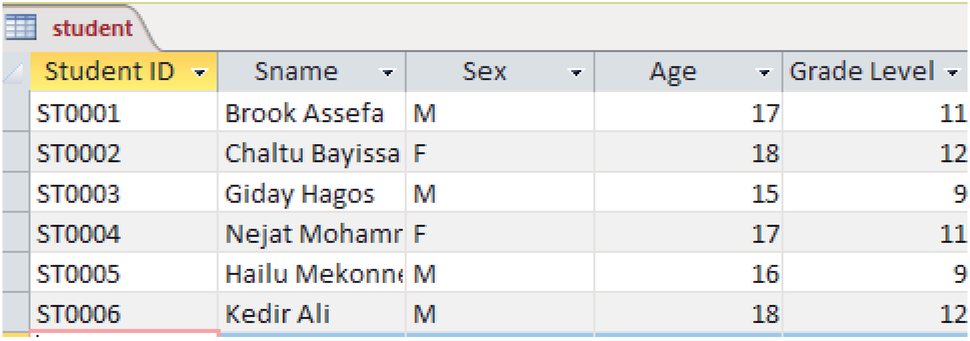
1. Open a database file.
2. Click on Table Design button from the Create menu.
3. Enter field names for the new table such as Student ID, Sname, Sex, Age and Grade_level (see Figure 3.15).
4. Specify the data type of the field. The data type can be text, number, date/time, currency, etc. depending on the type of data that the field is used to store.
5. When you finish, click on the Save button.
6. In the popup that is displayed, enter the table name and click on the Ok button.

Notes

- When you want to create a new table or add data into or modify an existing table, you must first open the database in which you want to store your database objects. This is important because there can be more than one database in a single computer.
- When you define a field to a table, you must specify the appropriate data type for a Field name. The data type could be text, number, date and currency. Data types are one form of validation mechanisms that ensure the correctness of data in the database. If you set the data type as Text, it will not accept its data as Number or any other type. Only text is a valid value to it.
- To set the field as primary key, go to the table design view, select the field and click on Primary Key (🔑) button in the toolbar.

Follow the following steps in order to enter data into a database table:

1. Open a database if it is not already opened
2. Click on the table name and select Datasheet View from View in the toolbar. For example, open **student** table.
3. Enter appropriate values for each field.
4. Enter all the records of the Student table shown in Figure 3.15. (See Figure 3.16)



Student ID	Sname	Sex	Age	Grade Level
ST0001	Brook Assefa	M	17	11
ST0002	Chaltu Bayissa	F	18	12
ST0003	Giday Hagos	M	15	9
ST0004	Nejat Mohamr	F	17	11
ST0005	Hailu Mekonn	M	16	9
ST0006	Kedir Ali	M	18	12

Figure 3.16 Adding records to a table

Activity 3.6

1. Create a database by your school’s name.
2. Create the three tables shown in Figure 3.15 in the new database you created.

3.3.3 Creating Query in Microsoft Access

Query is a database object that provides a custom view of data from one or more tables. It is a way of searching for and compiling data from one or more tables. In MS Access, data is retrieved through query by creating **graphical query** or writing Structured Query Language (SQL) statements. In this section, you will learn how to retrieve data using graphical query. A query is used to define specific search conditions to find exactly the data you want.

Follow the following steps in order to create a query in Microsoft Access:

1. Open a database where your database tables are stored
2. Click on Create menu button. Then, you get the following MS Access toolbar

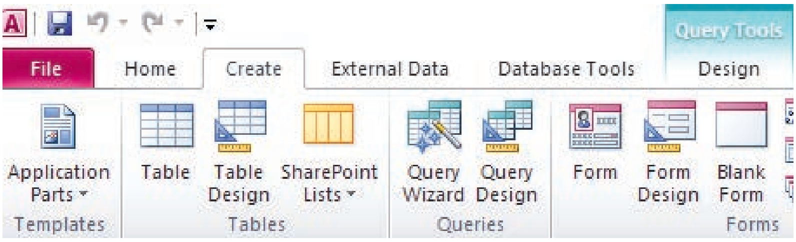
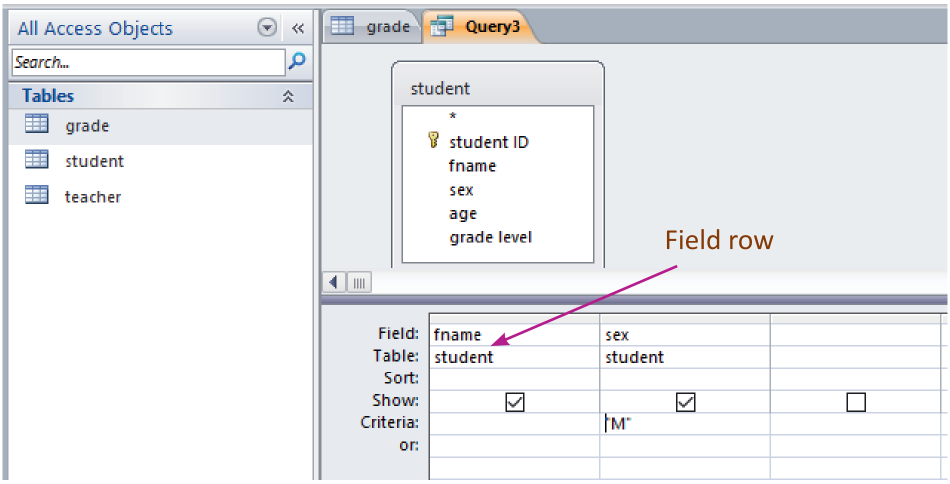

Query Tools
File
Home
Create
External Data
Database Tools
Design
Application Parts
Templates
Table
Table Design
SharePoint Lists
Tables
Query Wizard
Query Design
Queries
Form
Form Design
Blank Form
Forms

Figure 3.17 MS Access toolbar

You can create query using **Query Wizard** or **Query Design.** Let us see how to create a query using Query Design option.

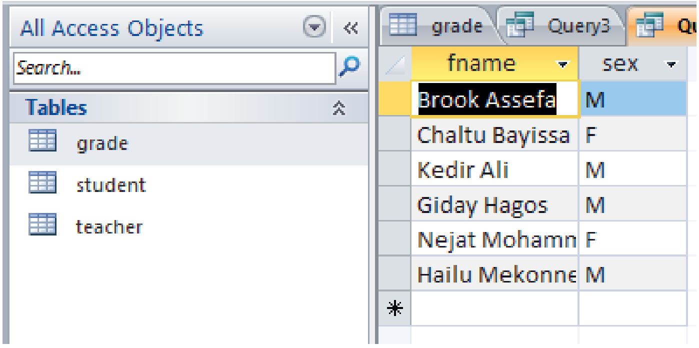
3. Click on **Query Design** button from Microsoft Access toolbar.
4. Select a table or tables from **Show Table** box from which you want to select records for your query (See Figure 3.18), and click on OK bottom. You then get the following window.


All Access Objects
Search...
Tables
grade
student
teacher
grade
Query3
student
*
student ID
fname
sex
age
grade level
Field row

Field:	fname	sex	
Table:	student	student	
Sort:			
Show:	☑	☑	☐
Criteria:		"M"	
or:			

Figure 3.18 Query Design Window

5. Select the **fields** in the **Field** row**.** For example, if you want to select only sname and sex field, select **sname** in the first column and **sex** in the second column of the Field row.
6. Select Datasheet View from the toolbar to see your query results (see Figure 3.19).If you do it correctly, you get the following results.



fname	sex
Brook Assefa	M
Chaltu Bayissa	F
Kedir Ali	M
Giday Hagos	M
Nejat Mohamn	F
Hailu Mekonne	M

Figure 3.19 Query Results

Activity 3.7

1. Create a query that displays teacher name and specialization from the teacher table (Figure 3.15). Save your query as Teacher_Specialization.

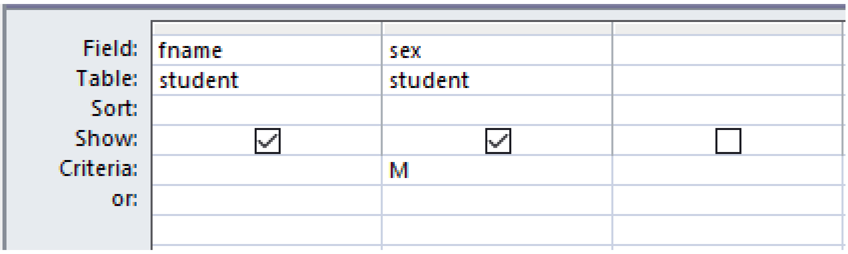
2. Create a query that displays student name and grade level from student table (Figure 3.15). Save your query by a appropriate name.

3.3.4 Adding Criteria to Query Design

By adding additional criteria to a query design, it is possible to retrieve specific data from a table.

Follow the following steps in order to add criteria to a query.

1. Open the Query Design Window.
2. Add a table to query design window.
3. Select fields to be displayed in Query Result Window.
4. In the Criteria row, enter query selection criteria. For example, if you want to display only Male students, under Sex column, enter **M** as your query selection criteria (See Figure 3.20).



Field:	fname	sex	
Table:	student	student	
Sort:			
Show:	☑	☑	☐
Criteria:		M	
or:			

Figure 3.20 Query Design with a Criteria

Notes

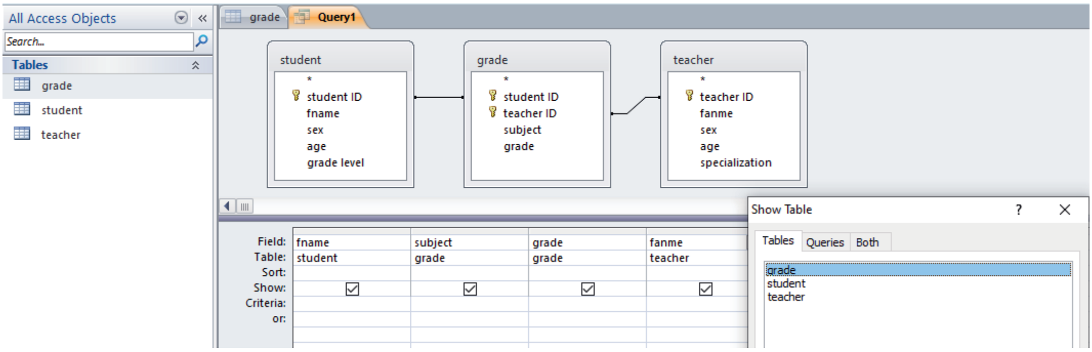
- The criteria you enter in the criteria row must be exactly the same with the data stored in the table. For example, if sex data is kept in the table using a single character (for example m), you cannot get the required result if you enter 'Male'.

3.3.5 Selecting Data from Multiple Tables

The power of a relational database is that it allows you to retrieve data from two or more tables.

Follow the following steps in order to select data from multiple tables:

1. Open the Query Design window.
2. Add a table to the Query Design window. If Show Table window is not displayed, click on Show Table button from the Toolbar. You will have a list of tables in the Show Table Box.
3. Select a table and click on **Add button** to add the table into **Query Design Window.**
4. Repeat step 3 to add more tables.
5. Establish a relationship between the tables by dragging the **primary key field** in the **Parent table** to the **Child Table** (See Figure 3.21).


All Access Objects
Search...
Tables
grade
student
teacher
grade
Query1
student
*
student ID
fname
sex
age
grade level
grade
*
student ID
teacher ID
subject
grade
teacher
*
teacher ID
fanme
sex
age
specialization
Show Table
?
Tables
Queries
Both
grade
student
teacher

Field:	fname	subject	grade	fanme
Table:	student	grade	grade	teacher
Sort:				
Show:	☑	☑	☑	☑
Criteria:				
or:				

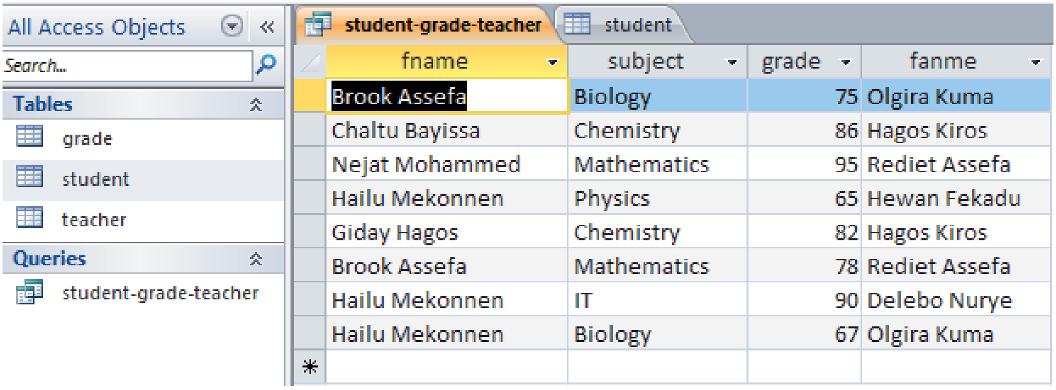
Figure 3.21 Query Design with Multiple Tables

6. Select the fields to be displayed in Query Datasheet View. For example, we want to select student name (fname) from student table, subject and grade from grade table, and teacher name (tname) from teacher table.

7. Choose the **Save** button from the File menu to save your query.

8. Enter a file name for the new Query, and click on the **OK** button.

9. Click on the View button in the Toolbar to see the query results (see Figure 3.22).


All Access Objects
Search...
Tables
grade
student
teacher
Queries
student-grade-teacher
student-grade-teacher
student

fname	subject	grade	fanme
Brook Assefa	Biology	75	Olgira Kuma
Chaltu Bayissa	Chemistry	86	Hagos Kiros
Nejat Mohammed	Mathematics	95	Rediet Assefa
Hailu Mekonnen	Physics	65	Hewan Fekadu
Giday Hagos	Chemistry	82	Hagos Kiros
Brook Assefa	Mathematics	78	Rediet Assefa
Hailu Mekonnen	IT	90	Delebo Nurye
Hailu Mekonnen	Biology	67	Olgira Kuma

Figure 3.22 Query Results from Multiple Tables

Activity 3.8

1. Create a query in the student database that lists female students. Save the query as Female_Students.

2. Create a query that selects data from student and grade table. Display only student name from student table, and subject and grade from grade table. Save the query as Student-Grade.

3. Create a query that lists students who scored above 85 in all subjects.

Unit Summary

In this unit, you have learnt about:

- what is meant by Emerging Technologies
- what is meant by a database
- file based data management
- database approach for data management
- what is meant by database management system (DBMS) software
- the different benefits of the database approach for data management
- what is meant by data models
- the structure of relational data model
- ERD as a data model representation tool
- what is meant by entity, attribute, and relationship
- the different types of relationships between entities
- implementation of relational database on Microsoft Access
- creation of Tables in Microsoft Access
- creation of Query in Microsoft Access
- selection of data from two or more tables using Microsoft Access Query

Key Terms

Attributes are properties of entities that are used to describe the entities.

Data model is a blueprint of the database.

Database is a shared collection of logically related data.

DBMS which stands for database management system is a software which is used to create and manage databases.

Entities are people, places, or things about which you want to keep information in a database.

Entity Relationship Diagram (ERD) is a visual representation tool for data models.

Field refers to a column of a table in the database table. It is similar to an attribute in the logical data model.

File based data management is a system of data management based on a single file.

Foreign key is an attribute in a table that matches the primary key of another related table.

Microsoft Access is relational DBMS software. It is used to manage databases.

Primary Key is a field which has a unique value for each record in a table.

Record is a row in a database table**.** It stores data about one real-world object represented in a table.

Relational data model is a type of data model that represents data in terms of two-dimensional tables called ***relations***.

Relational database is a type of database that contains a logically related set of tables.

Relationship is an association between entities.

Review Questions

Part I: Write True if the statment is correct and False if it is incorrect.

1. A database is a collection of related data.
2. A database approach improves data sharing.
3. ERD is a visual representation of data model.
4. There is only one type of relationship between entities in the ER model.
5. Attributes are used to describe the characteristics of an entity.
6. Relational database stores data in one file.
7. A Primary key is an attribute that has duplicate values for different records in a table.
8. Tables are used to store data in Microsoft Access.

Part II: Choose the correct answer from the given alternatives.

1. _____ is used to store a logically related data.

   A. file B. database
   C. data model D. DBMS

2. The element of ERD that represents real-world things such as people, places, or events about which we want to store data is called:

   A. attributes B. database
   C. relationship D. entities

3. The properties of entities that are used to differentiate one entity from the other entity is called:

   A. attributes B. database
   C. relationship D. entity

4. ______________ is considered as a blueprint of a database.

