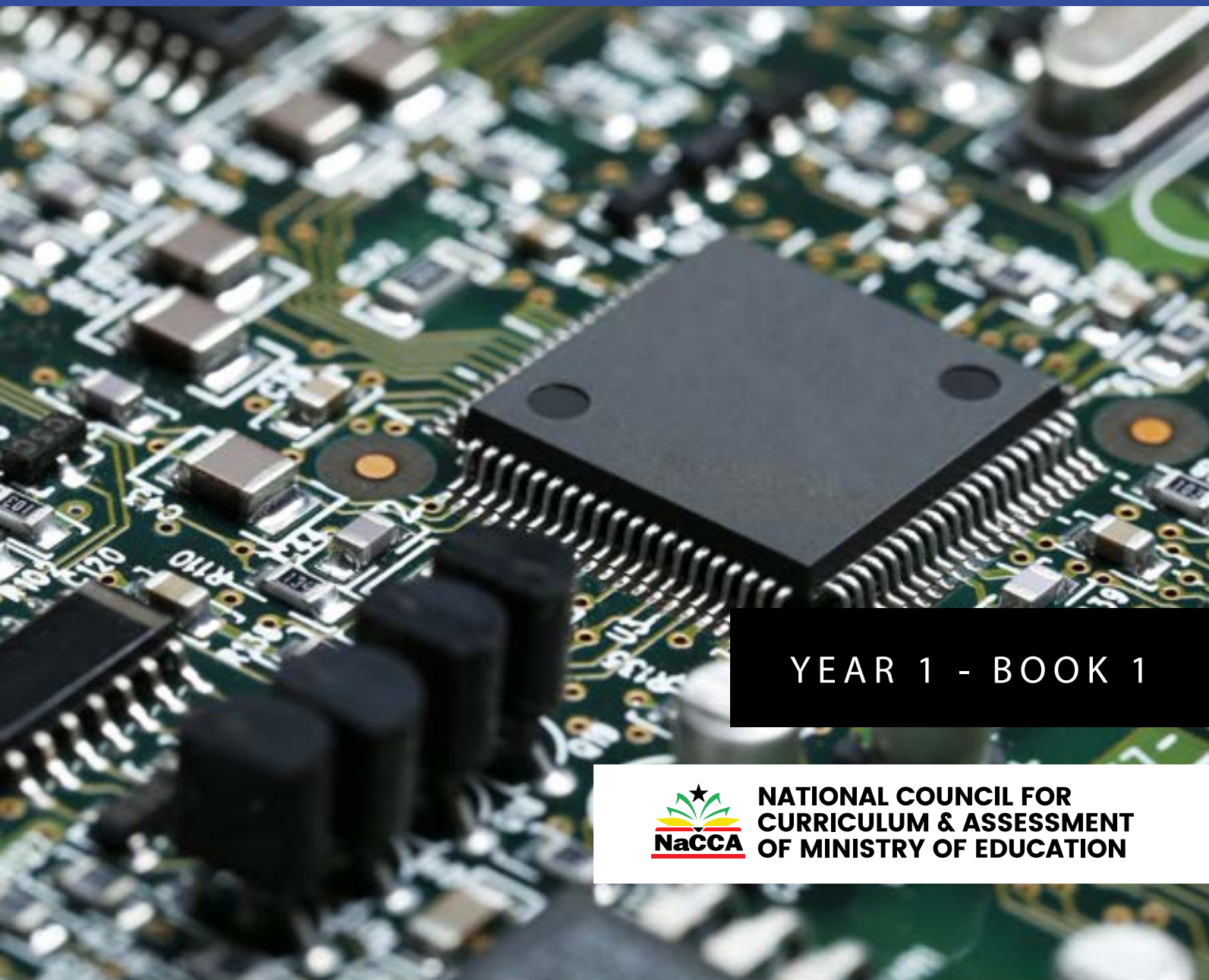
MINISTRY OF EDUCATION

# Computing

TEACHER MANUAL



YEAR 1 - BOOK 1

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

# MINISTRY OF EDUCATION

REPUBLIC OF GHANA

# Computing

## Teacher Manual

### Year One - Book One

NATIONAL COUNCIL FOR
CURRICULUM & ASSESSMENT
OF MINISTRY OF EDUCATION

**ART & DESIGN FOUNDATION TEACHERS MANUAL**

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# CONTENTS

# INTRODUCTION

The National Council for Curriculum and Assessment (NaCCA) has developed a new Senior High School (SHS), Senior High Technical School (SHTS) and Science, Technology, Engineering and Mathematics (STEM) Curriculum. It aims to ensure that all learners achieve their potential by equipping them with 21st Century skills, competencies, character qualities and shared Ghanaian values. This will prepare learners to live a responsible adult life, further their education and enter the world of work.

This is the first time that Ghana has developed an SHS Curriculum which focuses on national values, attempting to educate a generation of Ghanaian youth who are proud of our country and can contribute effectively to its development.

This Teacher Manual for Computing covers all aspects of the content, pedagogy, teaching and learning resources and assessment required to effectively teach Year One of the new curriculum. It contains this information for the first 12 weeks of Year One, with the remaining 12 weeks contained within Book Two. Teachers are therefore to use this Teacher Manual to develop their weekly Learning Plans as required by Ghana Education Service.

Some of the key features of the new curriculum are set out below.

## Learner-Centred Curriculum

The SHS, SHTS, and STEM curriculum places the learner at the center of teaching and learning by building on their existing life experiences, knowledge and understanding. Learners are actively involved in the knowledge-creation process, with the teacher acting as a facilitator. This involves using interactive and practical teaching and learning methods, as well as the learner's environment to make learning exciting and relatable. As an example, the new curriculum focuses on Ghanaian culture, Ghanaian history, and Ghanaian geography so that learners first understand their home and surroundings before extending their knowledge globally.

## Promoting Ghanaian Values

Shared Ghanaian values have been integrated into the curriculum to ensure that all young people understand what it means to be a responsible Ghanaian citizen. These values include truth, integrity, diversity, equity, self-directed learning, self-confidence, adaptability and resourcefulness, leadership and responsible citizenship.

## Integrating 21st Century Skills and Competencies

The SHS, SHTS, and STEM curriculum integrates 21st Century skills and competencies. These are:

- **Foundational Knowledge:** Literacy, Numeracy, Scientific Literacy, Information Communication and Digital Literacy, Financial Literacy and Entrepreneurship, Cultural Identity, Civic Literacy and Global Citizenship
- **Competencies:** Critical Thinking and Problem Solving, Innovation and Creativity, Collaboration and Communication
- **Character Qualities:** Discipline and Integrity, Self-Directed Learning, Self-Confidence, Adaptability and Resourcefulness, Leadership and Responsible Citizenship

## Balanced Approach to Assessment - not just Final External Examinations

The SHS, SHTS, and STEM curriculum promotes a balanced approach to assessment. It encourages varied and differentiated assessments such as project work, practical demonstration, performance assessment, skills-based assessment, class exercises, portfolios as well as end-of-term examinations and final external assessment examinations. Two levels of assessment are used. These are:

- Internal Assessment (30%) – Comprises formative (portfolios, performance and project work) and summative (end-of-term examinations) which will be recorded in a school-based transcript.
- External Assessment (70%) – Comprehensive summative assessment will be conducted by the West African Examinations Council (WAEC) through the WASSCE. The questions posed by WAEC will test critical thinking, communication and problem solving as well as knowledge, understanding and factual recall.

The split of external and internal assessment will remain at 70/30 as is currently the case. However, there will be far greater transparency and quality assurance of the 30% of marks which are school-based. This will be achieved through the introduction of a school-based transcript, setting out all marks which learners achieve from SHS 1 to SHS 3. This transcript will be presented to universities alongside the WASSCE certificate for tertiary admissions.

## An Inclusive and Responsive Curriculum

The SHS, SHTS, and STEM curriculum ensures no learner is left behind, and this is achieved through the following:

- Addressing the needs of all learners, including those requiring additional support or with special needs. The SHS, SHTS, and STEM curriculum includes learners with disabilities by adapting teaching and learning materials into accessible formats through technology and other measures to meet the needs of learners with disabilities.
- Incorporating strategies and measures, such as differentiation and adaptative pedagogies ensuring equitable access to resources and opportunities for all learners.
- Challenging traditional gender, cultural, or social stereotypes and encouraging all learners to achieve their true potential.
- Making provision for the needs of gifted and talented learners in schools.

## Social and Emotional Learning

Social and emotional learning skills have also been integrated into the curriculum to help learners to develop and acquire skills, attitudes, and knowledge essential for understanding and managing their emotions, building healthy relationships and making responsible decisions.

## Philosophy and vision for each subject

Each subject now has its own philosophy and vision, which sets out why the subject is being taught and how it will contribute to national development. The Philosophy and Vision for Computing is:

**Philosophy:** The next generation of ethical creators and developers of technology can be empowered through observation, curiosity, exposure to related computing concepts and opportunities that leverage hands-on activities in a learner-centred environment leading to local and global relevance.

**Vision:** To prepare learners with 21st Century skills and competencies to ethically design, develop and apply computing systems to solve real-world problems.