   A. attributes B. database
   C. data model D. entities

5. In a relational data model, entities are represented as:
    - A. attributes
    - B. relations
    - C. data models
    - D. databases

6. _____ is a container of database objects in Microsoft Access.
    - A. field
    - B. database
    - C. table
    - D. form

7. A field which has a unique value for each record of a table is called:
    - A. foreign key
    - B. attribute
    - C. data type
    - D. primary key

8. One of the following is not a valid data type name for a field ___.
    - A. text or string
    - B. number
    - C. entity
    - D. date

9. A Query in Microsoft Access is used to:
    - A. store data for future use
    - B. select records from the underlying table that meet some search criteria
    - C. create a form to facilitate data entry
    - D. None

10. In order to retrieve data from two or more tables through query, we must establish a _____ between tables
    - A. field
    - B. primary key
    - C. relationship
    - D. criteria

Part III: Write short answers to the following questions .

1. What is a database?
2. What are the basic elements of ERD?
3. What is a relational data model?
4. What is a one-to-many relationship? Give examples.
5. What is the use of table object in Microsoft Access
6. What is the use of query in Microsoft Access?

Part IV: Discussion questions

Answer the following case study questions in groups.

1. XY manufacturing company produces different types of products. The products are described by: product ID, product name, quantity, and price. The products are sold to different customers. The company also keeps track of its customers' information as customer ID, customer name, customer address. The customer makes orders to buy products from the company at different times. It is also necessary to keep order information, which includes order ID, product ID, customer ID, order quantity, and order date. Identify the entities, attributes, and relationships for the XY manufacturing company database and construct an ERD for the data model of XY manufacturing company.

UNIT 4

WEB DEVELOPMENT

Learning Outcomes

At the end of this unit, students will be able to:

- Define the Web
- Explain a website and its benefits
- Elaborate the purpose of web design
- Describe basic concepts of HTML and web development
- Create webpages with images, videos, links, tables, lists, and links

Unit Overview

Web development is the process of creating websites for various purposes such as information sharing and facilitating online businesses. In this unit, the World Wide Web (WWW) and its foundations as well as the concept and uses of websites are discussed. In addition, different types of HTML (Hypertext Markup Language) elements are presented with examples of how they work.

4.1. World Wide Web

Brainstorming 4.1

- What are the ways of communicating about a product or a service to a target audience?

World Wide Web (www), commonly known as the Web, is one of the most important services of the Internet. The Internet is a network of networks that the Web runs on. The Web is just one of the services of the Internet, and the most popular one. There are also many other services that are provided over the Internet such as email, file transfer and communication services.

The Web is a collection of websites or webpages that are accessed over the Internet using a web browser. Tim Berners-Lee invented the Web in 1989 in the famous laboratory found in Switzerland known as CERN. When the Web was invented, it was formed out of four essential foundations: HTML, HTTP, a web server, and a web browser.

HTML, which stands for HyperText Markup Language, is the language that is used to create webpages. A web browser is a software used by users to view webpages. A web server, on the other hand, is a software that stores webpages and responds to user requests that come through web browsers. HTTP, which stands for HyperText Transfer Protocol, is the set of rules that web browsers and web servers use to communicate with each other.

Links

The basics of HTML are discussed in detail in Section 4.3

A **website** is a publicly accessible collection of interrelated webpages. Hypertext is used to link a webpage with other resources like another webpage, videos, images, and the like.

Nowadays, websites are the most efficient and effective ways for organizations or individuals to present themselves to their target audiences. As a globally accessible platform, the web makes it possible for an organization to expand its reach to the entire world. A website that is physically placed in one part of the world can be accessed from any other part of the world. It is also how online transactions are conducted by e-commerce companies. Today, shoppers use websites to make orders of different types of products from their homes or workplaces. This avoids the need to physically go to shops, which reduces the cost of transportation and increases the efficient use of our limited time. Similarly, various government e-services are accessed through websites. For example, citizens do not need to go to the Immigration Nationality & Vital Events Agency office in person to make applications for passports. They can simply go to the website and make their requests online. Education is another example where websites are used to facilitate a lot of activities. For example, the Ethiopian Ministry of Education established a website to make educational resources accessible to students. Online learning has also become widespread in many parts of the world, especially following the outbreak of COVID-19.

Activity 4.1

1. Explain what the Web is and how it is related to the Internet.
2. List and explain the foundations of the Web.
3. Describe some of the benefits of websites.
4. Discuss among your class mates on how you can benefit from using the Web for educational purposes.

4.2. Website Design

Website design is concerned with the plan and design of various aspects of a website, such as layout, navigation, appearance, and graphics. The goal of a website design is to create a website that is appealing to its target audience. The design should also make the search for information easy by providing a well-organized presentation.

The following are some important guidelines to consider when a website is designed.

Target Audience

A website should be designed with the target audience in mind. The look and feel, presentation, and all other aspects of the website should take the target audience of the website into consideration. For example, a website that is intended for children in educational settings should have a presentation different from one that is designed for adults in the business environment.

Navigation

Webpages should be logically organized to allow easy navigation. A well-organized website with easy navigation helps users find what they seek fast. A website with poor navigation, on the other hand, confuses and drives away visitors.

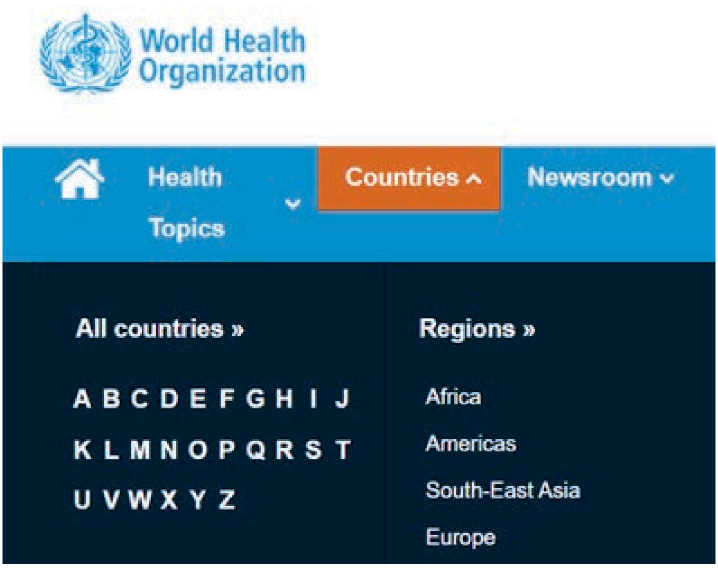

World Health Organization
Health Topics
Countries
Newsroom
All countries »
A B C D E F G H I J
K L M N O P Q R S T
U V W X Y Z
Regions »
Africa
Americas
South-East Asia
Europe

Figure 4.1 Navigation (Screenshot of part of the website of WHO)

As you can see from the way contents are organized on the website of WHO, it is easier for visitors to find what they are looking for because of the logical arrangement.

Consistency

The feel and look of webpages on a website should be similar. Better user experience is achieved with consistent use of backgrounds, colors, typefaces, and the like throughout the website.

Simplicity

Simplicity in website design applies to various elements of a website, such as the use of colors, graphics, typefaces, and the like. For example, it is recommended not to overcrowd a page with too many graphics. It is rather more helpful to use graphics when required. It is also recommended to use a maximum of five different colors (plus or minus two) to ensure a better user experience.

Accessibility

Designing a website with everyone in mind including people with disabilities is highly advised to make sure that no one is excluded.

Web development is the actual creation or building of websites while website design deals with defining the layout and overall look of the website. Websites can be developed using a WYSIWYG (What you see is what you get) software like Adobe Dreamweaver. Simple text editors such as Notepad are the other alternative software to develop websites. Though developing webpages using simple text editors is a little more difficult than WYSIWYG software, it is more effective in enabling the learner to master the language.

Activity 4.2

1. Describe the purpose of website design.
2. Discuss with your classmates the guidelines for website design.
3. Take the website of UN Women (https://www.unwomen.org/) and evaluate the website in a group using the guidelines discussed above. Then, present the result of your evaluation including suggestions for areas of improvement for the website.
4. Design a website layout on paper for your school taking the guidelines given above into consideration.

4.3. HTML Basics

HTML is a markup language that is used to create webpages. The different elements of a webpage such as headings, tables, paragraphs, images, and others are defined using the predefined set of markup tags of HTML.

HTML has gone through multiple revisions since its invention in 1989. The current version of HTML is HTML5.

HTML documents can be prepared using simple text editor software such as Notepad. The documents are saved with a ".html" extension. For example, **home.html** is a valid file name for an HTML document or a webpage.

4.3.1 HTML Tags and Elements

HTML tags are a set of predefined names enclosed in angle brackets. Each HTML tag has its specific meaning, and web browsers are designed to interpret or render HTML tags according to their intended purposes. Sample HTML tags and their meanings are shown in Table 4.1.

Table 4.1 Sample HTML tags

Tag Name	Meaning
<b>	Bold
<p>	Paragraph
<i>	Italic
<h1>	Heading

Links

Visit the following webpage for the list of all html tags:

https://www.w3schools.com/tags/default.asp

HTML elements are components of an HTML document and normally have a <*start tag*> followed by content and an </*end tag*>. HTML elements are the building blocks of a webpage. Figure 4.3 shows some examples of HTML elements and their outputs on the browser.

HTML Code

```
<h1>This is a heading</h1>
<p>This is a paragraph</p>
<b>This is a bold text</b>
<i>This is an italic text</i>
```

Output on the Web Browser

This is a heading

This is a paragraph

This is a bold text *This is an italic text*

Figure 4.2 HTML elements

Notes

- In Figure 4.3 that while the heading and the paragraph elements are displayed on a separate line each, the bold and italic texts are displayed next to each other. This is because the browser inserts a new line every time it finds HTML elements like <h1> and <p>, but it doesn't insert new lines for <b> and <i> HTML elements.

Activity 4.3

- Write an HTML document that has two paragraphs.

Though a significant majority of HTML elements conform to the **<start tag> content </end tag>** format, there are some HTML elements that have a different format. These HTML elements are known as *void elements*. The following table shows the format of void elements and their meanings. Void elements do not have an end tag.

Table 4.2 Void elements

HTML element	Meaning
<br>	Inserts a new line
<img>	Inserts an image
<hr>	Inserts a horizontal line

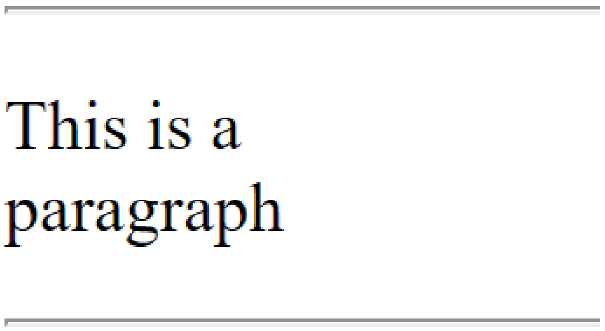
Notes

- Note that the <img> element needs an **attribute** that indicates the address of the image for the browser to insert the image into the webpage. An example of how to insert an image is given in Section 4.3.3

HTML Code

```
<hr >
<p>This is a <br> paragraph </p>
<hr >
```

Output on the Web Browser



This is a
paragraph

Figure 4.3 Inserting horizontal and new lines

Notes

- Note that the two horizontal lines placed above and below the paragraph are the result of the two <hr > elements. Also, note that the text “paragraph” is shown in a new line because the <br > element is inserted right before it, inside the <p> element.

Activity 4.4

- Create a webpage that has three paragraphs enclosed by horizontal lines.

4.3.2 Structure of HTML Documents

All HTML documents or webpages have a common structure. What changes from one webpage to another is what goes inside the <body> and the <head> sections of HTML documents. Figure 4.2 shows what the structure of HTML documents looks like in HTML5.

```
<!DOCTYPE html>

<html>
    <head>
        <title>
             Page title
        </title>
    </head>

    <body>
        <h1>This is a heading</h1>
        <p>This is a paragraph</p>
    </body>
</html>
```

Figure 4.4 Structure of an HTML document

Notes

- **<!DOCTYPE html>:** this element indicates the type of the document.
- **<html> …</html>**: represents the entire document, and it is divided into two major sections: the head (<head>..</head>) and the body (<body>…</body>) sections.
- **<head>..</head>:** this part of the HTML document is used to keep all the information about the webpage such as the page title.
- **<body>…</body>:** is the part of the HTML document where the content of the webpage is kept. Everything that is shown in the web browser, when the webpage is displayed, is what is contained in this part of the HTML document.

Activity 4.5

- Open a webpage from the Internet. Right-click on any area of the webpage and click on the “View page source” option. Then, after the complete HTML code is displayed, identify those tags that you are familiar with, and explore more about those that you do not recognize.

4.3.3 HTML Attributes

HTML attributes are used to define more properties to HTML elements. HTML paragraphs, for example, are left-aligned by default. However, if a paragraph is needed to be presented with the texts aligned to the right, the “align” attribute should be used. Attributes are written inside the start tag with attribute-value pairs (attribute=value). Figure 4.4 shows how the text of a paragraph is aligned to the right using the “align” attribute.

HTML Code

```
<h1>This is a heading</h1>
<p align="right" > This is a paragraph </p
```

Output on the Web Browser

This is a heading

This is a paragraph

Figure 4.5 HTML “align” attribute

Attributes are normally optional to many of the HTML tags. However, there are some HTML elements that cannot function as intended without the use of some attributes. The <img> HTML element is one such example. The <img> element should have the “src” attribute, which refers to the name and location of the actual image that is required to be inserted into the webpage. See the following example.

HTML Code

```
<img src="derartu tulu.jpg" >
```

Output on the Web Browser

Figure 4.6 <img> HTML element

Notes

- Note that the example in Figure 4.6 assumes that the image file and the HTML file are located in the same folder.

Activity 4.6

1. Write an HTML element that displays a heading with the text right-aligned.
2. Write an HTML document that has three images each placed in a separate line.

The other HTML element that uses the "src" attribute is the <video> element. <video> element is used to add a video to a webpage as shown in the following example.

HTML Code

```
<video width="320" height="200" controls
src="Country Landscape.mp4" >

</video>
```

Output on the Web Browser

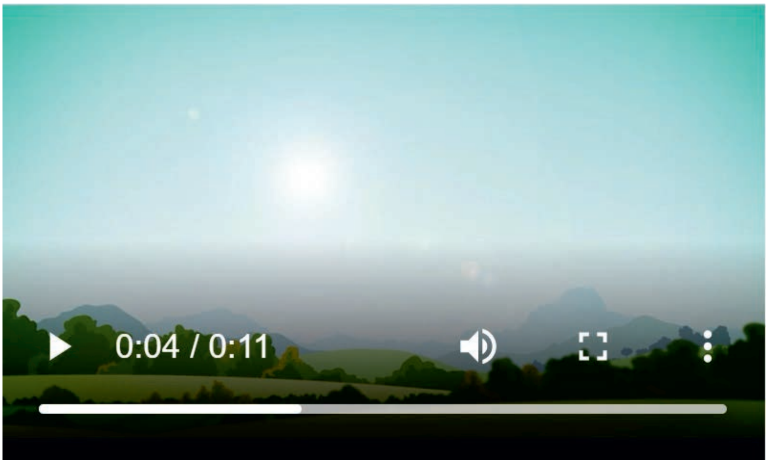


Figure 4.7 <video> HTML element

Notes

The meaning of the attributes in the <video> element is given as follows:

- The *controls* attribute adds controls like *play*, *pause*, and *volume*. Note that no value is assigned to the controls attribute.
- The *width* and *height* attributes control the width and height of the video on the webpage depending on the value given.
- The *src* attribute is used to refer to the file name of the video.

Activity 4.7

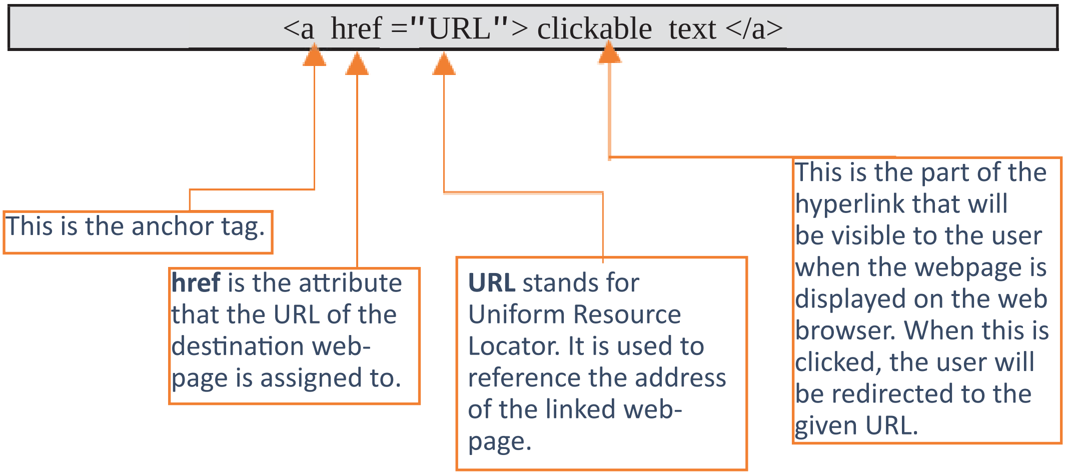
1. Get a short MP4 video and put it inside a folder.
2. Create an HTML document in the same folder and add a <video> element in the HTML document to display the video that you just added to the folder.
3. Open the HMTL document and see if the video opens.
4. Change the values of the height and width attributes and observe the differences on the webpage. Observe also the change on the video when the *controls* attribute is removed.