# ACKNOWLEDGEMENTS

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# SCOPE AND SEQUENCE

**Computing Summary**

| S/N | STRAND | SUB-STRAND | SENIOR HIGH SCHOOL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YEAR 1 | | | YEAR 2 | | | YEAR 3 | | |
| | | | CS | LO | LI | CS | LO | LI | CS | LO | LI |
| 1 | Computer Architecture and Organisation | Data Storage and Manipulation | 1 | 1 | 4 | 1 | 1 | 3 | 1 | 1 | 3 |
| | | Computer Hardware and Software | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 |
| | | Data Communication and Network Systems | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 3 |
| 2 | Computational Thinking (Programming Logic) | Algorithm and Data Structure | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 |
| | | App Development | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 |
| | | Web Technologies and Databases | 1 | 1 | 2 | 1 | 1 | 4 | 1 | 1 | 2 |
| **Total** | | | **6** | **6** | **15** | **6** | **6** | **16** | **6** | 6 | **14** |

**Overall Totals (SHS 1 – 3)**

| | |
|---|---|
| **Content Standards** | **18** |
| **Learning Outcomes** | **18** |
| **Learning Indicators** | **45** |

# SECTION 1: COMPUTER SYSTEMS A – Data Representation and Computer Structure

**STRAND: Computer Architecture and Organisation**

**Sub-Strand:** Data Storage and Manipulation

**Content Standard 1.1.1.CS.1:** *Demonstrate knowledge and understanding of data representation and Data Manipulation*

**Learning Outcome 1.1.1.LO.1:** *Apply Computer Architecture concepts related to the design of modern processors, memories, Input and Output to manipulate data.*

## INTRODUCTION AND SUMMARY OF SECTION

In this section, learners are required to study computer architecture and organisation, focusing on data representation as sequences of bits, how the bits are stored and manipulation by the computer. The teacher is expected to guide learners in investigating the working of different hardware as data is input and processed, and information (processed data) is output.

By the end of this section, learners should be able to describe how binary sequences are used to represent different types of data. As well as demonstrating an understanding of data representation, the learners should be able to demonstrate an understanding of bit storage and manipulation by a computer system. The goal is for learners to comprehend how modern processors, memories, and input, output and communication hardware devices work together to handle data effectively. Note that when researching the machine cycle teachers and learners will find that it is the Full-Disk Encryption (FDE) cycle that is more commonly detailed on the internet.

Learners' mastery of this content will enable them to comprehend and utilise various methods of data representation and manipulation, which are essential skills in the field of computer science and technology.

This section runs through from week 1 to week 4 to enable a comprehensive understanding of data storage and data manipulation by a computer system. The breakdown of the weekly learning indicators is as follows:

**Week 1:** Data as Bit Patterns

**Week 2:** Apply knowledge of Browser Cache to solve runtime issues (e.g. opening browsers).

**Week 3:** Describe the functions of the parts of the CPU: ALU, CU and registers

**Week 4:** Understand and explain the control bus, address bus, data bus and the internal clock, Machine Cycle/Fetch–Decode–Execute-Store Cycle, instruction set for a CPU and describe embedded systems.

## SUMMARY OF PEDAGOGICAL EXEMPLARS:

In this section, it is recommended that the teacher uses "Intro-Tag" for introductions, where learners write their names on pieces of paper tape and stick it to their clothes. This helps the teacher learn their names since it is their first meeting. The class then discusses career goals in Computer Science, aiding the teacher in guiding the future learning paths of the students.

When introducing focal areas, the teacher should explore a range of strategies. For example, passing around an old RAM module to the learners when introducing computer memory, whenever possible, the teachers should give a 'real world' context to the topics being studied. Team teaching to support the teaching of the focal areas is encouraged (such as teaming up with teachers from the Mathematics and Physics Departments when teaching the binary number system and logic gates respectively). This integrative approach provides learners with a learning environment that helps them make connections across curricula.

Many of the lessons in this section will include direct instructions using visual aids to explain the concepts being taught. Collaborative learning in mixed-ability groups (including peer teaching) should be encouraged, where appropriate. Reflective learning will be valuable, whether done independently by the learner, a shared peer activity or a one-on-one between the teacher and learner. All teachers nowadays need to develop a digital pedagogy and, of course, this is particularly important in the computing classroom where the teacher will be teaching the learners not just how to be digital users but how to be digital creators.

The teacher can differentiate any lesson by changing one or more of the elements: content, process and product. The content involves the curriculum, the information learned, the standards and skills being taught. The process is how students learn this content. And the product is what is produced by students, how they show their learning. Content differentiation is addressed through tasks in the key concept notes, and process differentiation will be found in the pedagogy notes. Teachers may choose to label the tasks/activities as AP (Approaching Proficiency), P (Proficient) and HP (Highly Proficient) to suit their learners' support access to the curriculum across a range of abilities.

Plenaries should be used by the teacher at the start or at the end of a lesson, to review and consolidate the students' learning.

## SUMMARY OF ASSESSMENT

In this section, Depth of Knowledge (DOK) is employed in the assessment of students to enhance the quality, validity, and fairness of assessments while promoting deeper learning and critical thinking skills. The DOK levels are used to ensure that assessments accurately measure learner's mastery of content and provide insights for instructional planning and support. Product differentiation is exemplified in the Key Assessments (KA) which reflect the DOK levels. Teachers are required to use the weekly tasks and assessment exemplars as a guide to make formative and summative assessments that examine the focal areas at the beginning of the computer systems sections, 'Data Representation and Computer Structure'.

**NB:** It is important to note that the test items in this manual are only to serve as a guide for the teacher to establish learners' understanding of the topics taught. They do not in any way limit the teacher from exploring and creating their own questions and tasks.

# WEEK 1

**Learning Indicator** 1.1.1. LI.1: Describe Data as Bit Patterns

## Theme/Focal Area:

**Explain how data is represented in a computer system**

*Note the use of the word 'data' in the LI instead of 'information' as given in the Computing Curriculum. These two terms are not interchangeable. Information = processed data or information = data + structure + context. 'Data' is the correct term and 'information' should not be used in this LI.*

## KEY CONCEPT NOTES

### Data as Bit Pattern Representations

Imagine bits as the smallest pieces of data in the digital world. Like letters from the alphabet put together (e.g.: h-e-l-l-o) to form an information (hello).

Inside today's computers, all data is encoded (represented) in the form of 0s and 1s. These digits are called bits, which stands for binary digits. Bits are the basic language of computers (Just like how alphabets are the basis for any language), telling the computers what to do and how to represent data. Patterns of bits combine to represent characters in alphabets, numeric values, images and sound.

A bit is the smallest unit of data in computing or the digital world which are only in two distinct states either "0" or "1". Where the "0" often signifies as "Off" or "False" and the "1" signifies as "On" or True" as in Figure 1.1.


***Figure 1.*** *1 Code of bits*

Eight contiguous bits make one byte (8 bits = 1 byte).

Representing data as bit patterns is a fundamental concept in digital computing. It involves using sequences of 0s and 1s (bits) to encode different types of data. For example, the wall socket switch below has the code (on and off) and could be represented by one bit (0 or 1).

A series of 0s and 1s is known as a bit pattern.

**Video:** What are binary numbers? | James May's Q&A (Ep 11100) - YouTube 5 mins

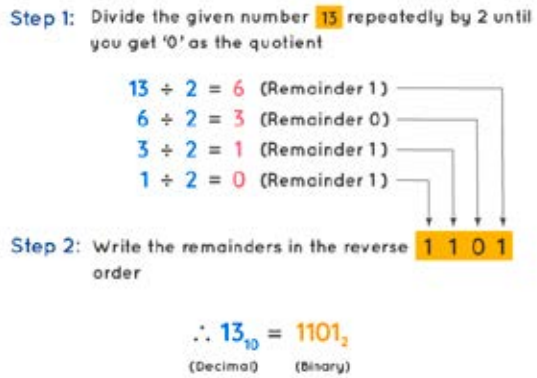
## 1. Numeric Representation

In binary numbers, the place values for each digit goes up in 2's, going from right to left. For example, the first five place values are:

$$\overline{2^4} \quad \overline{2^3} \quad \overline{2^2} \quad \overline{2^1} \quad \overline{2^0}$$

### *a). Decimal to Binary*

Decimal numbers can be represented in binary (base-2) notation. In the example below, the working of converting 13 to binary is shown.




In a similar way the binary representations of 7 and 169 could be calculated to give 111 and 10101001 respectively. Leading zeros can be added to make a byte (8 bits), as shown in Table 1.

| Decimal | Binary (8 bits) |
|---|---|
| 0 | 00000000 |
| 1 | 00000001 |
| 2 | 00000010 |
| 3 | 00000011 |
| 4 | 00000100 |
| 5 | 00000101 |
| 6 | 00000110 |
| 7 | 00000111 |
| 8 | 00001000 |
| 9 | 00001001 |

***Table 1.:*** *The 8-bit representation of numbers 0 to 9*

### *b). Binary to Decimal*

When converting from binary to decimal, the sum of the product of each digit and its place value is calculated. The worked example below shows that the binary number 10110 equals the decimal number 22.

$$\frac{1}{2^4} \qquad \frac{0}{2^3} \qquad \frac{1}{2^2} \qquad \frac{1}{2^1} \qquad \frac{0}{2^0}$$

$$(1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) = 16 + 0 + 4 + 2 + 0 = 22$$

## 2. Text Representation

Text characters are represented using standard character encoding schemes such as ASCII (American Standard Code for Information Interchange) and Unicode.