4.4. HTML Links

HTML links are used to navigate from one webpage to another or from one part of a webpage to another. The links could come in the form of text or images and are normally known as **hyperlinks**. Hyperlinks can easily be distinguished by the hand symbol that the mouse cursor is turned to when the mouse is hovering over the hyperlinks.

4.4.1 Links to other Pages

The anchor tag (<a>) is used to create hyperlinks. An HTML element that is formed from an anchor tag has the following format:



This is the anchor tag.

href is the attribute that the URL of the destination web-page is assigned to.

URL stands for Uniform Resource Locator. It is used to reference the address of the linked web-page.

This is the part of the hyperlink that will be visible to the user when the webpage is displayed on the web browser. When this is clicked, the user will be redirected to the given URL.

Figure 4.8 Format of HTML links

The example in Figure 4.9 shows how a link to Google is created and what the hyperlink looks like when it is displayed on the web browser.

HTML Code	Output on the Web Browser
`<a href="http://www.google.com">Google</a>`	Google

Figure 4.9 Defining a link to Google

Notes

- Note that it is only the clickable link that is displayed when the webpage is displayed on the browser. If the user clicks on Google, the user is moved to Google's webpage. That is because the URL of Google is given as a value to the href attribute.

Another important attribute of the anchor tag is the "target" attribute. The value of the "target" attribute determines where the linked document is displayed. See the following table for the meaning of each value of the "target" attribute.

Table 4.3 The "target" attribute and its values

Value	Meaning
_self	The webpage is displayed in the same window/tab. (Default)
_blank	The webpage is displayed on a separate window/tab.

Activity 4.8

1. Using Notepad, create an HTML document that has links to Ethiopian Airlines, ethio telecom, and Commercial Bank of Ethiopia using the following URLs:

   https://www.ethiopianairlines.com

   https://www.ethiotelecom.et

   https://www.combanketh.et

2. Modify the HTML code you just created above so that the pages are displayed in a new tab.

In addition to texts, images also can be used as links that users can click on to go to a specified webpage. To use images as a link, simply embed the image element inside the anchor tag as shown in Figure 4.10.

HTML Code

```
<a href="http://www.google.com"
target="_parent">

    <img src="google.png">

</a>
```

Output on the Web Browser

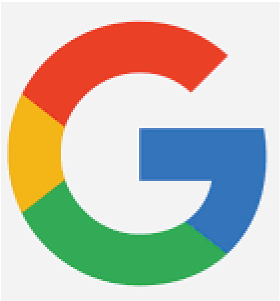


Figure 4.10 Image HTML link

Notes

- Note that the image element is placed between <a> and . Also note that a relative URL, as opposed to an absolute URL, is used to reference the "google.png" image. The assumption in the way the URL is given is that the image and the current webpage are found under the same folder.
- **Absolute URL**: is a URL that includes every element of a URL such as the protocol, the hostname, as well as path of the webpage. In other words, it will have a form such as this:
  http://www.somewebsite.com/somefile.html
- **Relative URL**: is a path given relative to the location of the current webpage. Example: somedirectory/somefile.html

Activity 4.9

- Redo the first question of Activity 4.8 using three images as hyperlinks.

4.4.2 Links to Page Sections

Hyperlinks can be created not only to establish links to other pages, but also to different parts, or sections of the same page. This is especially useful in a webpage that has a large size content. Readers can easily go to different sections of the page without having to scroll up and down.

To create such types of links, the <a> tag is used in two different ways: in designating names to specific locations and in creating links to the locations from other places on the same page. While the “name” attribute is used to designate a name to a location, the “href” attribute is used to create links to the locations. See the following example.

```
<h3>Section One
    <a name="section_one"></a>
</h3>
.
.
.
.
<a href="#section_one">Go to section one</a>
```

The HTML element you see at the bottom of the above code creates the Go to section one link. If this link is clicked, the user is moved back to the top of the webpage. (Note that in order to see this effect the webpage should be long enough that the link and the top of the document cannot be seen on one screen.)

Notes

- Note also that the way the value to the href attribute is given. The value is given as the # symbol followed by the name of the section.

Activity 4.10

1. Create three HTML documents in the same folder. Then create a link in each of the HTML documents to all the others so that one can access all the pages by simply opening only one of them.
2. Create a webpage that has a content that is grouped into at least three sections and then create:
    a. a link at the end of each section to the top of the document.
    b. a link at the beginning of each section to the beginning of all the other sections. (Note that the top of the document will be the same as the beginning of section one)

4.5. HTML Tables

An HTML table is used to organize data in terms of rows and columns. Tables are one way of organizing contents or defining a layout for contents in a webpage. The major HTML tags used for creating tables and their meanings are presented in the following table.

Table 4.4 HTML tags used for creating tables

HTML Tags	Meaning
<table>	Used to define the tables
<th>	Used to define table headers
<tr>	Used to define table rows
<td>	Used to define data cells

The number of rows of a table is determined by the number of <tr> elements that the <table> has while the number of columns is determined by the number of <td> elements that are found in each <tr>. The example in Figure 4.5 creates a table with 3 columns and 3 rows.

HTML Code

```
<table border=1>
    <tr>
         <th>Mountain Name</th>
         <th >Elevation</th>
    </tr>
    <tr>
         <td>Ras Dashen</td>
         <td>4,620 m</td>
    </tr>
    <tr>
         <td>Tullu Dimtu</td>
         <td>4,377 m</td>
    </tr>
    <tr>
         <td>Guge</td>
         <td>4,200 m</td>
    </tr>
    <tr>
         <td>Amba Alagi</td>
         <td>3,949 m</td>
    </tr>
</table>
```

Output on the Web Browser

Mountain Name	Elevation
Ras Dashen	4,620 m
Tullu Dimtu	4,377 m
Guge	4,200 m
Amba Alagi	3,949 m

Figure 4.11 HTML table

Notes

- Note the following points from Figure 4.11:
  - The table has a "border" attribute, which is assigned the value 1. This adds a border to the table when displayed on the web browser as shown in the example. If the border attribute is not used, the data will be displayed in the same way but without a border.
  - The information in the table is about some of the mountains found in Ethiopia.

Activity 4.11

1. Design a table that should look like the following when displayed on the web browser.

column 1	**column 2**	**column 3**	**column 4**
1	2	3	4
2	4	6	8
3	6	9	12
4	8	12	16

2. Modify the table you designed in the first activity so that the output on the browser will look something like the one shown below.

	column 1	**column 2**	**column 3**	**column 4**
row 1	1	2	3	4
row 2	2	4	6	8
row 3	3	6	9	12
row 4	4	8	12	16

When the layout of the table needs the merging of multiple columns or rows, "colspan" and "rowspan" attributes can be used respectively. For example, the HTML code in Figure 4.12 shows how two columns are merged both for the "Cases" and "Deaths" data cells of the table.

HTML Code

```
<table border=1>
  <tr>
    <th></th>
    <th colspan=2>Cases</th>
    <th colspan=2>Deaths</th>
  </tr>
  <tr>
    <th>Date</th>
    <th >Total</th>
    <th >New</th>
    <th >Total</th>
    <th >New</th>
  </tr>
  <tr>
    <td>07/29/21</td>
    <td>279,629</td>
    <td>3,592</td>
    <td>4,381</td>
    <td>61</td>
  </tr>
</table>
```

Output on the Web Browser

```
            Cases              Deaths
Date        Total      New     Total    New
07/29/21    279,629    3,592   4,381    61
```

Figure 4.12 Merging columns in HTML tables

Notes

- Note the following points from Figure 4.12:
    - The first <th> of the first <tr> does not have data as shown in the output.
    - As the value given to the “colspan” attribute of the second and third <th> of the first <tr> is 2, the “Cases” and “Deaths” columns span the two columns under them.
    - The data shown in the table is adopted from World Health Organization and is about the spread of COVID-19 in Ethiopia.

The “colspan” and “rowspan” attributes can also be used to define the layout of an entire page. The following HTML code generates a typical page layout with Header, Sidebar, Content area, as well as Footer using an HTML table as shown in the output of Figure 4.13.

HTML Code

```
<!DOCTYPE html>
<html>
<head>
</head>
<body>
<table width="100%">
  <tr>
     <td colspan="2" height="100px" bgcolor="#666666">
          <h1>Website Logo</h1>
     </td>
  </tr>
  <tr>
     <td width="20%" bgcolor="#cccccc" height="300px">
          <h3>Sidebar</h3>
     </td>
     <td width="80%" bgcolor="#eeeeee">
          <h3>Content</h3>
     </td>
  </tr>
  <tr>
     <td colspan="2"   bgcolor="#777777">
          Footer
     </td>
  </tr>
</table>
</body>
</html>
```

Figure 4.13(a) HTML code for Page layout using tables

Output on the Web Browser

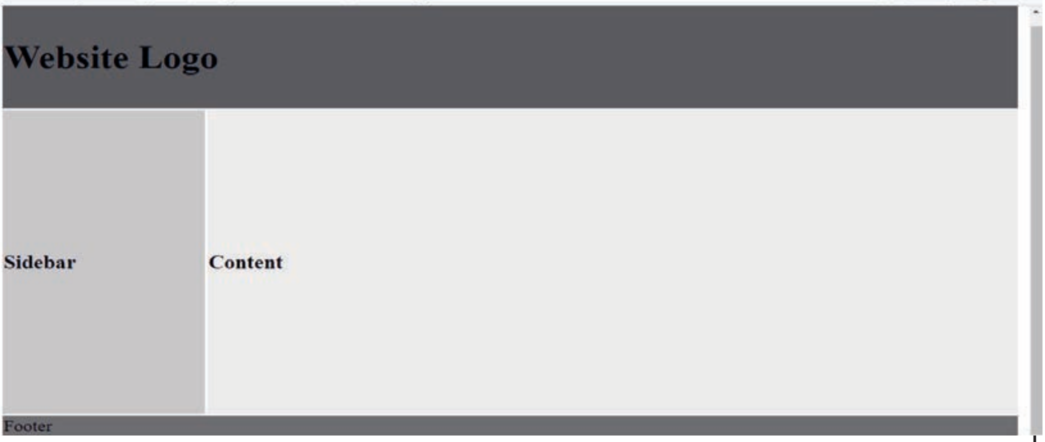


Figure 4.13(b) Page layout using tables

Notes

- Note the following points from Figure 4.13(a) and Figure 4.13(b):
  - The "width" attribute is given the value 100% so that the table occupies the entire width of the page.
  - "px" stands for pixel.
  - The "width" of the first <td> of the second <tr> is assigned 20% so that the "Sidebar" occupies 20% of the width of the table. 80% of the width of the table is occupied by the second <td> of the second <tr>.
  - "colspan" attribute is used to merge the top and bottom rows of the table.

Activity 4.12

- Create a table that has the following layout:
  - The table should occupy the entire width of the page.
  - The width of each of the first and third data cells of the second row occupies 20% of the width of the table.

4.6. HTML Lists

HTML lists are used to present different types of lists. The types of lists are known as ordered lists, unordered lists, and description lists.

4.6.1 Ordered List

 is the tag that is used to create ordered/numbered lists. The <li> tag, on the other hand, is used to insert individual items into the list. By default, Arabic numerals are used for ordering purposes in ordered lists. However, using the "type" attribute the ordering type can be changed to some other form such as the English alphabet. See Table 4.4 for the list of values that the "type" attribute can be assigned to and their meanings.

Table 4.5 The "type" attribute and its values for the Ordered List

Value	Meaning
1	Arabic numeral (Default)
I	Upper-case Roman number
i	Lower-case Roman numeral
A	Upper-case English alphabet
a	Lower-case English alphabet

The HTML code in Figure 4.15 shows an example of an ordered list, and what the output on the web browser looks like. (The data refers to the top 10 causes of death in Ethiopia. Source: World Health Organization 2018)

HTML Code	Output on the Web Browser
`<ol>`	
`<li>Coronary heart disease</li>`	1. Coronary heart disease
`<li>Influenza and pneumonia</li>`	2. Influenza and pneumonia
`<li>Diarrheal diseases</li>`	3. Diarrheal diseases
`<li>Stroke</li>`	4. Stroke
`<li>Tuberculosis</li>`	5. Tuberculosis
`<li>Road traffic accidents</li>`	6. Road traffic accidents
`<li>Liver disease</li>`	7. Liver disease
`<li>Diabetes mellitus</li>`	8. Diabetes mellitus
`<li>HIV/AIDS</li>`	9. HIV/AIDS
`<li>Breast cancer</li>`	10. Breast cancer
`</ol>`	

Figure 4.15 HTML Ordered List

Activity 4.13

1. Create an ordered list of the full names of your friends.

4.6.2 Unordered List

 is the tag that is used to create unordered/bulleted lists. The <li> tag and the "type" attribute are used similarly as they are used in ordered lists. The default bullet type is "disc". The "type" attribute is, therefore, used to change the default type to any of the other types. See Table 4.5 for the list of values that the "type" attribute can be assigned to and their meanings in unordered lists.

Table 4.6 The “type” attribute and its values for Unordered List

Value	**Meaning**
Disc	● (Default)
square	■
circle	○

Notes

- As stated in Table 4.6, the default bullet type for unordered lists is “disc”. In the example shown in Figure 4.9, however, the output shows the list using the “circle” bullet type. That is because the type is explicitly changed in the list as shown in the code.

HTML Code

```
<ul type="circle">
   <li>Save energy</li>
   <li>Plant trees</li>
   <li>Reduce water waste</li>
   <li>Avoid plastic wherever
possible</li>
</ul>
```

Output on the Web Browser

```
o  Save energy
o  Plant trees
o  Reduce water
   waste
o  Avoid plastic
   wherever possible
```

Figure 4.16 The “type” attribute in Unordered Lists

Activity 4.14

- By changing the value of the “type” attribute, design different types of ordered and unordered lists.

Lists can be nested. Any type of list can be placed under any other type of list. The following example in Figure 4.17 shows how an ordered list can be nested inside an unordered list.

HTML Code

```
<ul>
   <li>Actions one can do to stop
climate change
       <ol>
          <li>Save energy</li>
          <li>Plant trees</li>
          <li>Reduce water
            waste</li>
          <li>Avoid plastic
            wherever possible</li>
      </ol>
   </li>
</ul>
```

Output on the Web Browser

- Actions one can do to stop climate change
    1. Save energy
    2. Plant trees
    3. Reduce water waste
    4. Avoid plastic wherever possible

Figure 4.17 Nested lists

Notes

- In the HTML code of Figure 4.17, observe where the <li> of the <ul> begins and ends. As you can see, the <ol> is embedded inside the <li> of the outer <ul>.

Activity 4.15

- Create the following list.
    - Fruits:
        - Orange
        - Banana
        - Pineapple
    - Vegetables:
        - Carrot
        - Cabbage
        - Onion

4.6.3 Description List

In a description list, the <dl> tag is used to define the whole description. The <dt> tag, on the other hand, is used to add the item that is to be described or defined. The description or definition is added using the <dd> tag. See the example given in Figure 4.18 to learn how the three tags are used together.

HTML Code

```html
<dl>
  <dt>ol</dt>
  <dd>-Ordered list</dd>
  <dt>ul</dt>
  <dd>-Unordered list</dd>
  <dt>dl</dt>
  <dd>-Description list</dd>
</dl>
```

Output on the Web Browser

```
Ol
     -Ordered list
ul
     -Unordered list
dl
     -Description list
```

Figure 4.18 HTML Description List

Activity 4.16

- Create a description list for the dictionary definition of three of your favorite English words.