Standard ASCII uses a 7-bit code to represent 128 characters. These include 95 printable characters, like letters (A-Z, a-z), digits (0-9), and symbols, along with 33 non-printable characters for things like formatting and control (e.g., carriage return, line feed).

The Extended ASCII character set utilizes an 8-bit code to represent a wider range of characters. With 8 bits, Extended ASCII can accommodate an additional 128 characters and symbols. Extended ASCII is assumed when ASCII is mentioned for the remainder of these notes.

ASCII is a standard that allows computers to understand and communicate with each other. In ASCII, each letter, number, and symbol has its own unique code. For example, the letter "A" is represented by the binary number 01000001 (65), while "a" is represented by the binary number 1100001 (97). This system helps computers know what characters to display on the screen or how to store them in memory. So, when you type a letter on your keyboard, the computer translates it into its corresponding ASCII code to understand what you are saying. ASCII makes it possible for computers to communicate with each other and makes it easy for us to also interact with them through the text we type.

Another method of encoding scheme is the Unicode, which is a more recent standard, developed to overcome the limitations of ASCII by assigning 16-bits per character. Extended ASCII is a subset of Unicode (i.e. comprising its first 256 characters). Unicode aims to provide a unique number for every character, regardless of the platform, program, or language, supporting a global standard for text representation.

Sometimes an ASCII table can also show the hexadecimal and octal equivalent of the binary ASCII code as shown in the ASCII table extract in Figure 1.2.

| Decimal | Hexadecimal | Binary | Octal | Char |
|---|---|---|---|---|
| 48 | 30 | 110000 | 60 | 0 |
| 49 | 31 | 110001 | 61 | 1 |
| 50 | 32 | 110010 | 62 | 2 |
| 51 | 33 | 110011 | 63 | 3 |
| 52 | 34 | 110100 | 64 | 4 |
| 53 | 35 | 110101 | 65 | 5 |
| 54 | 36 | 110110 | 66 | 6 |
| 55 | 37 | 110111 | 67 | 7 |
| 56 | 38 | 111000 | 70 | 8 |
| 57 | 39 | 111001 | 71 | 9 |
| 58 | 3A | 111010 | 72 | : |
| 59 | 3B | 111011 | 73 | ; |
| 60 | 3C | 111100 | 74 | < |
| 61 | 3D | 111101 | 75 | = |
| 62 | 3E | 111110 | 76 | > |
| 63 | 3F | 111111 | 77 | ? |
| 64 | 40 | 1000000 | 100 | @ |
| 65 | 41 | 1000001 | 101 | A |
| 66 | 42 | 1000010 | 102 | B |
| 67 | 43 | 1000011 | 103 | C |
| 68 | 44 | 1000100 | 104 | D |

***Figure 1.2:*** *Extract from an ASCII table*

The ASCII binary codes for text characters are shown in Figure 1.3.

| ASCII - Binary Character Table | | | | | |
|---|---|---|---|---|---|
| Letter | ASCII Code (in decimal form) | ASCII Code (Binary) | Letter | ASCII Code | Binary |
| a | 097 | 01100001 | A | 065 | 01000001 |
| b | 098 | 01100010 | B | 066 | 01000010 |
| c | 099 | 01100011 | C | 067 | 01000011 |
| d | 100 | 01100100 | D | 068 | 01000100 |
| e | 101 | 01100101 | E | 069 | 01000101 |
| f | 102 | 01100110 | F | 070 | 01000110 |
| g | 103 | 01100111 | G | 071 | 01000111 |
| h | 104 | 01101000 | H | 072 | 01001000 |
| i | 105 | 01101001 | I | 073 | 01001001 |
| j | 106 | 01101010 | J | 074 | 01001010 |
| k | 107 | 01101011 | K | 075 | 01001011 |
| l | 108 | 01101100 | L | 076 | 01001100 |
| m | 109 | 01101101 | M | 077 | 01001101 |
| n | 110 | 01101110 | N | 078 | 01001110 |
| o | 111 | 01101111 | O | 079 | 01001111 |
| p | 112 | 01110000 | P | 080 | 01010000 |
| q | 113 | 01110001 | Q | 081 | 01010001 |
| r | 114 | 01110010 | R | 082 | 01010010 |
| s | 115 | 01110011 | S | 083 | 01010011 |
| t | 116 | 01110100 | T | 084 | 01010100 |
| u | 117 | 01110101 | U | 085 | 01010101 |
| v | 118 | 01110110 | V | 086 | 01010110 |
| w | 119 | 01110111 | W | 087 | 01010111 |
| x | 120 | 01111000 | X | 088 | 01011000 |
| y | 121 | 01111001 | Y | 089 | 01011001 |
| z | 122 | 01111010 | Z | 090 | 01011010 |

***Figure 1.3:*** *ASCII-Binary character code set*

### 3. Image Representation

A pixel is the smallest unit of a digital image or display. One way of thinking of an image to be displayed and stored by a computer is as lots of pixels. We then give each pixel a binary code to show its colour. When we put all these binary codes together, we get what is called a *bitmap,* which is an array/grid of binary data representing the colour values of pixels in an image or display. This method of the representation of an image by computers is called bitmapped graphics.

WithWith bitmapped graphics, if only 1 bit is used to represent each pixel, the binary code for each pixel is 1 or 0, giving 2 possible colours (such as black and white).

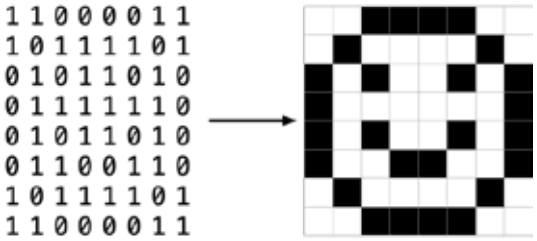



***Figure 1.4:*** *A Black and White Bitmap*

From the picture above, "1" is for "white" and "0" is for "black". If more bits are used to represent each pixel, then there are more combinations of binary numbers so more colours can be represented. For example, if two bits are assigned to each pixel, then four colours can be represented using the binary codes 00, 01, 10, and 11.

4. **Audio Representation:**

   One method of representing sound on a computer is digital audio. Digital audio is where sound is recorded as a sequence of samples, with each sample encoding the amplitude of the sound wave at a specific time. The amplitude value is represented using a series of bits.

5. **Video Representation**

   Digital videos are represented as a series of images (frames), where each frame is encoded using bit patterns to store the colour of each pixel in the frame. Videos are essentially a sequence of images played in rapid succession.

6. **File Representation**

   Files, such as documents, images, videos, and executables, are represented as collections of bits. The arrangement of these bits follows specific file formats, which dictate how the data should be interpreted and displayed.

   Examples of file formats: JPEG for pictures, DOC or DOCX for Word documents and XLS or XLSX for Excel spreadsheets.

7. **Data Transmission**

   When data is transmitted over networks, the binary representation of the data is broken up into same-sized pieces called packets for transmission and then reassembled back into its original form at the destination.

**Bit Patterns**

Representing data as bit patterns allows computers to process, store, and transmit data efficiently. The binary nature of computing enables the use of simple electronic circuits that can distinguish between two states (0 and 1). These bit patterns serve as the foundation of modern computing systems, enabling the vast array of applications and services we use in our digital world.

**Application of bit patterns in everyday life**

All the apps on your smartphone, be it for social media, navigation, or productivity, rely on bit patterns for their functionality and data representation. Every time you use your smartphone, tablet,

or computer, you are interacting with bit patterns. From browsing the web, to sending text messages, the digital data that powers these devices is stored and processed as bit patterns.

Bit patterns are at the core of the digital world, facilitating the efficient storage, processing, and communication of information in numerous aspects of our daily lives.

**Learning Tasks**

Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.

**Binary Numbers Conversion Tasks**

***For the whole class:***

1. The teacher can design a colouring activity where each colour is assigned a binary number. Learners colour a picture based on decimal numbers provided.

   Scan this QR code to see an example (Annex 1.pdf)

2. Play an activity ball game with the learners for the binary numbers' conversion. Write down a list of decimal numbers for the conversion (these varied numbers will cater for differentiation) and passing the activity ball to any learner randomly, the learner with the ball converts one of the decimal numbers of their choice in their books). A similar activity would be to have a hat containing numbers on paper, and learners pick random numbers to convert to binary.

   Use the answers of the learners to categorise the learners into proficiency levels and proceed to the differentiated tasks.

3. Play the online Cisco Binary Game on the data projector where the pupils take turns to be the leader and enter the binary/decimal answers. The game can be accessed at: https://learningcontent.cisco.com/games/binary/index.html. If resources allow, pupils can also access and play this game individually.

***For learners working independently or in small groups:***

4. Create flashcards with binary numbers on one side and their decimal equivalents on the other. Ask learners to think-pair and match items on the flashcards correctly.
5. Provide learners with a worksheet where they fill in missing binary or decimal numbers in a conversion table.
6. Create a quiz with true or false statements about binary and decimal conversion principles.
7. Give learners a list of binary numbers to convert to decimals and then a list of decimal numbers to binary numbers. Let learners order the binary numbers from smallest to largest.

8. In learners mixed-ability groupings, the teacher can ask learners to identify activities that can be represented as two states such as class attendance - present (1) or absent (0).
9. Pair learners up and organise a simple quiz competition where teams solve binary-to-decimal (and vice-versa) conversion problems at different stations.
10. Re-pair learners from the above activity to have them teach each other on the conversion they got wrong.
11. The teacher can design puzzles where learners use binary only to unlock clues and write the corresponding decimal number

    Scan this QR code to see an example (Annex 2.pdf)

12. Provide incorrectly converted binary and decimal numbers and task learners in pairs to identify errors and correct them.
13. Arrange learners in mixed gender and ability groups to do some internet research, and create a presentation on the history and importance of the binary system in the development of computers.

**ASCII Tasks**

*Learners should have access to an ASCII table (online or on paper) when completing these tasks.*

14. Learners are given a word /message in ASCII binary code and get them to convert to text.
15. Learners should write their full names and age in ASCII-Binary code on a gift card (created by them using pieces of papers) as exemplified in Figure 1.5.

| | Character | ASCII Value | Binary Code (8-bit) | Colour Code |
|---|---|---|---|---|
| First Name | A | 65 | 01000001 | |
| | m | 109 | 01101101 | |
| | a | 97 | 01100001 | |
| Surname | D | 68 | 01000100 | |
| | O | 111 | 01101111 | |
| | e | 44 | 01100101 | |
| Age | 1 | 49 | 00110001 | |
| | 6 | 54 | 00110110 | |

***Figure 1.5.:*** *ASCII gift card exemplar*

16. Ask learners in their mixed-gender ability groups (where applicable) to write a story about their first day in computing class in less than 15 words that includes a secret message encoded with ASCII and present to the class for decoding.

**Bitmapped Graphics Tasks**

17. Give learners a piece of paper with two identical 8 by 8 blank grids (each box in the grid representing a pixel) on a piece of paper. Ask them to shade in the pixels in one of the grids

to give the capital letter of their first name and the correct binary codes in the corresponding positions in the second grid to produce a black and white bit map.

18. Ask the learners to research five bitmapped graphics file formats and create a PowerPoint presentation to illustrate their findings.

## PEDAGOGICAL EXEMPLARS

***NB:*** *These examples are only to serve as a guide to the teacher.*

**Starter**

- The teacher can start the lesson by using "Into-Tag", where the teacher and learners write their names on a piece of paper tape and stick on their shirt or dress respectively since this is the first time the teacher is meeting his/ her learners.

  Scan this QR code for more information on how Intro-Tag is used:

- Using open class discussion, ask learners to share their career path in computer science and what they hope to achieve in the next three years in the subject. If possible, they should submit it via Google Forms for the teacher to keep as record to guide the learners.

**Content Introduction**

- The teacher could introduce the focal area: *Data as bits patterns* by showing learners this picture to guide them in the understanding of how data is represented as bit patterns.

  Scan this QR code for Picture

- A brainstorming session could also be used to introduce the focal area. The learners could brainstorm on the different types of data that a computer needs to represent/store.
- The video on page 4 is an excellent way of introducing /recalling the binary number system and why it is used by computers.
- Team teaching could be employed for the binary to and from decimal conversion activities. The teacher can invite a mathematics teacher to support him/her on the delivery of this content. The teacher(s) should emphasise on how computers understand only binary numbers ("0s" and "1s").

**Delivery of Key Concepts and Tasks**

- The lessons will consist of a variety of teaching and learning strategies, including direct instruction, collaborative learning, and the use of technology.
- The teacher will perform some binary to and from decimals conversions to the whole class and discuss the importance of binary in computing systems.
- Where possible, the learners should be active in the process of constructing meaning and knowledge rather than passively receiving information. The tasks given previously contain a variety of independent, paired and group activities.
- Creative activities should be included, for example, learners could be asked to create a poster to illustrate their understanding of the binary number system.

## ASSESSMENT

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for this focal area from Section 1 would be to ask learners to draw a concept map to represent their understanding of the binary number system.*

*The summative assessment questions below are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal area.*

**DOK Level 1: Recall**

**Decimal to and from Binary Conversion**

1. Convert the following decimal numbers into their binary representations:
   a. 25
   b. 57
   c. 128

2. Convert the following binary numbers into their decimal representations:
   a. 11010
   b. 100111
   c. 1110100

**DOK Level 2: Skills/Concept Application**

**Binary Conversion and Application**

1. If a computer has a 4-bit binary system, which of the following decimal numbers cannot be accurately represented, and why?
   a. 7
   b. 15
   c. 16
   d. 9

2. Given the binary number 101101, divide it into groups of three bits starting from the right. Add leading zeros if necessary. Convert each group into its decimal representation.

**Binary to Decimal Conversion Application**

3. A digital speedometer of a moving vehicle shows 8 bits reading as 11001100. What is the speed of the vehicle in decimal value?

Scan for solutions 

**Data Representation**

4. Create and present a slideshow on how computers represent the following data: numbers, text and graphics.

**DOK Level 4: Extended Thinking**

1. Research on vector graphics and use Word to create a document that compares bitmapped and vector graphics and the relative advantages and disadvantages of each.

# WEEK 2

**Learning Indicator** 1.1.1.LI.2: *Apply knowledge of Browser Cache to solve runtime issues. (e.g., opening browsers).*

## Theme/Focal Areas:

1. **Boolean logic and Binary**
2. **RAM and RAM as bit storage**
3. **Cache Memory**
4. **Memory Hierarchy**

*The use of the term 'cache memory' in this learning indicator does not make sense. Browser cache was the intended term. All learners of this subject need to study the fundamentals of computer memory, including cache memory. Cache memory is another name for CPU cache and has a different function from browser cache.*

## KEY CONCEPT NOTES

### Boolean Logic and Binary

Boolean logic is a type of algebra in which results are calculated as either True or False. Boolean logic drives modern digital devices, such as computers. It is used to describe electromagnetically-charged memory locations or circuit states in a computer that are either charged (1 or True) or not charged (0 or False).

#### Bit and their storage

To understand how individual bits are stored and manipulated inside a computer, it is convenient to imagine that the bit 0 represents the value False and the bit 1 represents the value True. Operations that manipulate True/False values are called Boolean operations.

#### Logic operations

Logic operations are fundamental concepts in digital computing that involve manipulating binary values (0s and 1s) to perform logical tasks. These operations are based on Boolean logic, which was developed by mathematician George Boole and is widely used in computer science and digital electronics (*In this lesson, emphasise the importance of mathematics to become a good computer scientist*). Logic operations are used in various aspects of computing, such as programming, digital circuit design, and data processing. Here are explanations of the three main logic operations using the logical operators: AND, OR and NOT.

1. **AND Operation**

   The AND operator takes two input values, often represented as A and B, and produces an output based on the following rule: If both A and B are 1 (True), the output is 1 (True). Otherwise, if either A or B (or both) is 0 (False), the output is 0 (False).

   In simple terms, the AND operation checks whether both input values are True, and if they are, the result is also True; otherwise, the result is False.

**Truth Table for AND operation:**

A truth table is a breakdown of all the possible truth values returned by a logical expression.

| A (Input) | B (Input) | A AND B (Output) |
|---|---|---|
| **0** | 0 | 0 |
| **0** | 1 | 0 |
| **1** | 0 | 0 |
| **1** | 1 | 1 |

***Figure 2.1:*** *AND logic truth table*

2. **OR Operation**

The OR operator also takes two input values (A and B) and produces an output based on the following rule: If either A or B (or both) is 1 (True), the output is 1 (True). Only when both A and B are 0 (False), the output is 0 (False).

In simple terms, the OR operation checks if at least one of the input values is True, and if it is, the result is True; otherwise, the result is False.

**Truth Table for AND operation:**

| A (Input) | B (Input) | A OR B (Output) |
|---|---|---|
| **0** | 0 | 0 |
| **0** | 1 | 1 |
| **1** | 0 | 1 |
| **1** | 1 | 1 |

***Figure 2.2:*** *OR logic truth table*

3. **NOT Operation:**

The NOT operator takes a single input value (A) and produces the opposite value as the output:
If A is 0 (False), the output is 1 (True).
If A is 1 (True), the output is 0 (False).
In simple terms, the NOT operator negates or flips the input value.

**Truth Table for NOT operation:**

| A (Input) | A-NOT (Output) |
|---|---|
| **0** | 1 |
| **1** | 0 |

***Figure 2.3:*** *Not Logic Truth Table*

Understanding logic operations is important for programming and working with digital circuits, as they form the basis for making decisions, comparisons, and computations in computer systems. By using truth tables and practical examples, learners can gain an understanding of logic operations and their significance in digital computing. A variety of examples can be explored with the learners.