Unit Summary

In this unit, you have learnt about:

- what the Web is and its relationship with the Internet
- foundations of the Web, such as HTTP, HTML, web browser, and web server
- what is meant by a website and its uses
- what is meant by website design
- some guidelines for website design
- the difference between website design and website development
- what HTML is and the structure of an HTML document
- HTML tags and HTML elements and their differences
- how to insert basic elements like images, videos, paragraphs, headings, and the like on webpages
- HTML attributes and how they are used to control the properties of HTML elements
- how hyperlinks are created using the anchor tag (<a>)
- how to use images as a hyperlink
- the difference between absolute and relative URL
- how links are created to different parts of the same page using the anchor tag (<a>)
- how HTML tables are created to define the structure of data as well as the layout of webpages
- the three types of lists namely, ordered lists (<ol>), unordered lists (<ul>), and description lists (<dl>)
- how lists can be nested and how one type of list is embedded under another type

Key Terms

Absolute URL is a URL that includes every element of a URL such as the protocol, the hostname, as well as path of the webpage

Description lists <dl> are used to create description/definition lists

HTML attributes are used to define more properties to HTML elements

HTML elements are components of HTML documents that normally begin with a start tag and end with an end tag

HTML tags are a set of predefined names enclosed in angle brackets

HTML is a language that is used to develop webpages

HTTP is a protocol that browser software and web server software used to communicate with each other

Hypertext is a link that connects webpages

**Ordered Lists ** are used to create ordered/numbered lists

Relative URL is a path given relative to the location of the current webpage

The Web is one of the popular services of the Internet

Uniform Resource Locator (URL) refers to the address of web resources

**Unordered Lists ** are used to create bulleted lists

Void elements are HTML elements that do not have end tags

Web Browser is a software that is used to view webpages

Web Server is a software that is used to manage websites

Webpage is a web document that can store text, images, videos, and the like

Website is a collection of interrelated webpages

Review Questions

Part I: Write True if the statment is correct and False if it is incorrect.

1. The Web and the Internet are the same things.
2. The <head> and the <body> sections are the two major sections of HTML documents.
3. “rowspan” is the attribute that is used to merge rows of a table.
4. “circle” is a valid value to the “type” attribute in ordered lists.
5. It is only texts that can be used as hyperlinks.

Part II: Match the items given under column B with associated items in column A

A	B
1. Internet service	a. Web Browser
2. Section of an HTML document where actual content goes	b. The Web
	c. <body>
3. User or Client-side web software	d. <h1>
4. An HTML element used to create headings	e. <dd>
	f. URL
5. Address of webpages	g. HTTP
	h. .html
	i. Internet

Part III: Choose the correct answer from the given alternatives.

1. Which of the following is the language used to develop webpages?

A. HTML B. HTTP
C. Web server D. Web browser

2. The building blocks of webpages are _____________.

A. HTML tags B. HTML elements
C. Images D. Headings

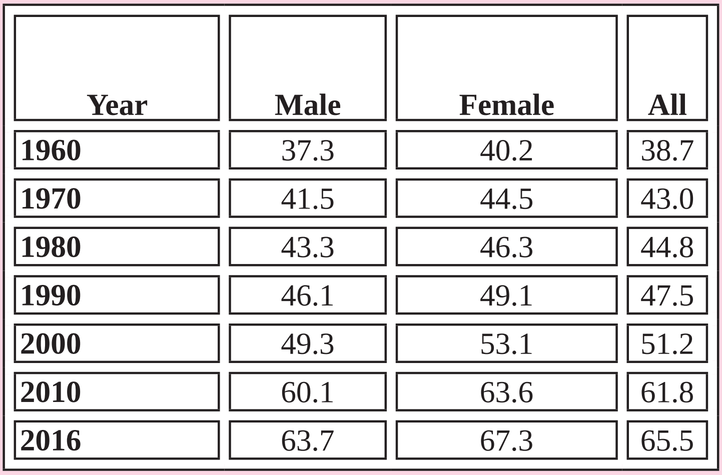
3. Which of the following is an example of void HTML elements?
   - A. <h1>
   - B. <p>
   - C. <img>
   - D. <b>
4. Which of the following is used to define additional properties to HTML elements?
   - A. HTML tags.
   - B. HTML attributes.
   - C. HTML documents.
   - D. URL
5. Which of the following is used to define a header for HTML tables?
   - A. <tr>
   - B. <td>
   - C. <th>
   - D. “colspan” attribute

Part IV: Fill in the blank spaces

1. A protocol that a web server and a web browser use to communicate with each other is ___________.
2. The extension used for file names in HTML documents is _________.
3. A type of URL that doesn’t contain information such as web protocol is called _______________.
4. The attribute of <a> that is used to give names to sections of a webpage is ___________________.
5. A tag that is used to create horizontal line is ___________________

Part V: Code Writing

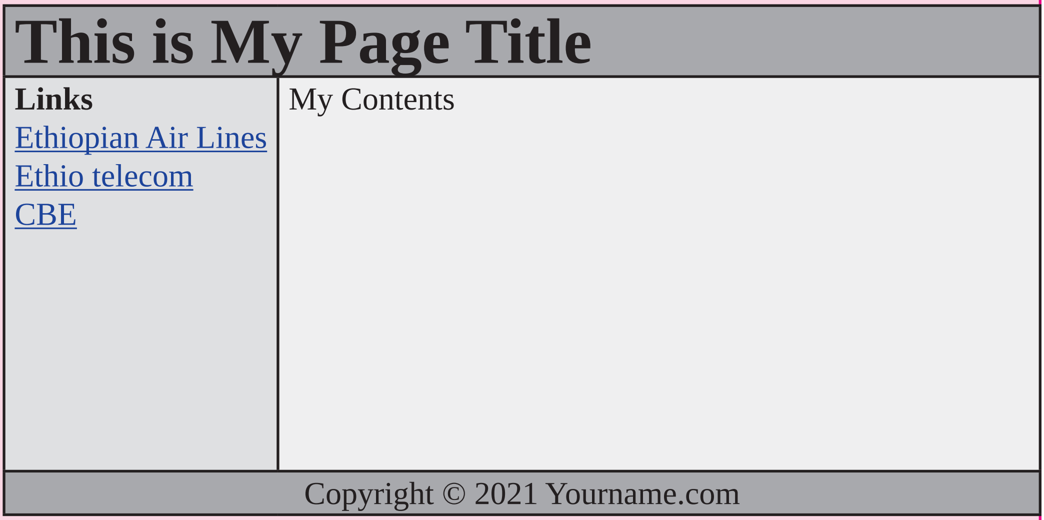
1. The following data is about life expectancy in Ethiopia between 1960 and 2016. (Source: World Health Organization). Create an HTML table that displays the data as shown below.



Year	Male	Female	All
1960	37.3	40.2	38.7
1970	41.5	44.5	43.0
1980	43.3	46.3	44.8
1990	46.1	49.1	47.5
2000	49.3	53.1	51.2
2010	60.1	63.6	61.8
2016	63.7	67.3	65.5

2. Create an Ordered List of the subjects you are currently taking in the order of your preference.
3. Create the following list:
    1. Famous Ethiopian female athletes:
        - Derartu Tulu
        - Tirunesh Dibaba
        - Meseret Defar
    2. Famous Ethiopian male athletes:
        - Abebe Bikila
        - Haile Gebrselassie
        - Kenenisa Bekele

4. Create the layout of a page using an HTML table according to the example shown below. The table has the following features:
    - The “width” attribute of the table is assigned to the value "100%"so that the table occupies the entire width of the page.
    - The “bgcolor” attribute of the data cell of the first row has the value "#999999".
    - The “bgcolor” attribute of the first data cell of the second row has the value "#dddddd", and its “width” attribute is assigned to the value "25%". This data cell also has hyperlinks to the three organizations shown in the example. Moreover, the content should be aligned to the top using the “valign” attribute.
    - The “bgcolor” attribute of the second data cell of the second row has the value "#eeeeee", and its “height” attribute has the value "200". The content should be aligned to the top using the “valign” attribute using the value "top".
    - The data cell of the last row has the same background as the first one and, its text is center-aligned.



This is My Page Title

Links
Ethiopian Air Lines
Ethio telecom
CBE

My Contents

Copyright © 2021 Yourname.com

UNIT 5

HARDWARE TROUBLESHOOTING AND PREVENTIVE MAINTENANCE

Learning Outcomes

At the end of this unit, students will be able to:

- Explain maintenance procedures and troubleshooting
- State hardware problems
- Describe hardware preventive maintenance
- Perform basic hardware troubleshooting & preventive maintenance
- Recognize the value of hardware troubleshooting to keep computer safety

Unit Overview

Computers must be protected from any kind of threat that causes the computer to malfunction. Computer users should have some basic knowledge of troubleshooting and solving hardware-related problems. This unit covers hardware troubleshooting and preventive maintenance.

5.1. Hardware Troubleshooting

Brainstorming 5.1

- What do you know about computer hardware troubleshooting and maintenance?

Hardware troubleshooting is a systematic approach to locating the cause of a fault in a computer system and solving technical problems. It starts with general issues and then gets more specific.

5.1.1 Hardware Troubleshooting Procedures

Hardware troubleshooting is the process of reviewing, diagnosing, and identifying operational or technical problems within a hardware device or equipment. It aims to resolve physical and/or logical problems and issues within computing hardware. On the other hand, software troubleshooting is the process of scanning, identifying, diagnosing, and resolving problems, errors, and bugs in software.

Computers can malfunction and get damaged if computer users are not aware of some of the basic procedures for checking hardware problems. Many computer problems can be solved by checking the following simple hardware problems:

- Check that your computer is plugged into a working power outlet.
- Check that everything is turned on.
- If the computer is on but the screen is blank, there may be an issue with the connection between the computer and the screen. First, check to see if the monitor is plugged into a power outlet and if the connection between the monitor and computer system unit is connected securely.
- Check that the keyboard, mouse, monitor, speakers, etc. are properly plugged into the computer system. Try a different port to check if it is a port issue, or change the device if the device is damaged.

Notes

- It is necessary to switch off the computer before undertaking any hardware maintenance such as removing or replacing computer parts.

5.1.2 Check POST

POST stands for **Power On Self-Test**. This is part of a computer's startup program that is used to diagnose the keyboard, the Random Access Memory (RAM), disk drives, and other hardware to make sure they are working properly. If the POST detects any errors in the hardware, it either displays a text error message on the screen or emits a series of short and long beeps.

If an error message appears as you boot your computer, type the exact error message and then search on the Internet to find more information about the error.

Activity 5.1

1. If your computer cannot start, what are the preliminary hardware diagnoses you do to identify and fix the problems?

5.1.3 Beep Codes

Beep codes are sounds emitted by the computer during Power on Self-Test (POST). Each BIOS manufacturer has a unique beep sequence, a combination of long and short beeps, for hardware failures. If there is a problem with the computer, listen for the **beep codes** when the computer starts. As the system proceeds through the Power on Self-Test (POST), most computers emit one beep to indicate that the system is booting properly. If there is an error, you might hear multiple beeps. You need to document the beep code sequence and search on the Internet to determine the specific problem. Some of the beep codes and the respective problems are as follows:

- **No beep but the system turns on and runs fine** - Under normal circumstances, most computer systems will beep one short beep when turned on. If your computer doesn't produce a beep sound, your "beeper" may have died out.

- **No beep** - The power supply is not plugged in or turned on. If not, the power supply is completely dead.

- **Steady, short beeps** - The power supply may be bad or the voltages might be wrong. A replacement would usually be necessary.

- **Steady, long beeps** - The power supply has gone bad.

- **Long, continuous beep** - Your Random Access Memory (RAM) sticks may have gone bad. If there is more than one stick installed, try taking one out to see if the computer boots. If it does not, try the same thing with the other stick. This will tell you which stick has gone bad, and you can replace or upgrade accordingly. If there is only one stick installed, you will need to replace or upgrade it to fix the problem.

- **One long, two short beeps** - There has been a video card failure. Your first action is to try reseating the video card. This often solves the problem when the computer system is connected to projectors because the VGA/DVI or Video cable gets moved so often that the card can be slowly unplugged. If reseating doesn't work, replace the video card.

5.1.4 BIOS Information

BIOS stands for basic input/output system. **BIOS** is a program used by a computer to start the computer system after it is powered on. It also manages data flow between the computer's operating system (OS) and attached devices, such as the hard disk, video adapter, keyboard, mouse, and printer. If the computer boots and stops after the POST, your computer has a BIOS setting problem. Fixing BIOS problems requires a good knowledge of computer hardware. Therefore, when you face a BIOS setting problem, you are advised to contact a computer hardware technician to solve the problem.

5.1.5 CMOS Error

The **CMOS** (Complementary Metal-Oxide Semiconductor) is an onboard chip that stores information ranging from the time and date to system hardware settings; its primary function is to handle and store the BIOS configuration settings. If a computer shows a CMOS alert message on the screen, it indicates that the CMOS battery needs to be replaced. Upon receiving such type of error message, remove the CMOS battery carefully, and insert a new battery that is exactly the same as the old one.

Notes

- Replacing a CMOS battery may be more difficult in laptop computers than in desktop computers. If the user of the computer does not have sufficient computer hardware troubleshooting experience, leaving the task to a professional computer technician is advised.

5.1.6 Event Viewer

When system or application errors occur on a computer running Windows, the Event Viewer is updated with information about the errors. The **Event Viewer**, shown in Figure 5.1, records the following information about the problem:

- The problem that occurred
- The date and time of the problem
- The severity of the problem
- The source of the problem
- The event ID number
- Which user was logged in when the problem occurred

The following steps can be followed to launch the Event Viewer:

1. On the Windows Search box, write **event viewer**
2. A pop-up menu appears which looks like the one shown in Figure 5.1
3. Click on Event Viewer

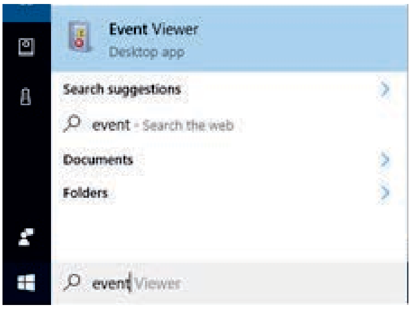
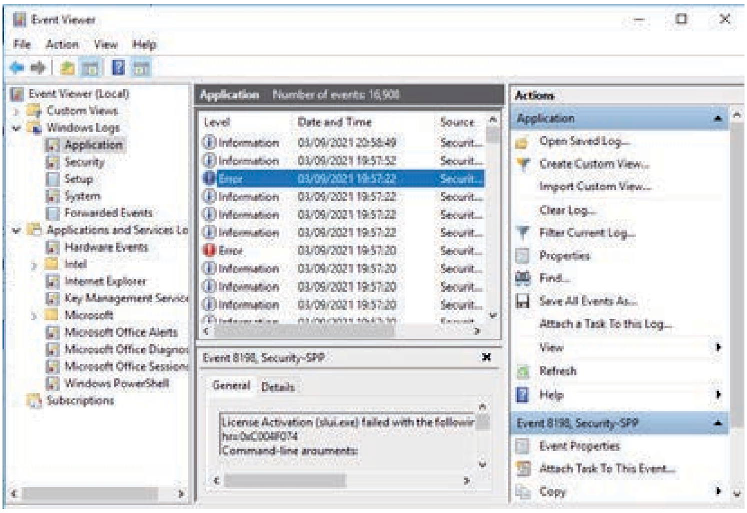


Figure. 5.1 Launching Event Viewer

Events are placed in different categories as shown on the left side of Figure 5.2. Expand each category to get more information. Each category is related to a log that Windows keeps on events regarding that particular category. While there are a lot of categories, the vast amount of troubleshooting you might want to do is related to the **Windows Log category**, which contains the following items:

- **Application:** The Application log records events related to Windows system components, such as drivers and built-in interface elements.
- **System:** The System log records events related to programs installed on the system.

- **Security:** When security logging is enabled (it is off by default in Windows), this log records events related to security, such as logon attempts and resource access.


Event Viewer
File
Action
View
Help
Event Viewer (Local)
Custom Views
Windows Logs
Application
Security
Setup
System
Forwarded Events
Applications and Services Lo
Hardware Events
Intel
Internet Explorer
Key Management Service
Microsoft
Microsoft Office Alerts
Microsoft Office Diagnos
Microsoft Office Sessions
Windows PowerShell
Subscriptions
Application Number of events: 16,908
Event 8198, Security-SPP
General
Details
Actions
Application
Open Saved Log...
Create Custom View...
Import Custom View...
Clear Log...
Filter Current Log...
Properties
Find...
Save All Events As...
Attach a Task To this Log...
View
Refresh
Help
Event 8198, Security-SPP
Event Properties
Attach Task To This Event...
Copy

Level	Date and Time	Source
Information	03/09/2021 20:58:49	Securit...
Information	03/09/2021 19:57:52	Securit...
Error	03/09/2021 19:57:22	Securit...
Information	03/09/2021 19:57:22	Securit...
Information	03/09/2021 19:57:22	Securit...
Information	03/09/2021 19:57:22	Securit...
Error	03/09/2021 19:57:20	Securit...
Information	03/09/2021 19:57:20	Securit...
Information	03/09/2021 19:57:20	Securit...
Information	03/09/2021 19:57:20	Securit...

```
License Activation (slui.exe) failed with the followir
hr=0xC004F074
Command-line arguments:
```

Figure 5.2 Event Viewer

When you click on **Application** under Windows log, you get a list of **Application log records events.**

If you want to get detailed information about the error, double-click on the error, and then you get detailed information in the pop-up window. Although the Event Viewer lists details about an error, you might need to do further searching on the Internet about the problem to identify an appropriate solution.