One possible example is a truth table for analysing the statement "*The dog is black, and you are the dog's owner*". This is a statement with two propositions, where the logic operator is the **AND**. therefore "the dog is black" (labelled as A) and "you are the dog's owner" (labelled as B).

| A (Input) | B (Input) | A AND B (Output) |
|---|---|---|
| **0** | 0 | 0 |
| **0** | 1 | 0 |
| **1** | 0 | 0 |
| **1** | 1 | 1 |

***Figure 2.4:*** *Truth table for the given statement above*

## COMPUTER MEMORY

### Units of Memory

Units of memory in computing are typically measured in bytes. Here's a breakdown of some common memory units:

1. Bit (b): The smallest unit of memory, representing a binary digit (0 or 1).
2. Byte (B): A group of 8 bits.
3. Kilobyte (KB): 1 KB is equal to 1024 bytes.
4. Megabyte (MB): 1 MB is equal to 1024 KB or 1,048,576 bytes.
5. Gigabyte (GB): 1 GB is equal to 1024 MB or 1,073,741,824 bytes.

### Structure of a Computer System

A computer system is made up of a processor/CPU (Central Processing Unit) and memory together with input, output and storage devices. The CPU (examined in more detail in later weeks) is the part of the computer where all the calculating, sorting, searching and decision making happens. The main or primary memory is made up of a set of memory chips.

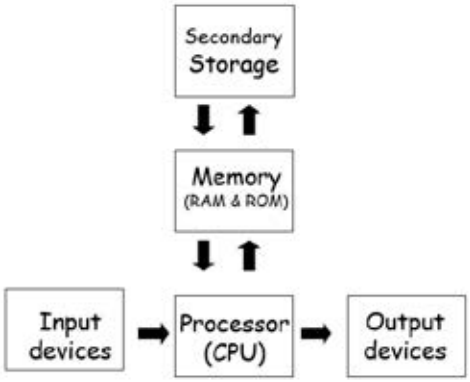



***Figure 2.5:*** *Basic block diagram of a computer system*

Input and output devices are piece of equipment used to provide data and control signals to the computer. Secondary or backing storage will retain saved computer data even after the computer is powered off.

**Memory as Bit Storage**
Having understood what bits are "as the smallest pieces of data (either "0" or"1"), the question is how are bits stored in the computer's memory?

**Flip-flop**
A flip-flop is a basic electronic circuit used for storing bits in other words, a flip-flop is a fundamental unit of computer memory. A flip-flop can store only one bit of data. Some types of memory (for example, a type of RAM called SRAM) use flip-flop circuits.

**Types of Memory**

**1. Random Access Memory**
RAM (Random Access Memory) serves as the primary storage location for data that the CPU is actively working on or requires for quick access. This type of primary or main memory holds data and instructions that are currently being processed by the CPU. RAM is directly accessible by the CPU.


***Figure 2.6:*** *A RAM module*

RAM has a limited capacity compared to secondary storage devices which will be studied in the next section. The capacity of RAM is typically measured in gigabytes (GB) or terabytes (TB). The amount of RAM in a computer affects its ability to run multiple programs simultaneously and handle large amounts of data efficiently.

Binary numbers (called memory addresses) are used to identify storage locations in RAM.
RAM is described as volatile, meaning it requires power to retain data. When the computer is turned off, the data stored in RAM is lost.

**2. ROM - Read Only Memory**
Read-Only Memory (ROM) is another type of primary memory in a computer system, distinct from RAM (Random Access Memory). Unlike RAM, which is volatile and loses its contents when the power is turned off, ROM is non-volatile, meaning it retains its data even when the power is switched off. ROM is generally read-only, meaning that while data can be read from ROM, it cannot be written to or modified by normal program execution.

***Figure 2.7:*** *A ROM chip*

### 3. Secondary Memory/Storage

Secondary memory is external, non-volatile memory where data can be stored permanently. Examples includes internal/external hard disk drives (HDDs), Pen drive (Flash drive), CDs, and solid-state drives (SSDs). Secondary storage has much larger capacity than main memory but is slower in terms of access times.

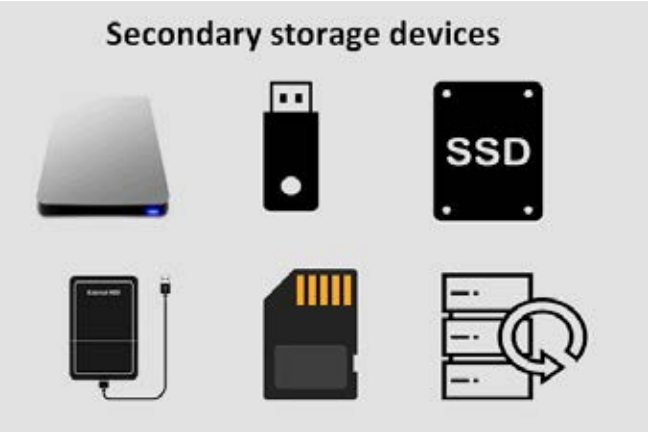



***Figure 2.8:*** *Secondary Storage Devices/Media*

### 4. Cache Memory

Cache memory or CPU cache is a small, high-speed memory for temporary data storage located directly on the CPU or close to it. It acts like a buffer between the CPU and RAM, holding frequently used data and instructions which the processor may require next. This reduces the need for frequent slower memory retrievals from RAM which may otherwise keep the CPU waiting.

Video: CPU Cache Explained - What is Cache Memory? - YouTube 4 mins

### 5. Registers

Registers are the fastest access and smallest capacity storage units located within the CPU itself. They serve as temporary storage areas that store the data, instructions and memory addresses that the CPU is currently processing.

## Memory Hierarchy

Memory hierarchy is a hierarchical arrangement of different types of memory in a computer system, organised in levels according to their speed, capacity and cost. The memory hierarchy is designed to optimise data access and storage, ensuring that the computer can efficiently process and retrieve data at various speeds. It consists of several levels, each with different characteristics, purpose and proximity to the CPU. The key levels in the memory hierarchy, from the fastest access time and smallest capacity to the slowest access time and largest capacity.

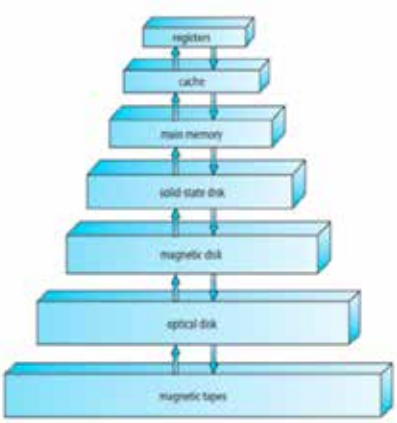



***Figure 2.9:*** *Memory hierarchy pyramid*

Since CPU registers are the fastest to read and write, they are placed at the top of the hierarchy. On the other hand, secondary storage devices like optical drives (CDs and DVDs) and magnetic tapes are the slowest and largest and therefore occupy the last level in the pyramid.

A significant way to increase system performance is minimising how far down the memory hierarchy has to be gone to manipulate data

### Cache

In computing, a cache is a hardware or software component that stores data so that future requests for that data can be served faster. Cache memory/CPU cache is one example. Another example is browser cache, also known as web cache.

### Browser Cache/Web Cache

Browser cache is a temporary storage area in RAM or on disk that holds the most recently downloaded web pages. As you jump from web page to web page, the caching of those pages in memory lets you quickly go back to a page without it having to be downloaded again. In order to ensure that the latest page is displayed, the browser compares the dates of the cached page with the current web page. If the web page has not changed, the cached page is displayed immediately. If the web page has changed, it is downloaded, displayed and cached.

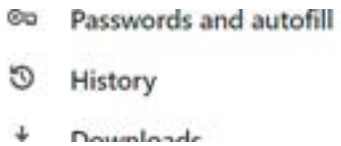
When you quit the browser session, the cached pages are stored on disk.

### Errors and clearing browser cache

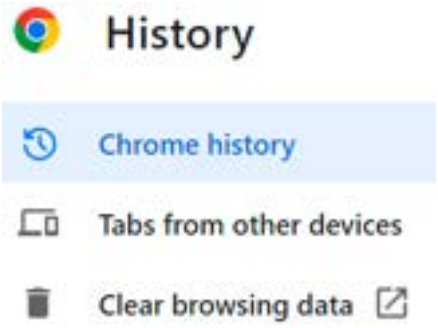
If a user gets a run-time error message when trying to access a particular webpage, this can indicate a corrupt browser cache. The user may also be unable to load the webpage if the website owner has

made updates, and the user's browser program tries to use an old file stored in its cache. A possible solution to these issues is to clear the browser cache. Below are the instructions for clearing the browser cache in Chrome.

1. On your computer, open Chrome and click on the three dots ⋮ (top right of the window)
2. Click History.




3. On the left, click Clear browsing data.




Video: What is a Browser Cache? How Do I Clear It? (youtube.com) – 6 minutes

**Learning Tasks**

*Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.*

***For learners working independently or in small groups:***

**Understanding the Logic Operations Tasks**

1. With little assistance, ask learners to fill logic truth tables and determine the output for all possible combinations of input values.
   a. Give learners a series of binary inputs to apply the AND operator to produce a truth table.
   b. Create a quiz where learners must use the OR operator on given binary inputs and select the correct outcome from multiple choices.
   c. Give learners a list of binary values and the instruction to apply the NOT operator.
   d. In a game format, learners compete to correctly fill in truth tables for mixed sets of logic operations, earning points for speed and accuracy.