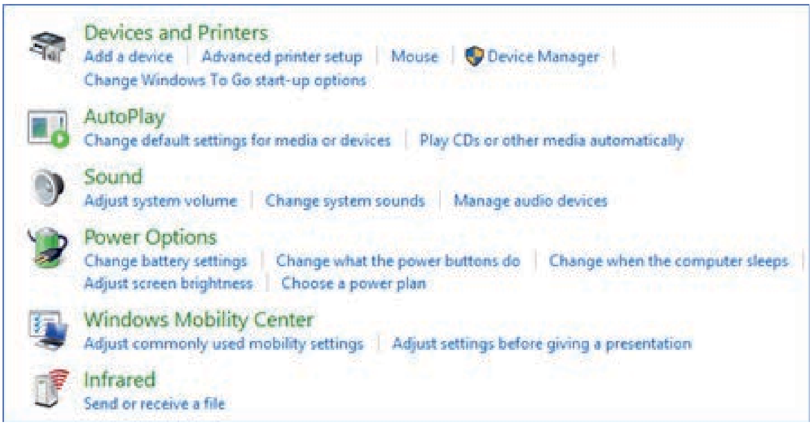
5.1.7 Hardware Problems

Many computer problems are caused by hardware failures or problems with hardware drivers. Windows usually displays notifications about devices that have a problem. Device Manager is used to check the status of different hardware devices. The following steps can be followed to identify hardware problems in Windows-based systems:

1. Click on the Windows search box in the lower-left corner.
2. Type **Control Panel**.
3. Double-click the **Control Panel** on the Windows pop-up menu.

4. Click **Hardware and Sound**.

5. Under Device and Printers, Click on **Device Manager** (see Figure 5.3)



Devices and Printers
Add a device | Advanced printer setup | Mouse | Device Manager |
Change Windows To Go start-up options

AutoPlay
Change default settings for media or devices | Play CDs or other media automatically

Sound
Adjust system volume | Change system sounds | Manage audio devices

Power Options
Change battery settings | Change what the power buttons do | Change when the computer sleeps |
Adjust screen brightness | Choose a power plan

Windows Mobility Center
Adjust commonly used mobility settings | Adjust settings before giving a presentation

Infrared
Send or receive a file

Figure 5.3 Windows Control Panel

The Device Manager has the following four benefits.

1. It works as a centralized utility from which all the hardware on a system can be configured.

2. It provides a central and organized view of all hardware- Microsoft Windows-recognized hardware- installed on a system.

3. It helps to manage all the hardware devices installed on a system. This includes keyboards, hard disk drives, USB devices, etc.

4. It helps to change hardware configuration options, manage drivers, enable or disable hardware, identify conflicts between hardware devices, etc.

When you click on the Device Manager on the Control Panel as shown in Figure 5.3, the Device Manager window is displayed (see Figure 5.4). The devices that have a problem would have an error icon displayed right next to the name of the device. The operating system flags the devices with an error icon.

- A **yellow triangle** with an exclamation mark indicates that the device has a problem.

- A **red X** means that the device is disabled or removed or Windows can't locate the device.

- A **downward-pointing arrow** means the device has been disabled.

- A **yellow question mark** indicates that the system does not know which driver to install for the hardware. This problem will be solved by installing the appropriate driver software for the device

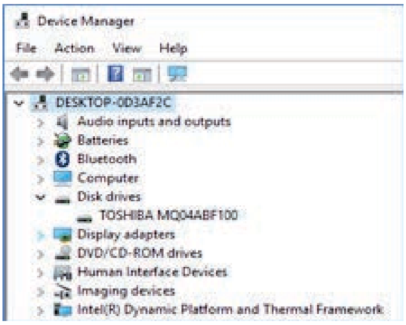

Device Manager
File
Action
View
Help
DESKTOP-0D3AF2C
Audio inputs and outputs
Batteries
Bluetooth
Computer
Disk drives
TOSHIBA MQ04ABF100
Display adapters
DVD/CD-ROM drives
Human Interface Devices
Imaging devices
Intel(R) Dynamic Platform and Thermal Framework

Figure 5.4 Device Manager

Activity 5.2

1. Open the Device Manager and check if there is any problem on your DVD/CD-ROM drives.

2. If you find a **yellow triangle** with an exclamation mark on one of your hardware devices, what will you do to solve the problem?

5.1.8 Diagnostic Tools

Diagnostic Tools are software tools that are used to help troubleshoot, diagnose and solve hardware problems. Manufacturers of system hardware usually provide diagnostic tools of their own. For instance, a hard drive manufacturer might provide a tool to boot the computer and diagnose why the hard drive does not start the operating system.

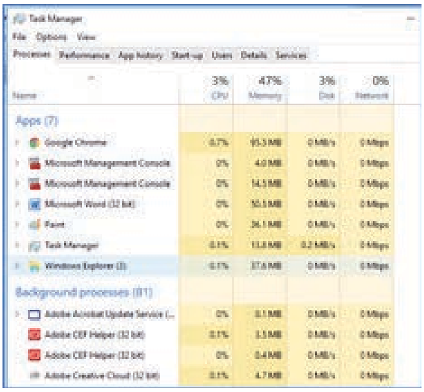
The top two diagnostic tools are Windows Performance Monitor and Windows Resource Monitor.

a) Windows Performance Monitor

The performance monitor gives a quick view of vital information about computer hardware. The computer's CPU, Memory, Disk, and Ethernet information can be checked from there. Performance Monitor is used to examine the effects of running applications in both real-time and by collecting data to check out for later analysis (See Figure 5.5).

For example, to view the Performance Monitor, the following steps can be followed:

1. Press CTRL + ALT + Delete button at the same time.
2. Choose Task Manager, and the window shows that appears in Figure 5.5.r
3. Then click on the Performance tab to see the performance of the CPU and other devices in the computer.



Name	3% CPU	47% Memory	3% Disk	0% Network
Apps (7)				
Google Chrome	0.7%	95.3 MB	0 MB/s	0 Mbps
Microsoft Management Console	0%	4.0 MB	0 MB/s	0 Mbps
Microsoft Management Console	0%	14.5 MB	0 MB/s	0 Mbps
Microsoft Word (32 bit)	0%	50.5 MB	0 MB/s	0 Mbps
Paint	0%	26.1 MB	0 MB/s	0 Mbps
Task Manager	0.1%	13.8 MB	0.2 MB/s	0 Mbps
Windows Explorer (3)	0.1%	37.6 MB	0 MB/s	0 Mbps
Background processes (81)				
Adobe Acrobat Update Service (...	0%	0.1 MB	0 MB/s	0 Mbps
Adobe CEF Helper (32 bit)	0.1%	3.5 MB	0 MB/s	0 Mbps
Adobe CEF Helper (32 bit)	0%	0.4 MB	0 MB/s	0 Mbps
Adobe Creative Cloud (32 bit)	0.1%	4.7 MB	0 MB/s	0 Mbps

Figure 5.5 Task Manager

Notes

- One quick way of reducing the load from the CPU in Windows is to restart the computer to remove any unwanted temporary files. Make sure that all files are saved before proceeding with this step.
- The other option is to look for the applications that are using maximum CPU resources on the Task Manager. If any application shows CPU usage of almost 100%, disable the application and then start it again.

Activity 5.3

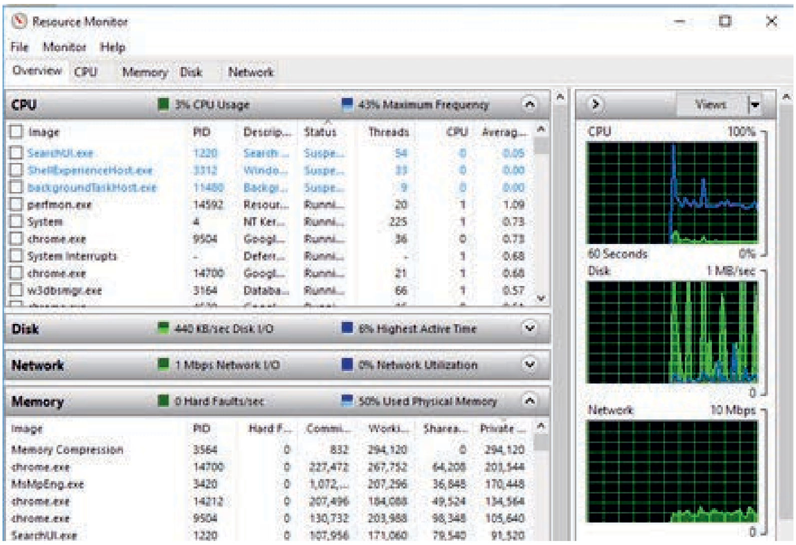
- Open Task Manager and see if any applications are using excessively large amounts of the computer’s CPU or memory, and if there are any, disable them.

b) Windows Resource Monitor

Windows Resource Monitor is better suited for tracking CPU, Network, Memory, and Disk usage. This tool allows to take an in-depth look into which processes are affecting the CPU, how much memory is being used, the disk activities, and the network information such as current TCP (Transport Control Protocol) connections, and which processes are listening on which port.

The following steps can be followed to open the Windows Resource Monitor:

1. On the Windows search box, write Resource Monitor
2. Click on the Resource Monitor, and then the window shows what appears in Figure 5.6.



CPU 3% CPU Usage 43% Maximum Frequency

Image	PID	Descrip...	Status	Threads	CPU	Averag...
☐ SearchUI.exe	1220	Search ...	Suspe...	54	0	0.05
☐ ShellExperienceHost.exe	3312	Windo...	Suspe...	33	0	0.00
☐ backgroundTaskHost.exe	11480	Backgr...	Suspe...	9	0	0.00
☐ perfmon.exe	14592	Resour...	Runni...	20	1	1.09
☐ System	4	NT Ker...	Runni...	225	1	0.73
☐ chrome.exe	9504	Googl...	Runni...	36	0	0.73
☐ System Interrupts	-	Defer...	Runni...	-	1	0.68
☐ chrome.exe	14700	Googl...	Runni...	21	1	0.68
☐ w3dbsmgr.exe	3164	Databa...	Runni...	66	1	0.57

Disk 440 KB/sec Disk I/O 6% Highest Active Time

Network 1 Mbps Network I/O 0% Network Utilization

Memory 0 Hard Faults/sec 50% Used Physical Memory

Image	PID	Hard F...	Commi...	Worki...	Sharea...	Private ...
Memory Compression	3564	0	832	294,120	0	294,120
chrome.exe	14700	0	227,472	267,752	64,208	203,544
MsMpEng.exe	3420	0	1,072,...	207,296	36,848	170,448
chrome.exe	14212	0	207,496	184,088	49,524	134,564
chrome.exe	9504	0	130,732	203,988	98,348	105,640
SearchUI.exe	1220	0	107,956	171,060	79,540	91,520

Figure 5.6 Windows Resource Monitor

Clicking on the CPU tab in the Windows Resource Monitor lists the four sections namely, Processes, Services, Associated Handles, and Associated Modules. The processes that are running are shown in black color under the Processes section, and those that are suspended are shown in blue color while the processes that are not responding are shown in red color. Upon selection of a specific running process from the Processes section the related data under the Services, Associated Handles, and Associated Modules get populated.

If you find your computer slowing down unexpectedly, take a look at the CPU column. If an application is taking up a lot of CPU resources, shut down the application and restart it.

To stop the application

1. Open resource monitor window
2. Right-click on the application
3. Click on End process

If you want to know more about an application, you can follow the following steps in the Resource Monitor window:

1. Right-click on the name of the application
2. Choose Search online

This opens your default browser displaying the search result of the application on the default search engine of your browser. Click on the application links and learn more about the application.

Activity 5.4

1. What do you understand by hardware troubleshooting?
2. If your computer is slow, what will be the possible problem and what course of action can you take to solve it?

5.2. Basics of Preventive Maintenance

Brainstorming 5.2

- Reflect on any preventive maintenance methods you are aware of.

Preventive maintenance is the practice of routinely taking measures in hardware administration that reduces the risk of hardware failures. It also improves the likelihood of quick recovery in the event that a failure does occur. Maintenance activities include performing diagnoses on different hardware components such as circuit boards and memory and replacing any components that show signs of excess wear. It also includes keeping hardware components clean from dust to reduce the likelihood of overheating and hardware failures.

5.2.1 Preventive maintenance for Dust

There are various ways of cleaning dust off the computer. Some examples of preventive maintenance against dust such as Cloth, chemical cleaners, and vacuum cleaners are presented below.

1) Cloth

The outside of the computer case can be cleaned using a soft cotton cloth. Special cleaning cloth like microfiber cloth is effective in removing dust without damaging screens (See Figure 5.7). Microfiber cloth is made from a high-quality material that absorbs and removes all fingerprints, smudges, oils, and dust from the screen. Use of this material as a first step before applying any liquid sanitizing wipe or screen cleaner is recommended.

Figure. 5.7 Microfiber Cleaning Cloth

2) Chemical cleaner

There are different chemical cleaners in the market which can be used to clean computer screens. Alcohol-Free Sprays such as Koala Cleaner are safe for all kinds of screens. It can be used on all screens from tablets to laptops.

3) Vacuum Cleaner

Dust on the outside of a computer can travel through cooling fans to the inside part of the computer. Accumulated dust prevents the flow of air and reduces the cooling of components. Hot computer components are more likely to break down. Using a combination of compressed air, a low-air-flow vacuum cleaner, and a small lint-free cloth, dust can be removed from the inside of a computer. It is good to make it a regular habit like monthly to clean computers' air ventilators, connection ports, and keyboards with a vacuum cleaner.

5.2.2 Run antivirus

A **computer virus** is a type of computer program that(when executed) replicates itself by modifying other computer programs and inserting its own code. Computers may be infected with viruses when they are connected to the Internet or when someone else's flash disk is inserted into a computer system. Virus infection is not detected until it creates a problem on the computer.

Antivirus, which is also known as anti-malware, is a computer program used to prevent, detect and remove malware. There are freeware and commercial antivirus software. The freeware antivirus software can be freely downloaded and used. Some examples of free antivirus software are AVAST, AVG, AVIRA, and Bitdefender.

In order to install antivirus software:

1. Search the antivirus software, for example, on Google
2. Then click on the search result on the name of the Antivirus software you want to download (see Figure 5.8)
3. You can directly install from the Internet or save the antivirus software on your hard disk

4. If it is saved on the hard disk, install the antivirus software in the same way you install other types of application software by starting the **setup** file.

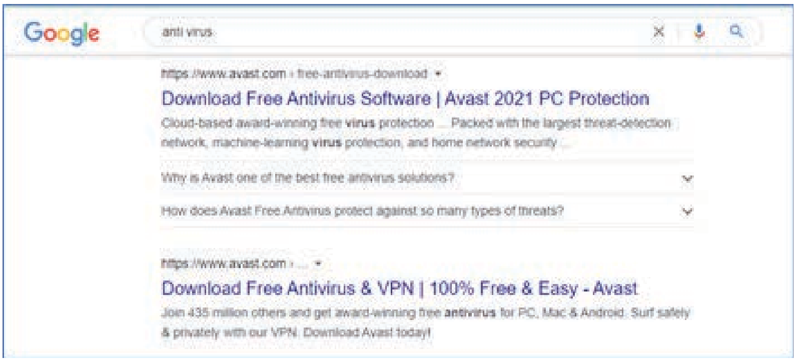


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Figure 5.8 Installing Antivirus Software

It is important to run the antivirus program on a regular basis to make sure any changes made, or files that are downloaded have not compromised the system. Additionally, running the antivirus program because some malicious programs embed into systems without warning and require specific actions to trigger. Scanning computer systems regularly with antivirus software help prevent the computer system from virus infection.

Activity 5.5

1. Discuss the problems you will face if you do not have installed antivirus software on your computer.
2. Reflect on computer problems that will be caused by dust.

5.2.3 Backups

Backup is a process of transferring data or files from a computer system to external storage devices. The backup file is used to recover data loss during computer failure. Computer users should have at least one method for backing up users data, whether it is on a cloud storage server or an external hard drive (see Figure 5.9). It is necessary to take time to update the backups as frequently as needed. If up-to-date backups are available, computer users will not have to worry about losing a day’s work in the event a PC is unexpectedly crashed.

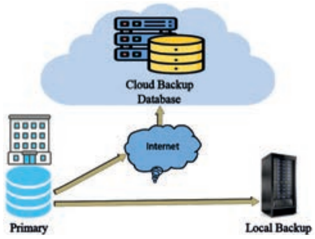

Cloud Backup Database
Internet
Primary
Local Backup

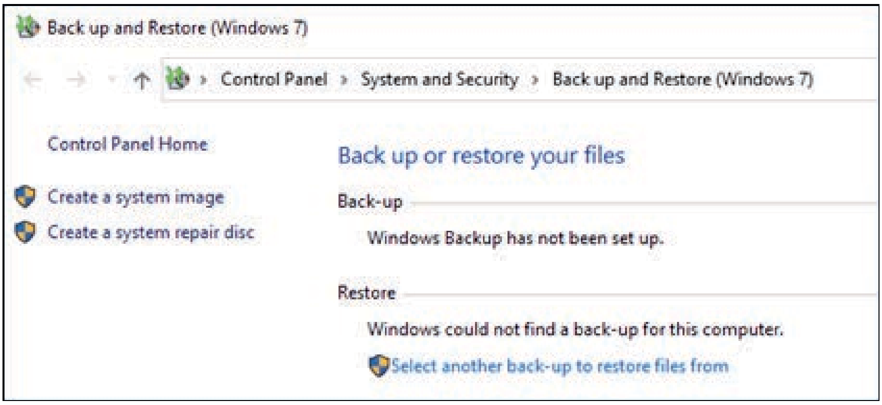
Figure 5.9 Data backup

Notes

- Backup is the first step before any troubleshooting on a computer system is done. If a backup has not been taken, do not take any troubleshooting activity. Before undertaking any troubleshooting, it is recommended to check with the computer user about the date of the last backup, contents of the backup, data integrity of the backup, and availability of all backup media for data restore.

The following steps can be followed to take a backup on a Windows-based computer:

1. Open the Control Panel
2. Choose Backup and Restore
3. Choose Set up back-up
4. The window will be displayed as shown in Figure 5.10.


Back up and Restore (Windows 7)
Control Panel › System and Security › Back up and Restore (Windows 7)
Control Panel Home
Create a system image
Create a system repair disc
Back up or restore your files
Back-up
Restore
Select another back-up to restore files from

Windows Backup has not been set up.

Windows could not find a back-up for this computer.

Figure 5.10 Disk Backup Window

5. Click on **Create a system image**,

6. Select the storage drive either a hard disk, DVD disk, or a Network drive where you intend to store your backup.
7. Then click on the next button, and
8. Finally click on the **start backup** button

Notes

- *You can alternatively write backup on the Windows search box at the lower left corner, and then select backup settings to open the backup window.*

5.2.4 Scan Hard Disk

When old files are deleted from the hard disk and new files are saved, the files become fragmented. *Fragmentation is the scattering of portions of files in the disk in nonadjacent areas, thus greatly slowing access to the files.*

When a hard disk is new, the operating system puts files on the disk contiguously (next to one another). However, when a file is updated over time, new data for that file is distributed to unused spaces. These spaces may not be contiguous to the older data in that file. It, therefore, takes the operating system longer to read these fragmented files.

A defragmenter utility program, commonly called a "defragger," finds all the scattered files on the hard disk and reorganizes *them* into the smallest number of adjoining regions (See Figure. 5.11). In other words, defragmentation is a process that reduces the degree of fragmentation. This increases the computer's speed.

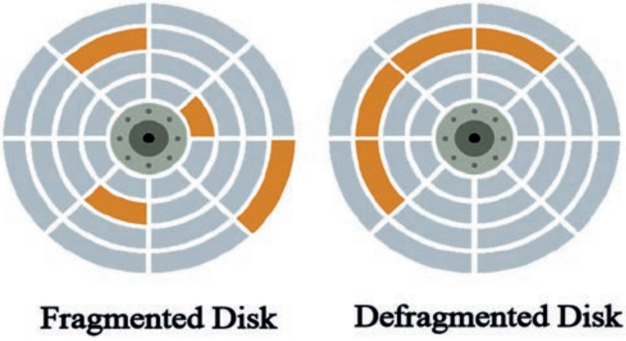
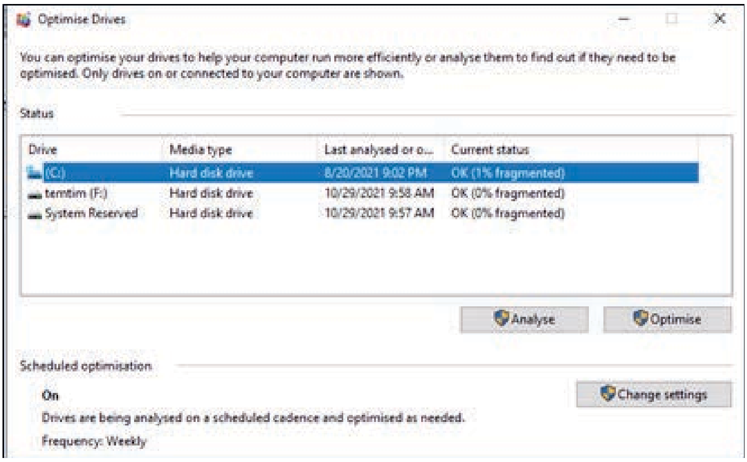


Figure 5.11 Disk Defragmentation

The following steps can be followed to undertake disk defragmentation:

1. Type Windows Administrative Tools on the Windows search box and click on Windows Administrative Tools.
2. Double-click on Defragment and Optimize Drives.
3. Then the window shown in Figure 5.12 will be displayed.
4. Select the drive, and then click on the Optimize button.



You can optimise your drives to help your computer run more efficiently or analyse them to find out if they need to be optimised. Only drives on or connected to your computer are shown.

Status

Drive	Media type	Last analysed or o...	Current status
(C:)	Hard disk drive	8/20/2021 9:02 PM	OK (1% fragmented)
temtim (F:)	Hard disk drive	10/29/2021 9:58 AM	OK (0% fragmented)
System Reserved	Hard disk drive	10/29/2021 9:57 AM	OK (0% fragmented)

Scheduled optimisation

On

Drives are being analysed on a scheduled cadence and optimised as needed.

Frequency: Weekly

Figure 5.12 Disk Optimization Window

Notes

- *As shown in Figure 5.12, if the drive's current status says (0% fragmented), there is no need to do defragmentation.*

5.2.5 Power Protection Devices

Electric power causes many problems on computer hardware components. The following tools are used as a means to prevent potential damages that can be caused by electric powers.

1) **Use a surge protector to protect against too much electricity**: Plug all your hardware into a surge protector (suppressor), which will prevent damage to your equipment if there is a power surge (See Figure 5.13).

2) **Use a stabilizer to ensure the level of voltage being supplied at a desired level:** Plug your computer into a stabilizer (See Figure 5.13) to adjust

for power variations, which will deliver a consistent voltage level to the equipment. Power fluctuations can cause damage to electrical motors and components. This damage could be severe and immediate. It may result in a shorter operating lifespan.

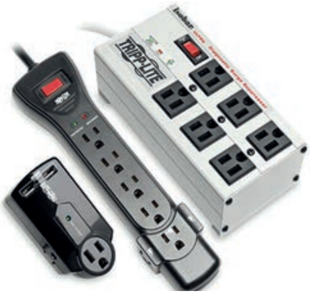


Figure 5.13 Power surge protectors

3) **Use a voltage regulator to protect against too little electricity**: Plug your computer into a voltage regulator (also called a line conditioner) to adjust for power sags or brownouts (see Figure 5.14).

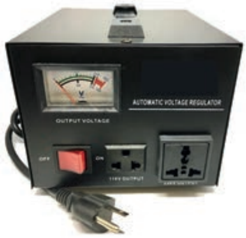


Figure 5.14 Power voltage regulator

4) **Consider using a UPS to protect against the complete absence of electricity**: Consider plugging your computer into a UPS (Uninterruptible Power Supply). The UPS is kind of a short-term battery that (when the power fails) will keep your computer running long enough (5–30 minutes) for you to save your data before you turn off the computer (See Figure 5.15). It also acts as a surge protector.

Figure 5.15 UPS power surge

5.2.6 Shut Down Properly

At the end, make sure you save your work before closing all your programs and shutting down your PC. Leaving your PC turned on when it is not used prevents it from cooling, and can impact the machine's performance. If shutting down interferes with your daily routine or business requirements, put your computer into a low-power or hibernation mode instead.

Activity 5.6

1. Discuss the purpose of taking backups of your computer files.
2. Reflect on the effect of disk fragmentation on your computer.

Unit Summary

In this unit, you have learnt about:

- what is meant by hardware troubleshooting and preventive maintenance
- messages of POST, which stands for Power On Self-Test
- beep code sounds as alert message for hardware failures
- what is meant by CMOS alert message
- how to identify system or application errors through event viewer window
- how to identify and troubleshoot hardware problems through device manager
- how to use Diagnostic Tools to diagnose and troubleshoot hardware problems
- how to use Windows Resource Monitor to track CPU, Network, Memory and Disk usage
- the different hardware prevention mechanisms
- how to clean a computer from dust.
- what is meant by Virus and Antivirus software
- how to protect a computer from virus.
- how to undertake system data backup.
- what is meant by disk fragmentation and defragmentation
- mechanisms for protecting computers from power problems

Key Terms

Antivirus is computer software that is used to clean viruses from a computer system.

Backup is a process of transferring data or files from a computer system to external storage devices so as to recover data lost during a computer failure.

Beep codes are sounds emitted by the computer during Power on Self-Test (POST).

BIOS is a program used by a computer to start the computer system after it is powered on.

The CMOS (Complementary Metal-Oxide Semiconductor) is an onboard chip that stores information ranging from time and date to system hardware settings.

Diagnostic Tools are software tools that are used to help diagnose and solve hardware problems.

Power On Self-Test (POST) is part of a computer's startup program that is used to diagnose the keyboard, the Random Access Memory (RAM), disk drives, and other hardware to make sure they are working properly.

Preventive maintenance is a regular and systematic inspection, cleaning, and replacement of worn parts, materials, and systems that ensure computer hardware have long and productive life.

Troubleshooting is a systematic approach to locating the cause of a fault in a computer system and solving technical problems. It starts with general issues and then gets more specific.

Virus is a type of computer program that (when executed) replicates itself by modifying other computer programs and inserting its own code.

Review Questions

Part I: Write True if the statment is correct and False if it is incorrect.

1. Preventive maintenance is a regular and systematic inspection, cleaning, and replacement of worn parts of the computer to ensure smooth operation of the organization
2. Troubleshooting is a systematic approach to identify and solve hardware problems.
3. Cleaning dusts off from the inside and outside parts of a computer system may lead to hardware problems.
4. Beep codes are used to identify software problems on a computer system.
5. Diagnostic Tools are software tools that are used to diagnose hardware failures.
6. Antivirus is software that is used to prevent, detect and remove malware.
7. Backup is used to clear viruses from a computer system.
8. Disk fragmentation reduces the speed of a computer.
9. A surge protector is used to protect a computer against too little electricity.
10. When a computer is not used, shutting down computers is useful for a longer life of hardware components.

Part II: Fill the blank spaces

1. _________ sounds indicate a hardware problem on a computer system.
2. _________ are software tools that are used to help troubleshoot, diagnose and solve hardware problems.
3. A data protection mechanism through copying data from a computer system to external storage devices is known as _____________________.
4. A type of software that is used to clean virus from a computer system is called __________________.
5. A regular and systematic inspection, cleaning, and replacement of worn hardware components is called _________________.

Part III: Give short answers to the following questions

1. What is hardware troubleshooting?
2. What is a software tool that is used to check the status of different hardware devices?
3. What are the different hardware preventive maintenance methods?
4. What are the software tools used to monitor the performance of a computer system?
5. How do you solve the problem of slow CPU performance while it is in operation?

Part IV: Discussion Questions

1. Discuss in groups the problems organizations face if they do not take timely backup?
2. Form a group and maintain a computer that does not work entirely. Write down the procedures you followed to identify the problem and fix the problem. Share your experience with the class.

UNIT 6

FUNDAMENTALS OF PROGRAMMING

Learning Outcomes

At the end of this unit, students will be able to:

- Define computer programs
- State and describe types of programming languages
- Explain syntax and semantics of programming languages
- Explain variables and data types
- Differentiate the concept of statements and expressions in Python
- Analyze simple programs written in Python
- Write simple programs with input and output

Unit Overview

A computer program is a set of instructions that commands a computer what to do. Computers do whatever task they do by simply following the instructions stated in programs. This unit covers topics related to computer programs including programming languages, syntax, and semantics. The high-level programming language known as Python is used to demonstrate the basic concepts of programming.

6.1. Types of Programming Languages

Brainstorming 6.1

- How do computers do the types of tasks we observe them doing?

Programming languages are computer languages that are used to write different types of computer programs. They are generally grouped into machine language, assembly language, and high-level language.

6.1.1 Types of Programming Languages

Machine Language

Machine language is a low-level computer language. It is a language in which everything including instructions, numbers, and memory locations are represented in 1s and 0s – binary system. Machine language is the language that computers understand directly without any need for translation. That is why it is very fast and uses memory efficiently. However, writing programs in machine language is very difficult.

Assembly Language

Assembly language is also a low-level computer language but, instead of 1s and 0s, it uses symbols known as mnemonics. Though it is easier than using a binary system, assembly language is still difficult.

Since computers do not directly understand any program outside the machine language, programs that are written in assembly language require a special type of software. This software is known as *Assembler*, and it is used to translate assembly language instructions into machine language.

High-Level Language

High-level languages are closer to human languages compared to both assembly and machine languages. This type of language allows programmers to focus more on the problem they want to solve than on the programming language. Examples of high-level programming languages include C, C++, Java, C#, Python, Perl, and Ruby.

Just like assembly language programs, high-level language programs also cannot be directly executed by the computer. The programs have to be first translated into a machine language using translator software. Depending on the programming language, the translator software can be either a *Compiler* or an *Interpreter*.

Compilers translate high-level language written programs all at once into machine language. The machine language is then executed by the computer. Examples of programming languages that use compilers are C, C++, Java, and C#.

Interpreters, on the other hand, translate and execute programs a statement at a time. They don't translate the whole program together as do compilers. Examples of programming languages that use interpreters include Python, Perl, and Ruby.

6.1.2 Syntax and Semantics

Like any human language, all programming languages have **syntax** and **semantics**. Syntax refers to the rules of the programming language. It defines the structure or grammar of the language that programs should strictly follow. The semantics of a programming language, on the other hand, is related to the meaning of elements of a program and what they do.

A program must be written with the correct syntax dictated by the programming language for the program to be executed by the computer. If a program violates any of the syntax rules of a language, the compiler or the interpreter produces an error message. Such type of error is known as a *syntax error*.

A program can have no syntax error and get executed properly but can still behave in a way different from what it is intended to. This kind of error is known as *logic error* and is associated with the semantics of a language. Since compilers or interpreters do not catch logic errors, they are far more difficult to identify and fix than syntax errors.

Links

See Section 6.2 for practical examples of syntax and logic errors.

Activity 6.1

1. Compare and contrast the three types of programming languages.
2. Why are logic errors more difficult to fix than syntax errors?

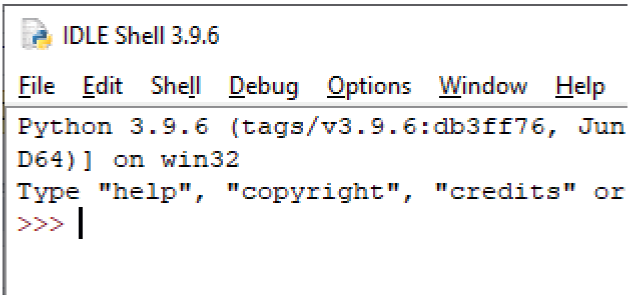
6.2. Basics of Python

Python is one of the popular high-level programming languages in use today. It is widely considered a much easier language to learn. This is one of the main reasons why it is a widely chosen language for teaching programming to those who are new to programming.

Python has a free integrated development environment known as IDLE. IDLE stands for Integrated Development and Learning Environment. To write Python codes, the *interactive interpreter* or the *text editor* of the IDLE can be used. The interactive interpreter is used to write one line of Python code at a time and is less convenient to write and execute a large number of codes. Using the text editor, however, any number of codes can be written and get executed with a single command.

6.2.1 Using the Interactive Interpreter

The Interactive Interpreter contains a *Python shell*, which is a textual user interface used to work with the Python language. The Interactive Interpreter is displayed when the IDLE is opened. Figure 6.1 shows the Interactive Interpreter.



```
Python 3.9.6 (tags/v3.9.6:db3ff76, Jun
D64)] on win32
Type "help", "copyright", "credits" or
>>> 
```

Figure 6.1 IDLE Interactive Interpreter

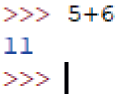
Links

See Section 6.4 to learn about expressions in Python.