2. Ask students in their mix-ability groups to create truth tables for each logic operation (AND, OR, NOT) from scratch and explain their significance in computing.

3. Design puzzles that require applying a combination of AND, OR, and NOT operations to solve the puzzles. Share the puzzles among groups for an extra challenge.

**Computer Memory Tasks**

4. Learners should arrange a given set of memory units in order largest to smallest.
5. Learners should match the names of different types of memory with given descriptions.
6 If network permissions permit, each learner should clear the browser cache of the device they are using.
7. Learners should investigate the amount RAM in the device that they are using.
8. Each learner in their mixed-ability groups should explain the following memory terms in their own words: *volatile, capacity, ROM, RAM, cache memory, browser cache.* The group decides on one explanation of each to present to the whole class. This could also work as a Think-Pair-Share activity.
9. Give each group a blank Memory Hierarchy Pyramid (with seven levels) and they should label each level.

## PEDAGOGICAL EXEMPLARS

**Starter:**

1. The teacher can still use the "Intro-Tag" if he/she is still familiar not with the names of the learners.

**Whole Class**

2. Talk for Learning activity to introduce computer memory: learners brainstorm the different types of data that a computer may need to store.

**Direct Instruction**

3. Learners observe photos or videos depicting a *real-life situation of how logic operations work* and photos of storage devices.
4. The teacher should then begin with clear, step-by-step explanations of the logic operation in the photo or video and linking it to types of logic operations (AND, OR and NOT).

   Scan for the video link: 

5. A practical activity to demonstrate the link between memory and binary: Use 8 bottle covers (representing flip-flop, labelling 4 bottles covers as "0" and the other 4 as "1") and a sachet of water (representing bits) to the class. Randomly call two learners (GESI centred) to fill the covers with the water (bits). This demonstrates flip-flops as the smallest storage unit of a computer memory.
6. Teacher explains that Flip-flops are an application of logic gates. Think of flip-flops as simple binary memory cells. Each flip-flop is able to store one bit—either a 0 or a 1. Guide the learners using a whole class discussion to build on the explanation into units of memories.
7. The teacher should demonstrate several examples of Boolean Operations on the board or through a projector/ Kahoot virtual interactive boards (scan code to see how it is used:) before learners attempt their own. **Note that only an understanding of simple truth tables is expected at this level.**

Scan for a Kahoot whiteboard tutorial:

8. Illustrate how a traffic light controller would use logic gates to make decisions and perform specific actions based on input conditions, and discuss. An understanding of logic gates is not required at this level but is related (A logic gate is a device that acts as a building block for digital circuits) and may help learners understand how logic operation link to computer design.

   The teacher can illustrate how a traffic light controller would use logic gates to make decisions and perform specific actions based on input conditions, and discuss. The use of a Raspberry Pi connecting to 3 LEDs on a breadboard would certainly enhance understanding and engagement here. Alternatively, if there is no access to a physical kit, but there is internet, a nice interactive activity that demonstrates how a traffic light controller uses logic gates can be found at https://www.101computing.net/traffic-lights-controller-using-logic-gates/
9. Show images of RAM and ROM in class and establish the learners' prior understanding of main memory.
10. Discuss the concept of volatile memory and how data in RAM is lost when the computer is turned off (could be compared to a human's temporary/short-term memory).
11. Show a number of images of computers for sale with their main specifications. Highlight the RAM and processor specification such as below, and discuss how the different specifications can affect applications and performance.


12. Cache is a difficult concept for learners at this stage, The video on page 21 should be played twice, pausing second time around at various points to ask questions.
13. Show a visual representation of the memory hierarchy pyramid, including registers, cache memory, main memory, and secondary storage. Briefly explain the purpose of each level and how they work together to provide different levels of speed and capacity.

**Collaborative Learning**

14. Organise learners into small mixed-ability groups to discuss and work through tasks together. Some collaborative tasks are given earlier. This method encourages peer teaching, where students can learn from each other's reasoning and problem-solving strategies.

**Reflective Learning**

15. After completing tasks, encourage learners to reflect on their learning experiences and understanding gained from the tasks.

16. Where possible, ask learners to connect the concepts learned with real-world applications or their prior knowledge. For example, ask the learners to give scenarios where the main memory is accessed (e.g., running applications, loading files)

**ASSESSMENT:**

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for the focal areas from Section 1 would be to ask learners to create a storyboard for an animation that explains how cache memory works.*

*The summative assessment questions that follow are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal areas.*

**DOK Level 1: Recall**

1. What does the AND operation do if both input values are 1?
   a. Outputs 0
   b. Outputs 1
   c. Outputs either 0 or 1 randomly

2. Which logic operation inverts the input value?
   a. AND
   b. OR
   c. NOT

3. The OR operation requires both inputs to be 1 to produce an output of 1
   a. True
   b. False

4. What does RAM stand for in computer terminology?
   a. Random Access Memory
   b. Readily Available Memory
   c. Randomly Allocated Memory
   d. Read Access Memory

5. Is ROM permanent storage?
   a. Yes
   b. No

6. Convert 1024 bytes to kilobytes (KB).
   a. 1 KB
   b. 10 KB
   c. 0.1 KB
   d. 100 KB

**DOK Level 2: Skill/ Concept Application**

1. Given the binary inputs A = 1010 and B = 1100, what is the result of the A OR B operation?
   a. 1110
   b. 1010
   c. 0001

2. If you apply the NOT operation to the binary number 0011, what is the result?
   a. 1100
   b. 0011
   c. 1111

3. Which statement is true about the AND operation?
   a. It produces a 1 only if both inputs are different.
   b. It produces a 1 only if at least one input is 1.
   c. It produces a 1 only if both inputs are 1.

4. Which of the following best describes the difference between RAM and ROM?
   a. RAM is volatile and ROM is non-volatile.
   b. RAM is used for permanent storage, and ROM is used for temporary storage.
   c. RAM is non-volatile, and ROM is volatile.

5. Given that 1 KB equals 1024 bytes, how many bytes are there in 7 KB?

6. Why is ROM considered non-volatile?
   a. It retains data without power.
   b. It loses data when power is turned off.
   c. It can be easily rewritten.
   d. It operates at high speeds.

**DOK Level 3: Strategic Thinking**

1. Given two binary numbers A = 01101 and B = 10011, after performing the AND operation on A and B, how many 1s are in the output?
   a. 1
   b. 2
   c. 3

2. If a binary sequence represents a digital circuit's input, and applying the NOT operation changes its output state, what can be inferred about the initial state of the output?

3. Analyse the following statement: "Using the OR operation on any binary number with 1111 will always result in 1111." Is this statement true or false, and why?

4. If a computer has 8GB of RAM and a program requires 8000 MB of memory to run, can the program run efficiently? Explain your reasoning.

5. A student claims that deleting files from a computer's ROM can speed it up. Evaluate this statement and explain why it is correct or incorrect.

6. Given the following storage units, arrange them in order from smallest to largest: 1 terabyte (TB), 1 gigabyte (GB), 1 megabyte (MB), and 1 kilobyte (KB).

   Scan this code for the solutions to the above questions:

7. Create a truth table for the following statement:
   *"Kojo is not an artist and Abena is not a musician"* (see solution below)

8. Explain why cache memory improves system performance.

9. A user gets a run-time error message when trying to access a particular webpage. Explain a possible reason for this and how it can be rectified.

**DOK Level 4: Extended Thinking**

1. Investigate the difference between DRAM and SRAM and write a short report on your findings.

2. Research the three levels of cache memory: L1, L2, and L3. Write a short report on the features of each level and how they differ.

Solution to question 19:

*Truth table:*

| A | B | NOT(A) | NOT(B) | NOT(A) AND NOT(B) |
|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 |

Only in case 4 is the statement true

# WEEK 3

**LEARNING INDICATOR 1.1.1.LI.3:** *Describe the functions of the parts of the CPU: Arithmetic and Logic Unit (ALU), Control Unit (CU) and registers*

*LI 3 has been amended to make more sense.*

## Theme/Focal Areas:

1. **Identify the components of the Central Processing Unit**
2. **Describe the functions of the three main components: ALU, CU and Registers**
3. **Describe the role of buses within the CPU.**

## KEY CONCEPT NOTES

### Central Processing Unit

The part of a computer that manages all the work with data is called the central processing unit or CPU. It's often just called the processor. The CPU is often referred to as the "brain" of the computer, and is responsible for executing instructions and performing calculations that enable various computing tasks. The CPUs in computers are small flat chips that can fit in your hand. They have connecting pins that go into a socket on the motherboard. In smartphones, tablets, and other mobile devices, CPUs are even smaller, about half the size of a postage stamp. So, there are different types of CPUs and CPU specifications will vary. The CPU in a mobile phone, for example, will have considerably less processor speed than in a supercomputer.

Scan the QR code for more on where the CPU fits in a computer system using a block diagram:

The CPU together with the memory and the Input/Output subsystems establish a computer system. It includes small layers of hundreds of transistors. Transistors are microscopic bits of substances that block electricity at one voltage (non-conductor) and enable electricity to move through them at multiple voltages (conductor).

It regulates all internal and external devices and implements arithmetic and logic operations to perform the set of instructions saved in the computer's memory.

Scan the QR code for more details on how a CPU works:

## Components of a CPU

The CPU is made up of the following parts:

1. **Control Unit (CU)**
   This is the part of the CPU that manages the operations within the CPU.

   Functions:
   - Controls the order in which instructions are executed.
   - Manages the other CPU components, such as ALUs and registers. The CU communicates with these parts using the CPU internal buses.

2. **Arithmetic and Logic Unit (ALU)**
   The Arithmetic and Logic Unit is responsible for arithmetic and logic operations, Logic operations involve performing comparisons and making decisions.

   Functions:
   - Performs arithmetic operations.
   - Performs logical operations to make decisions.

3. **Registers:**
   Registers temporarily store data being processed, program instructions and memory addresses to be accessed. Different types of registers perform different functions.

   Names and Functions of three of the CPU registers:
   - The memory address register (MAR) stores the address in memory currently to be read from/ written to.
   - The program counter stores the memory address of the next instruction to be executed.
   - The memory data register (MDR) holds data being transferred to and from the processor.

4. **Cache:**
   Cache memory is a fast random-access memory that temporarily stores a small amount of data and instructions that the CPU is likely to use.

   Functions:
   - Temporarily store data and instructions for later
   - Allows faster processing as the CPU can get the data and instructions directly from cache and does not have to wait to retrieve them from RAM.

5. **Clock:**
   The clock is the part of the CPU that sends out regular pulses that keep the CPU and its related components in step with one another. The CPU clock speed, also known as clock rate or clock frequency, is measured in Gigahertz (GHz) and indicates the number of cycles per second that the CPU's clock executes.

   Each cycle of the CPU clock represents one basic unit of work that the CPU can perform, such as fetching, decoding, and executing an instruction. A higher clock speed means the CPUs

can execute more cycles per second, leading to faster processing of instructions and improved performance.

Function:

- Generates electrical pulses at a specific frequency, which determines how quickly the CPU can process.

**6. System Bus:**

A bus is a communication channel/series of lines that connect the processor to another part of the computer's architecture.

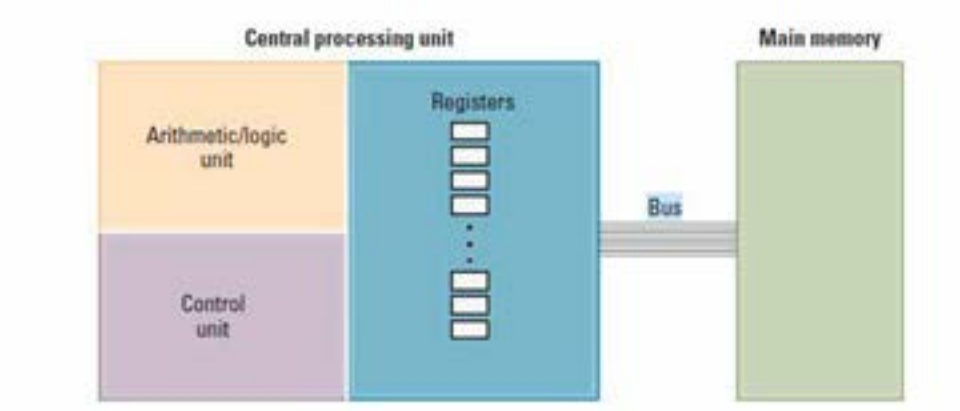



***Figure 3.1:*** *CPU is linked to main memory via buses*

The processor also has a set of internal buses that allow signals and data to pass between its different components.

The three types of buses are address bus, data bus and control bus. These buses collectively are called the system bus.

Functions:

- The processor uses the address bus to send memory addresses to other components.
- The processor uses the data bus to send the actual data to/from the component.
- The processor uses the control bus to send control signals to other devices.

The three main parts of the CPU are considered to be the control unit, arithmetic and logic unit, and registers.

**Learning Tasks**

*Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.*

**CPU Tasks**

1. State the name of the part of the processor that carries out logical operations and makes decisions.
2. What do computer buses do inside the processor?

3. Use one of your school's computers to find out
   (a) the name and manufacture of the processor used
   (b) the quantity of RAM installed.
   (For a Windows device: click on the Windows Start button, then click on Settings (the gear icon). In the Settings menu, click on System., scroll down and click on About).

4. Identify the component of the CPU that sends out regular pulses that synchronises its internal operations.

5. Draw a 5-block diagram of a computer system (see page 17). Show the three main components of the CPU/processor in its block.

## PEDAGOGICAL EXEMPLARS

***NB:*** *These examples are only to serve as a guide to the teacher.*

1. The teacher should build on learners' understanding and lead the discussion of what a CPU is in the computer. Start the lesson with an open class discussion about statement: 'The CPU is considered to be the brain of the computer'.
2. Learners should complete the following table (individually or as a whole class exercise) which relates the concept of processing to real-life scenarios:

| Input | Processor | Output |
|---|---|---|
| Dirty clothes | Washing machine | Clean clothes |
| | Garage | |
| | Oven | |
| Person with long hair | | |

This exercise illustrates that inputs may vary but the output is a result of some processing being done by the processor to the input.

A possible solution is:

| Input | Processor | Output |
|---|---|---|
| Dirty clothes | Washing machine | Clean clothes |
| Broken car | Garage | Fixed car |
| Raw Chicken | Oven | Roast chicken |
| Person with long hair | Hairdressers | Person with short hair |

3. Visually show what a CPU chip looks like (old hardware, image from book or internet).
4. Relate CPU concepts to everyday experiences or familiar technology. The learners could brainstorm everyday items that contain a processor(s) (examples include television sets,

washing machines, and cars. Guide a discussion about the role of a processor in these devices to deepen understanding of

5. Individually or in pairs, the learners should be given the names of three or so different processors to research, for example, Intel Core i5-14600K and AMD Ryzen 9 7950X. They should report their findings to the whole class. No more than two different groups should be given the same processors.
6. In learners' mix-ability groupings the teacher should give learners a project to create a short video explaining what the CPU is, how it functions, and how its specifications can affect system performance (They can use simple animations or diagrams to illustrate the concept). This activity could also take the form of a slideshow.

## ASSESSMENT:

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for these focal areas from Section 1 would be to ask learners to evaluate the advantages and possible uses of one processor over another from a given printout/weblink to two different processors.*

*The summative assessment questions below are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal area*

**DOK Level 1: Recall**

1. What does CPU stand for?

2. The CPU is also known as the brain of the computer.
   a. True
   b. False

3. Which unit is primarily responsible for executing instructions in a computer?
   a. RAM
   b. ROM
   c. CPU
   d. SSD

4. Name the three main components of a CPU.
   a. Arithmetic Logic Unit (ALU), Control Unit (CU), and Cache
   b. Hard Drive, Monitor, and Keyboard
   c. Motherboard, Power Supply, and Fan
   d. RAM, ROM, and SSD

5. Which part of the CPU makes sure that the program instructions are carried out in the right order?

**DOK Level 2: Skill/ Concept Application**

1. Identify two items that a CPU register may store.

2. What function does the Arithmetic Logic Unit (ALU) serve in a CPU?
   a. Stores data

b. Controls other components
c. Performs arithmetic and logical operations.
d. Manages power supply.

3. Which component of the CPU is responsible for decoding instructions?

**DOK Level 3: Strategic Thinking**

1. How does increasing the clock speed of a CPU affect its performance and heat generation?

2. Describe how cache memory benefits CPU performance.

Scan for solutions to some of the above questions: 

**DOK Level 4: Extended Thinking**

Investigate what is meant by a multi-core processor and why such a processor may perform better than a single-core processor. Summarise your findings in a short written report.

# WEEK 4

**LEARNING INDICATOR 1.1.1.1.LI.4:** *Understand and explain the control bus, address bus, data bus and the internal clock, Machine Cycle, Fetch–Decode–Execute-Store Cycle, instruction set for a CPU and describe embedded systems*

## Theme/Focal Areas:

1. **Describe the steps involved in the Machine Cycle/Fetch-Decode-Execute-Store (FDES) cycle.**
2. **Explain the role of the address, control and data buses in the machine cycle**
3. **Explain what is meant by a CPU's instruction set.**
4. **Describe what is meant by an embedded system and give examples.**

*Note that the internal clock and the CPU clock (described in Week 3) in a computer are related (they both synchronises the computer's operations) but serve different purposes. At this level, take internal clock and the CPU to be the same.*

*The machine cycle is also known as the fetch–decode–execute-store cycle, hence ',' replaced with '/' in LI4.*

## KEY CONCEPT NOTES

### Computer Buses

Buses on the motherboard are used to connect the CPU to other components, and within the processor to connect its components. A bus moves instructions and data around. The three main buses are the control, address and the data bus. These buses also connect the CPU and main memory (see Figure 4.1) and allow the CPU to transfer instructions and data to and from main memory.