Notes

- The >>> is where codes are written and is called the *prompt*. After a user writes a code and presses the enter key, the prompt (>>>) reappears for the user to write the next code.

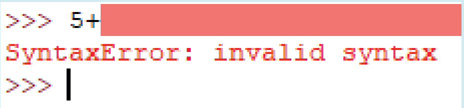
The following example demonstrates what the Interactive Interpreter does when the enter key is pressed after a simple *expression* is written.



```
>>> 5+6
11
>>> 
```

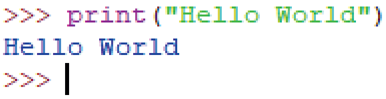
Notes

- 5+6 is a syntactically valid expression that evaluates to 11. Therefore, the Python interpreter evaluated the expression and displayed 11. If, for example, a syntactically invalid expression like 5+ is given, the interpreter generates the following syntax error:



```
>>> 5+
SyntaxError: invalid syntax
>>> 
```

To display something on the screen, the print() function is used in Python. The following example shows how a string is displayed using the print() function.



```
>>> print("Hello World")
Hello World
>>> 
```

Notes

- Note that the IDLE uses different types of colors for the different elements of a Python code to make them easily distinguishable. By default, outputs are displayed in blue color; functions are displayed in purple color, and strings are displayed in green color. A string is a sequence of characters placed under quotation marks such as "Hello World" as can be seen in the above example. See Table 6.1 for more on strings and operators in Python.

Links

See Section 6.5 for more on the print() function.

Activity 6.2

- Use the print() function and display your full name on the screen using the interactive interpreter.

6.2.2 Using the Text Editor

Python codes can be written in a file using the text editor of Python's IDLE. The code that is kept in such files is known as a script. A file that keeps Python scripts is saved with the .py extension and is called a script file.

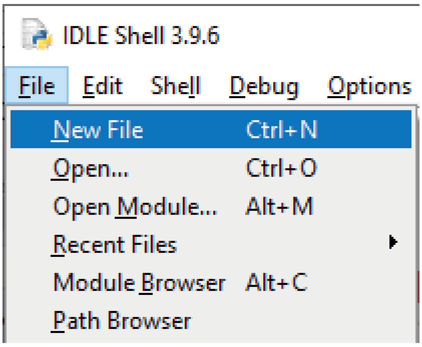

IDLE Shell 3.9.6
File Edit Shell Debug Options
New File Ctrl+N
Open... Ctrl+O
Open Module... Alt+M
Recent Files
Module Browser Alt+C
Path Browser

Figure 6.2 Opening a Text Editor

A script file can be easily created by selecting "New File" from the "File" menu in the IDLE's interactive interpreter as shown in Figure 6.2. Then the text editor is opened in a separate window, and it looks something like what is shown in Figure 6.3.

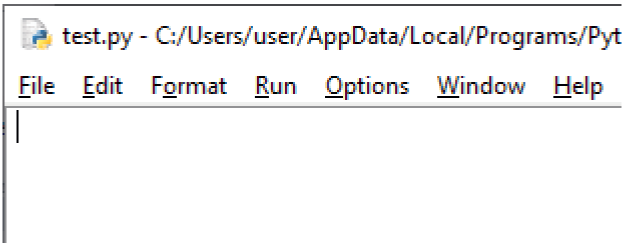
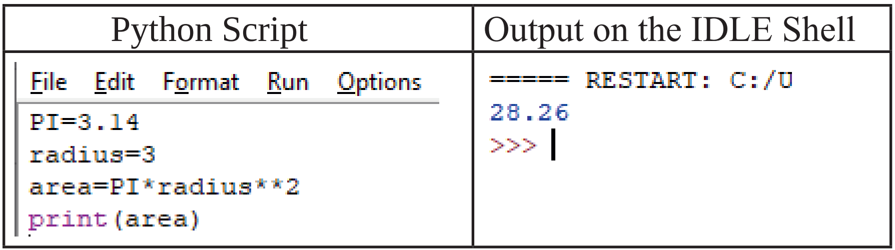

test.py - C:/Users/user/AppData/Local/Programs/Pyt
File Edit Format Run Options Window Help

Figure 6.3 Python IDLE's Text Editor

Notes

- Note that the prompt (>>>) is not shown in the text editor. The >>> appears only when code is written in the interactive interpreter, not in the text editor. While only one line of code is written and executed in the interactive interpreter, as many lines of code as required can be written in the text editor.

The example shown in figure 6.4 is a script that calculates and displays the area of a circle for a given radius value of 3. Before the script is run/executed, the script has to be saved with the .py extension by selecting the "save" option from the "file" menu in the text editor. To execute the script, the "Run Module" option from the "Run" Menu should be selected. After the script is executed, the output is displayed in the IDLE shell/interactive interpreter in a format as shown in the figure below.



Python Script

```
PI=3.14
radius=3
area=PI*radius**2
print(area)
```

Output on the IDLE Shell

```
===== RESTART: C:/U
28.26
>>> 
```

Figure 6.4 Running a script file

Notes

Note the following points from the script shown above:

- There are four statements in the script. However, the script is executed with a single command.
- There is no prompt (>>>) in the script. The prompt is shown only in the interactive interpreter.
- Though there are four statements in the script, only one output is shown in the IDLE shell. This is because it is only the last statement that produces an output.
- The output of a script written in the text editor is shown in the IDLE shell or the interactive interpreter.

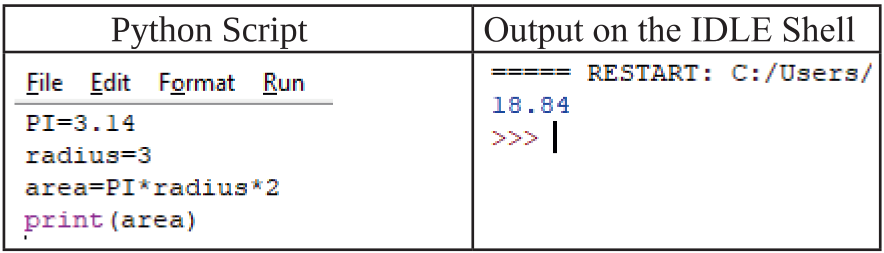
Links

The * is multiplication operator in Python and ** is exponentiation operator. Operators are discussed in section 6.3

Links

See section 6.4 to learn about statements in Python.

The example in Figure 6.5 demonstrates a logic error that is related to the semantics of programming languages.



Python Script

```
PI=3.14
radius=3
area=PI*radius*2
print(area)
```

Output on the IDLE Shell

```
===== RESTART: C:/Users/
18.84
>>> 
```

Figure 6.5 Logic error

Notes

- Note that the area of a circle in the above example in Figure 6.5 is incorrectly calculated as “area=PI*radius*2”. The correct formula for the area of a circle is “area=PI*radius**2”. However, the interpreter did not generate any error and simply displayed the incorrect output. This is a **logic error**: even though the program does not have any syntax error, it does not produce the intended correct output.
- The * symbol serves as a multiplication operator in Python. Table 6.1 of this chapter has a list of operators in Python and examples of how they are used.

Activity 6.3

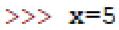
1. What is the difference between Python’s interactive interpreter and text editor?
2. Use the print() function to display your full name on the screen using the text editor.

6.3. Variables and Data Types

6.3.1 Variables

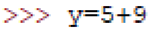
Variables are computer memory locations. They are the means to store data in computer memory. A variable is used every time user data or intermediary data is needed to be kept.

In Python, a variable is created along with its value. Values are assigned to variables using the assignment (=) operator, which has two operands. The operand to the left of the operator is always a variable while the operand to the right of the operator is either a literal value or any other type of expression. The following example demonstrates how a variable named “x” is created with the value 5 in the interactive interpreter.



```
>>> x=5
```

The example that follows shows how a variable named “y” is created and assigned to the result of an expression. The value of “y” would be the sum of 5 and 9, which is 14.

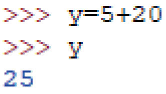


```
>>> y=5+9
```

Links

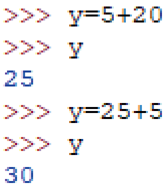
See section 6.4 to learn about expressions in Python.

To see the current value of a variable, you can simply type the name of the variable and press the enter key in the interactive interpreter. The value will then be displayed as shown in the following example.



```
>>> y=5+20
>>> y
25
```

The value 25 that is shown in blue color is the value of the variable y. Moreover, a variable can be assigned to another value than the one it was previously assigned to. The following example shows how the value of y is changed from 25 to 30.



```
>>> y=5+20
>>> y
25
>>> y=25+5
>>> y
30
```

6.3.2 Identifier

The name that is given to variables is called an *identifier*. Identifiers are a string of one or more characters and have to conform to some rules in Python to be considered valid. The rules of identifiers are:

- The first character should be either a letter or an underscore (_).
- If the identifier is made up of more than one character, the characters after the first one should be a letter, number, or underscore.
- An identifier cannot be the same as any of the *keywords* in Python. See Figure 6.6 for a list of keywords in Python.
- Identifiers are case-sensitive. (For instance, x and X are considered as different identifiers in Python)

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

Figure 6.6 Keywords in Python

Notes

- **Keywords** are reserved words that have predefined meanings in a programming language.

According to the above rule, the following are valid identifiers:

```
X
area
area_5
x5
```

The identifiers given below, on the other hand, are not valid identifiers as they violate the rules stated above.

```
1x
*_5
while
X_&
```

Notes

- The first two identifiers begin with a character that is not allowed. The third identifier used the name that is considered a keyword in Python. The last identifier is invalid because its last character is not allowed to be used in identifiers.

Although meeting the above requirements suffices to define a valid identifier, it is always recommended to use identifiers that are self-descriptive. Self-descriptive identifiers are names that express what they are intended to be used for. Using such types of identifiers makes programs more understandable and clearer.

Activity 6.4

- Identify the valid identifiers and explain why they are so.
  - a. x
  - b. 1x
  - c. _x
  - d. x*y

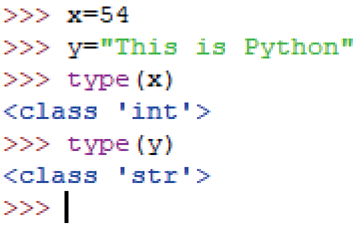
6.3.3 Data Types

A data type is a classification that specifies the type of values a variable can have, and the type of operations defined on the values. Integer (int), floating-point number (float), string (str), and Boolean (bool) are some of the major built-in data types in Python.

Notes

- **Floating point numbers** are numbers with decimal points that represent real numbers. See Table 6.1 for more on Python operators.
- **Built-in data types** are data types that are built into the Python language.

The data type of variables in Python is set when values are assigned to the variables. If an integer number is assigned to a variable, the variable will be of type int. If a string is assigned to a variable, the variable then will be of type str. The following example in the interactive interpreter shows how data types are set to variables based on the value assigned to the variables.



```
>>> x=54
>>> y="This is Python"
>>> type(x)
<class 'int'>
>>> type(y)
<class 'str'>
>>> 
```

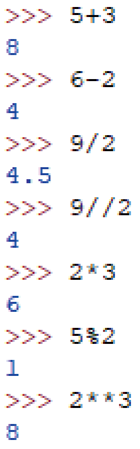
Notes

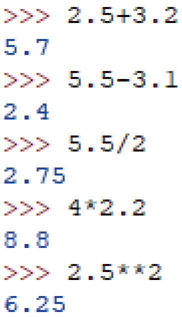
- As you can see in the above example, string values should be placed in quotation marks.
- To learn the data type of a particular variable, the type() function can be used. Simply write type(variable_name) and press enter. The interactive interpreter displays the data type of the variable as shown above. In the above example, the data type of the variable x is **int** while the data type of the variable y is **str**.

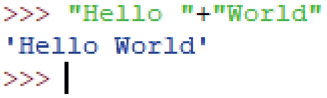
The four major built-in data types in Python and their descriptions are given in Table 6.1. The table also contains the various types of operators that apply to the respective data types with examples of how the operators are used.

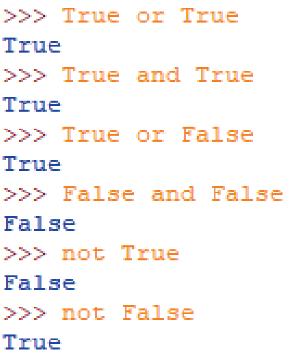
Table 6.1 Data types

Data Type	Meanings and sample values	Associated operators	Sample expressions

Int	Integer numbers
	Example:
	34
	4
	56
	10
		Arithmetic operators
		• Addition (+)
		• Subtraction (-)
		• Division (/)
		• Floor Division (//)
		• Multiplication (*)
		• Modulus (%)
		• Exponentiation (**)
			
			`>>> 5+3`
			`8`
			`>>> 6-2`
			`4`
			`>>> 9/2`
			`4.5`
			`>>> 9//2`
			`4`
			`>>> 2*3`
			`6`
			`>>> 5%2`
			`1`
			`>>> 2**3`
			`8`

float	Floating-point numbers.
	Example:
	4.5
	10.6
	100.0
		Arithmetic operators
		• Addition (+)
		• Subtraction (-)
		• Division (/)
		• Multiplication (*)
		• Exponentiation (**)
			
			`>>> 2.5+3.2`
			`5.7`
			`>>> 5.5-3.1`
			`2.4`
			`>>> 5.5/2`
			`2.75`
			`>>> 4*2.2`
			`8.8`
			`>>> 2.5**2`
			`6.25`

Str	A sequence of characters enclosed in a double quotation.
	Example:
	"Hello world"
		Concatenation (+)	
			`>>> "Hello "+"World"`
			`'Hello World'`
			`>>>`

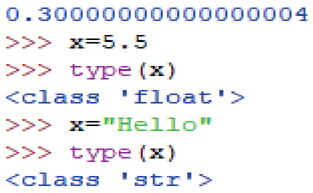
Bool	True or False values.
	Example:
	True
	False
		Boolean operators
		• and
		• or
		• not
			
			`>>> True or True`
			`True`
			`>>> True and True`
			`True`
			`>>> True or False`
			`True`
			`>>> False and False`
			`False`
			`>>> not True`
			`False`
			`>>> not False`
			`True`

Notes

Note the following points on some of the operators listed in Table 6.1:

- The + operator behaves differently depending on the type of the operand. When the operands are integer or floating-point numbers, the operator serves as a normal addition operator known in mathematics. But when the operands are strings, the operator serves as a concatenation operator, which combines the strings given to it into one.
- The modulus (%) operator returns the remainder of the division of the left operand by the right one.
- The floor division also known as integer division (//) operator divides and returns only the integer value of the quotient. The division (/) operator, however, generates the exact division result including the fraction part if any.
- The exponentiation (**) operator raises the left operand to the power of the right operand.

Variables can be assigned to values of a different data type than the one they were previously assigned to. Therefore, the value of a variable, as well as its type, can be changed to something different from what it was first set to in Python. As you can see in the following example, the variable “x” is first assigned to a floating-point number. Then it is assigned to a string value ʺHelloʺ. The second assignment results in a change not only in the value but also in the data type of the variable.



```
0.30000000000000004
>>> x=5.5
>>> type(x)
<class 'float'>
>>> x="Hello"
>>> type(x)
<class 'str'>
```

Activity 6.5

- Write the results of the following expressions.

a. 10%2 ________________

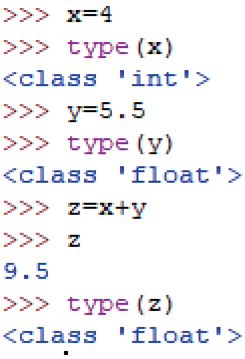
b. 2.5**3 ________________

c. 11//3 ________________

6.3.4 Data Type Conversion

Type conversion is the process of converting the value of one data type to another. Type conversion is of two types in Python: implicit conversion and explicit conversion.

Implicit conversion is a type of conversion in which Python does the conversion without the involvement of the programmer. This is usually done to avoid loss of data. See the following example.



```
>>> x=4
>>> type(x)
<class 'int'>
>>> y=5.5
>>> type(y)
<class 'float'>
>>> z=x+y
>>> z
9.5
>>> type(z)
<class 'float'>
```

Notes

Note the following points from the above example:

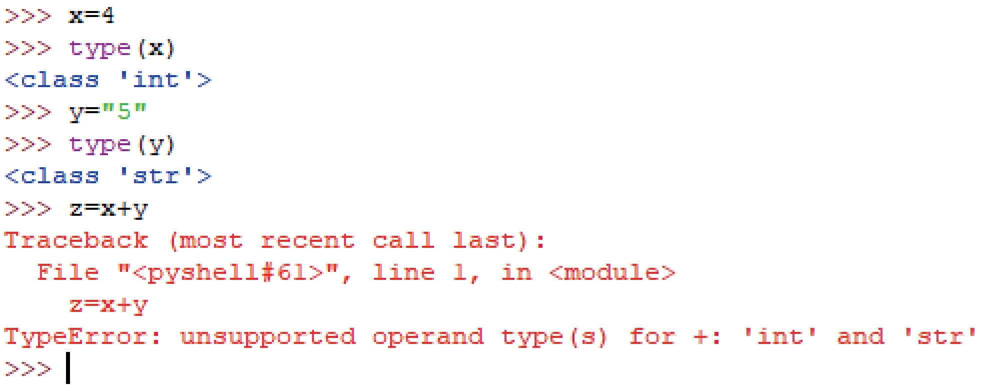
- The data types of x and y are int and float respectively as shown in the example.
- The variable z is assigned to the value of x+y, and its data type is automatically set to float. This is because Python always converts smaller data types (int in this case) to larger data types (float in this case) to avoid data loss. If the data type of z is set as int, the value that will be stored in it will not be the correct value.

Explicit conversion is a type of conversion of one data type to another that is done by the programmer. The predefined functions associated with the different kinds of data types such as int(), float(), and str() are used for explicit conversion.

The syntax for conversion is given as follows:

```
<required_dataType>([value])
```

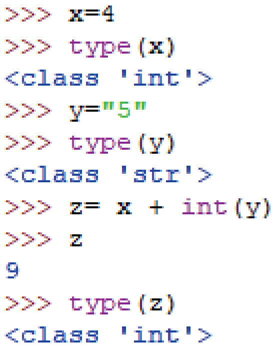
The following example demonstrates how Python responds to an attempt to add string and integer variables.



```
>>> x=4
>>> type(x)
<class 'int'>
>>> y="5"
>>> type(y)
<class 'str'>
>>> z=x+y
Traceback (most recent call last):
  File "<pyshell#61>", line 1, in <module>
    z=x+y
TypeError: unsupported operand type(s) for +: 'int' and 'str'
>>> 
```

Notes

- As shown in the above example, Python does not allow adding an integer number with a string. If the numbers stored in the integer and the string variables are to be added up, an explicit type conversion has to be used. See the following example to learn how the above error is avoided using explicit type conversion.



```
>>> x=4
>>> type(x)
<class 'int'>
>>> y="5"
>>> type(y)
<class 'str'>
>>> z= x + int(y)
>>> z
9
>>> type(z)
<class 'int'>
```

Notes

- As shown in the above example, the code did not generate any error this time. This is because explicit type conversion is used to convert the value of y to int type before it is added with the value of x.

Activity 6.6

- Write the expressions used to convert the value **1.5** into integer as well as string values?

6.4. Statements and Expressions

A **statement** is an instruction that the Python interpreter executes. As discussed in the introduction section, instructions are the orders or commands that the computer follows to do something. Assignment and print() statements are the two types of statements that are in some ways mentioned in the previous sections. An assignment statement, for instance, assigns value to a variable while a print() statement displays the value that is given to it. There are several other types of statements in Python including the "if" statement, "while" statement, and "for" statement, which are covered in the 12th Grade IT textbook.

The example in Figure 6.7 demonstrates the use of assignment and print() statements in Python.

Python Script	Output on the IDLE Shell

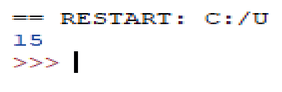
`x=5`
`y=10`
`print(x+y)`
	
	`== RESTART: C:/U`
	`15`
	`>>>`

Figure 6.7 Assignment and print() statements

Notes

- As you can see in the output in Figure 6.7, it is only the print statement that produces an output. The two assignment statements simply assign values to the variables and do not produce any output.

Expressions are what the Python interpreter evaluates to produce some value. An expression could be a simple literal value, a variable, or something more complex which is a combination of literals, variables, and operators.

Table 6.2 shows the three types of expressions, and how they are used in assignment and print() statements.

Table 6.2 Types of expressions

Literal value expressions	Variable expressions	Complex expressions
x=7 y=“Hello” z=5.5 print(“Python”)	x=y print(x)	x=4*(y-5) print(x+5)

Notes

- Note that the expressions in the above table are those encircled with red.

Using the print() and assignment statements, Figure 6.8 further shows the differences and relationships between statements and expressions in Python.

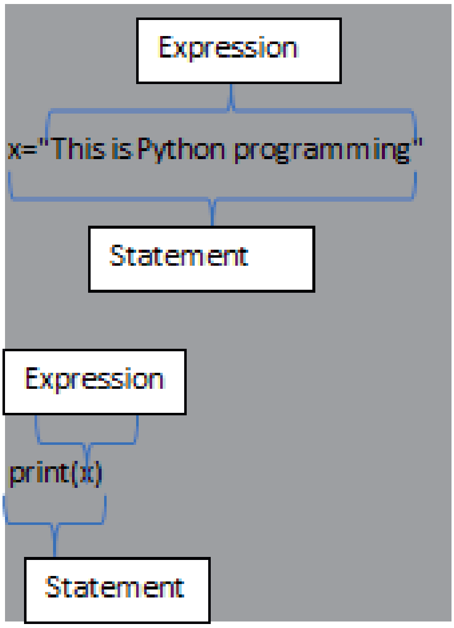
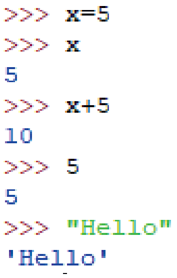


Figure 6.8 Statements and Expressions

If an expression is typed into the interactive interpreter, the Python interpreter evaluates and displays the value as shown in the following example.



```
>>> x=5
>>> x
5
>>> x+5
10
>>> 5
5
>>> "Hello"
'Hello'
```

Notes

- However, if any expression is written in the text editor, it will not be displayed unless it is put inside the parenthesis of a print() statement. Therefore, to see the value of expressions on the screen while using the text editor, the print() function has to be used.

Activity 6.7

1. What is the difference between statements and expressions in Python?
2. Identify the statements from the following list that produce outputs.

   x=4*3

   y="Programming in Python is fun"

   print(y)

   z=x/2

   print(z)

   y=10

   print(type(x))

3. When the code given in activity #2 is executed, what would be the output on the screen?

6.5. Writing a Simple Program

Programs normally accept input and process the input to produce an output. As shown in the preceding sections, the print() function is used to produce output on the IDLE shell. As shown in multiple examples in the preceding sections, the print() function has the following syntax:

```
print([value])
```

A **function** is a piece of code that performs some task and is called by its name. It can be passed data as input to operate on, and can optionally return data as output. print(), input() and type() are examples of functions.

In the above syntax, the name of the function is print. The value that is given to the print() function as input can be any type of expression that evaluates to some value.

See the example in Figure 6.9 for the different types of values that the print() function can take as input.

Notes

- A **function** is a piece of code that performs some task and is called by its name. It can be passed data as input to operate on, and can optionally return data as output. print(), input() and type() are examples of functions.
- In the above syntax, the name of the function is print. The value that is given to the print() function as input can be any type of expression that evaluates to some value.
- See the example in Figure 6.9 for the different types of values that the print() function can take as input.

Python script	Output on the IDLE Shell

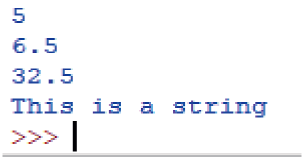
`x=6.5`
`print(5)`
`print(x)`
`print(x*5)`
`print("This is a string")`
	
	5
	6.5
	32.5
	This is a string
	>>>

Figure 6.9 Inputs of the print() function

To accept input from the keyboard, the input() function is used. The input() function has the following syntax.

```
variable_name=input([prompt])
```

Notes

The following points are important to understand how the input() function works:

- The prompt that is given as input to the input() function is a string that tells the user what kind of value the user is expected to enter. Example "Enter an integer number"
- After the user enters a value and presses the enter key, the input() function returns the value the user entered as str type. This means that irrespective of the type of value that the user enters, the value that the input() function returns is of str type. Therefore, if the value that is required is of another type, the str type should be converted to the required type.

Example:

```
x=input("Enter an integer number")
x=int(x)
```

- The value the input() function returns should be assigned to a variable. This indicates that when the input() function is used, it is used as an expression in an assignment statement.

Activity 6.8

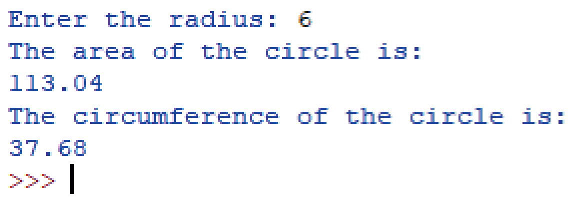
- Write a program in the text editor that has the following elements:
    - Accept the name, age, and Body Mass Index (BMI) of a person from the keyboard using the input() function,
    - Convert the values to their appropriate data type , and
    - Display the values using the print() function.

The following example demonstrates how the input() and the print() functions are used in a program. It shows how the input() function is used to accept data from the keyboard, and how the print() function is used to display the result on the screen. The program simply accepts the radius of a circle from the user and displays the area and circumference of the circle.

Python Script

```
PI=3.14
x=input("Enter the radius:")
radius=float(x)
area=PI*radius**2
circumference=2*PI*radius
print("The area of the circle is:")
print(area)
print("The circumference of the circle is:")
print(circumference)
```

Output on the IDLE Shell



```
Enter the radius: 6
The area of the circle is:
113.04
The circumference of the circle is:
37.68
>>> 
```

Figure 6.10 Using input() and print() functions

Notes

The following points are important to note regarding the program shown in Figure 6.10:

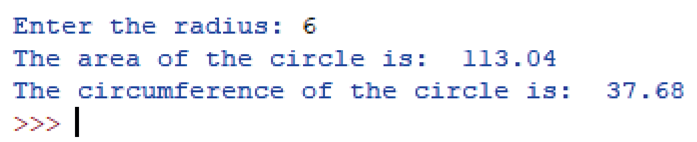
- The prompt given to the input() function should be written in a manner that helps the user clearly understand what to do.
- The data type of the value that is returned by the input() function is changed to float, which is the right data type for values like the radius of a circle.
- print() function displays its outputs in separate lines. Therefore, the strings and the values are displayed each on a separate line.

In the example shown in Figure 6.10, a print() function is used to display each output separately. However, if multiple values are required to be displayed in one line, the values should be given to the print() function with comma separation. See Figure 6.11 for the modified version of the program in Figure 6.10.

Python Script

```
PI=3.14
x=input("Enter the radius:")
radius=float(x)
area=PI*radius**2
circumference=2*PI*radius
print("The area of the circle is:", area)
print("The circumference of the circle is:", circumference)
```

Output on the IDLE Shell



```
Enter the radius: 6
The area of the circle is:  113.04
The circumference of the circle is:  37.68
>>> 
```

Figure 6.11 Displaying multiple values in one line

Notes

- As shown in Figure 6.11, the string literal values and the variables are given to the print() function with comma separation. As a result, the results are displayed in one line.

Activity 6.9

1. Write a program that accepts two numbers from the user and displays the product on the screen.
2. Write a program that displays the BMI of a person by accepting the weight and height from the keyboard.

Unit Summary

In this unit, you have learnt about:

- what is meant by a computer program
- the three types of programming languages, namely, machine language, assembly language, and high-level language
- translation software, such as Assembler, Compiler, and Interpreter
- the difference between compilers and interpreters
- the concept of syntax and semantics in programming languages, and the associated error types
- what the high-level programming language called Python is
- how to write Python scripts using the interactive interpreter and the text editor
- how to save Python script files and how to run the scripts
- the concept of variables and data types in Python
- valid and invalid identifiers
- the basic built-in data types
- assigning values to variables using an assignment operator
- operators, such as arithmetic operators (+, -, /, //, %, *, **), Boolean operators (and, or, not) and assignment operator (=)
- conversion of values from one data type to another using explicit and implicit type conversion methods
- the concept of statements and expressions in Python
- the differences and relationships between statements and expressions
- how to write a simple program by reading data from the keyboard using the input() function and displaying results using the print() function

Key Terms

Assembler is a software used to translate programs written in assembly language into machine language.

Assembly Language is a low-level programming language that uses symbols/ mnemonics.

Assignment Operator (=) is an operator used to assign values to variables.

Binary System is a system in which everything is represented in terms of 1s and 0s.

bool is a data type that represents True or False values.

Data type specifies the type of values a variable can have and the operations defined on the values.

Explicit type conversion is a data type conversion done by the programmer using built-in functions.

Expression is what the Python interpreter evaluates to a certain value.

float is a data type for floating-point numbers.

Floating Point Number is a number with a decimal point.

Function is a piece of code that performs some tasks.

High-level Language is a programming language closer to human language.

Identifier is the name of variables.

IDLE shell is the same as the interactive interpreter.

IDLE stands for Integrated Development and Learning Environment.

Implicit type conversion is a data type conversion done by Python without the involvement of the programmer.

int is a data type for integer values.

Keywords are reserved words that have predefined meanings in Python.

Machine Language is a low-level programming language that the computer understands directly.

Program is a set of instructions that commands the computer what to do.

Programmer is a professional who writes computer programs.

Programming Languages are computer languages used to write computer programs.

Python is a popular high-level programming language.

Python's Interactive Interpreter contains Python shell to write and execute Python codes one line at a time.

Python's Text Editor is a text editor to write unlimited lines of Python codes that can be saved.

Script file is a file with Python scripts.

Script is codes found in a file saved with .py extension.

Semantics is related to the meaning of elements of a program and what they do.

Statement is an instruction executed by the Python interpreter.

str is a data type for strings enclosed with a double/single quotation.

Syntax is the grammatical rules of a programming language.

Type conversion is the process of converting values from one data type to another.

Variable is a computer memory location used to store data.

Review Questions

Part I: Write True if the statment is correct and False if it is incorrect.

1. A program written in assembly language can be directly understood by the computer.
2. It is only high-level programming languages that have syntax and semantics.
3. Syntax errors are easier to fix than logic errors.
4. Python’s interactive interpreter can be used to execute multiple lines of codes at a time.
5. When Python’s text editor is opened, the prompt (>>>) immediately appears.
6. Once a variable is set to a specific data type, its type cannot be changed.
7. The results of the two expressions 5/2 and 5//2 are not the same.
8. In implicit type conversion, the programmer has to use built-in functions to convert values from one type to another.
9. The data type “bool” has only two possible values.
10. Expressions and statements are the same things in Python.

Part II: Match the items given under column B with associated items in column A

A

1. Rules of a language
2. A keyword such as str
3. Name of variables
4. That which is evaluated to some value
5. Meanings of elements of a language
6. 1s and 0s
7. Interface to work with Python language
8. Mnemonics
9. Translating the whole program
10. Translating one line at a time

B

a. Interpreter
b. Compiler
c. Machine Language
d. Assembly Language
e. Statement
f. Syntax
g. Operator
h. Semantics
i. IDLE shell
j. Identifier
k. Type conversion
l. Data type
m. Expression

Part III: Choose the correct answer from the given alternatives.

1. Which of the following programming languages is the one that is directly understood by the computer?

A. Assembly Language B. High-level language
C. Machine language D. Python

2. Which of the following is not an example of high-level programming languages?

A. C++ B. Java
C. Python D. None of the above

3. The operand on the left side of the assignment operator (=) is always:

A. A variable B. String value
C. Integer value D. An expression

4. Which of the following is a valid identifier?

   A. &_x B. _xs.
   C. 123 D. print

5. Identify the function that is not used for type conversion purposes.

   A. int() B. type()
   C. str() D. float()

Part IV: Fill in the blank spaces

1. A programming language that is an example of those that use compilers is ______________.
2. A special type of software used to translate assembly language programs into machine language is known as _______________.
3. A type of error related to violating the rules of a programming language is known as ________________.
4. A type of error related to the semantics of a programming language is known as _______________.
5. The extension with which Python script files are saved by is __________.

Part V: Code Writing

1. Using the print() function, write a program in the text editor that displays all of the subjects you are taking in the current semester each on a new line.
2. Write a program in the text editor that does the following:
    - a. Creates three variables with integer, floating-point number, and string values.
    - b. Displays their values and data types. (hint: use the type() function to know the data types)
3. Write a program in the text editor that does the following:
    - a. Creates a variable with one type of value.
    - b. Reassigns the variable to a different type of value.
    - c. Displays the data type of the variable before and after the reassignment.
4. Write a program in the text editor that converts the following two string values into floating-point numbers and displays their product on the screen.

   "4.5" "30.2"
5. Write a program that accepts two numbers from the user and displays the following:
    - a. The sum
    - b. The product
    - c. The average value