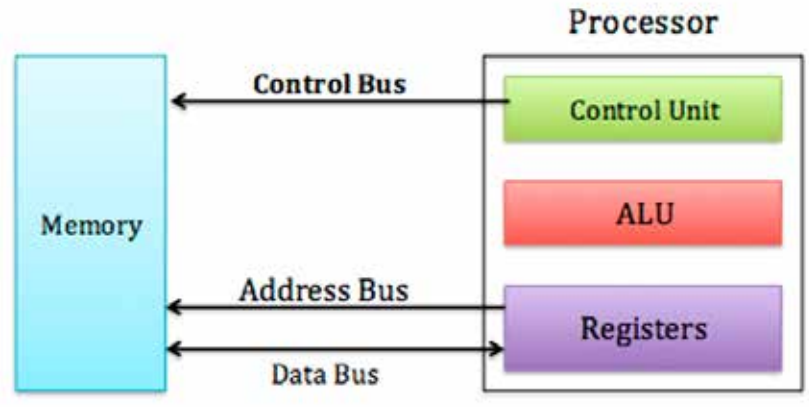



***Figure 4.1*** *Buses connecting the processor and main memory*

As mentioned in previous notes, the control, address and data buses collectively are called the system bus.

Scan the QR code for more details on the system bus:

## MACHINE CYCLE

The CPU does its work by following a specific process called the *machine cycle*, which consists of four main steps: fetch, decode, execute and store. For this reason, the machine cycle is also known as the *Fetch-Decode- Execute-Store cycle*. This process is like a routine that the CPU repeats repeatedly to run a program/set of instructions. The four main processes are shown in Figure 4.2.

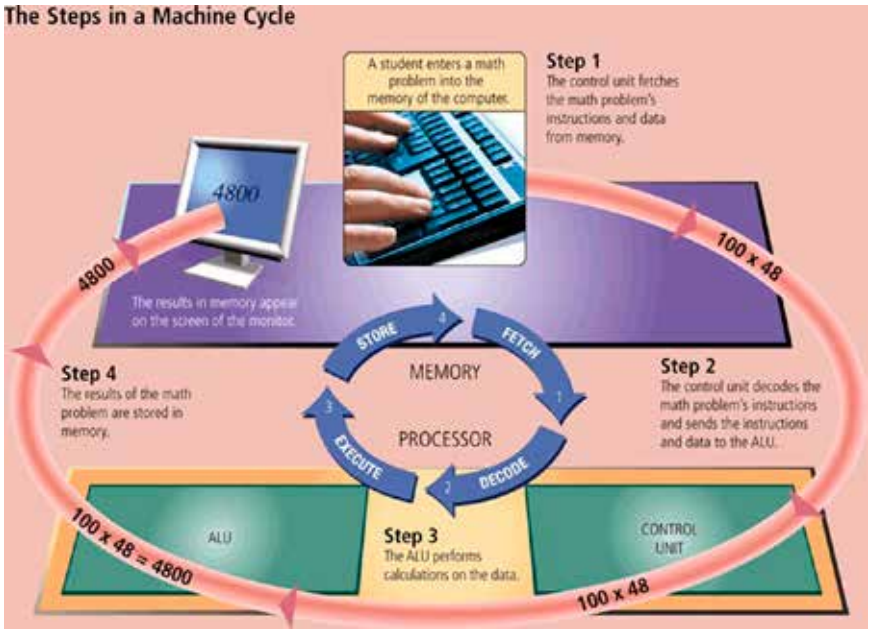



***Figure 4.2:*** *Steps in Machine Cycle*

1. **Fetch:**

   During the Fetch stage, the CPU retrieves an instruction from memory by the address bus pinpointing the required location in RAM of the instruction. The data bus transfers this instruction it to the processor The program counter is a register that keeps track of the memory address of the next instruction which is passed to the address bus before being incremented to point to the next instruction. The fetched instruction is then stored in a designated register within the CPU for further processing.

2. **Decode:**

   In the Decode stage, the CPU interprets the fetched instruction. It identifies the operation to be performed and determines the operands involved. The instruction is decoded into a format that the CPU can understand and execute.

3. **Execute:**

   Once the instruction has been decoded, the CPU carries out the execution of the instruction, that is, carry out the necessary operations specified by the instruction. This stage may involve arithmetic or logical calculations, data manipulation, or control flow modifications.

4. **Store:**

   The final stage of the machine cycle is the Store stage. Here the results of the executed instruction are stored back in memory or in designated registers. This stage ensures that the changes made during the execution are preserved for future operations or for the overall program's functioning.

   The FDES cycle repeats continuously, with each cycle processing one instruction at a time. By following this cycle, a computer system can execute complex programs by sequentially fetching, decoding, executing instructions, and storing any results from these instructions.

Video: The Fetch-Execute Cycle: What's Your Computer Actually Doing? - YouTube 9 mins

The CPU clock generates regular electronic pulses that synchronise the various stages of the cycle, ensuring each step happens at the right time.

## CPU INSTRUCTION SET

A CPU's instruction set, also known as an instruction set architecture (ISA), is a set of commands that the CPU can understand and execute. It defines the operations that can be performed, the data types that can be manipulated, and the addressing modes for accessing memory. The instructions tell the CPU to perform certain tasks. Some instructions are simple read, write and move commands that direct data to different hardware elements.

## EMBEDDED SYSTEMS

An embedded system is a special-purpose computer system, which is completely encapsulated by the device it controls. Its purpose is to control the device and to allow a user to interact with it.

An embedded system has specific requirements and performs pre-defined tasks, unlike a general-purpose personal computer.

Embedded systems are a combination of hardware and software which facilitates mass production and variety of applications. Embedded devices are not usually programmable by a user – the programming is usually done beforehand by the manufacturer. However, it is often possible to upgrade the software on an embedded device. For example, fitness trackers are embedded systems whose software can be upgraded. However, the upgrade can only be done upgraded by connecting the tracker to a computer/ smartphone (wirelessly or wired) and installing the new software.
Examples of embedded systems are shown in Figure 4.3.


***Figure 4.3:*** *Examples of Embedded Systems*

Programs on an embedded system often run in real-time with limited hardware resources. For example, often there is no disk drive. The software may be stored in a type of memory called Flash ROM. If a user interface is present, it is often a small keypad and screen, or touch screen.

**Advantages of an embedded system**

- They can be used in a wide variety of products and devices and to create new ones
- They are ROM based so operate very quickly

**Learning Tasks**

*Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.*

**Computer Buses Tasks**

1. What is the role of system buses in a computer system?
2. Identify the three buses involved when the processor is executing instructions.
3. Describe the role of each of the buses in the Fetch stage of the machine cycle.

**Machine Cycle Tasks**

4. Explain the link between program execution and the machine cycle.
5. List the steps in the machine cycle.
6. Explain what happens at the Decode stage of the machine cycle.

**Embedded Systems Tasks**

7. Give two examples of an embedded system that you might find in
   (a) a home
   (b) a school
8. State two features of an embedded system.
9. Create and present a presentation (with suitable images and video links) on how embedded systems can be used for the following:
   - Running a house
   - Healthcare
   - Transport

## PEDAGOGICAL EXEMPLARS

***NB**: These examples are only to serve as a guide to the teacher.*

1. Explain that to actually run the code, the processor needs to first retrieve instructions one by one from memory. This process consists of four stages: fetching the instruction, decoding the instruction, executing the instruction, and storing the result - these four steps are known as the machine cycle.

2. Introduce each stage of the cycle separately - fetch, decode, execute, and store. This approach helps learners understand each step before moving on to the next.

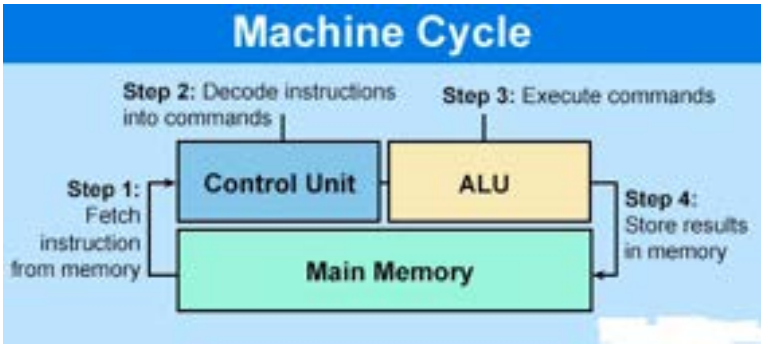



***Figure 4.4:** The machine cycle*

3. Show Figure 4.4 to learners to help explain how the steps in the machine cycle fit together. Emphasise the involvement of the main components of the CPU and computer buses in the cycle.

4. Show the video at the top of the previous page to illustrate the FDES steps in more detail. There are many other online videos and animations on the machine cycle available. The teacher should select these resources to best suit his or her learners.

   Another video that goes into more detail (with no reference to the Store step) can be accessed by scanning the QR code:

5. Using open class discussion, the teacher should guide a deeper understanding by providing real-world examples to demonstrate the machine cycle and show its relevance in everyday technology. Possible examples:
   a. Personal Computers: Almost every modern personal computer, from laptops to desktops, utilises CPUs that perform machine cycles to execute various processes. To process user applications, like opening a web browser or running a video game, the CPU fetches the relevant instruction one at a time, decodes them, executes the required operation, and stores the data if necessary.
   b. Smartphones: Smartphones are equipped with processors (CPUs) that are responsible for running applications, managing the device's operating system, and carrying out multiple tasks seamlessly. The speed and efficiency of a smartphone's performance depend on its processor's capability to execute machine cycles quickly and efficiently.

6. Role play: Divide students into groups, assigning each group a specific role in the FDES cycle (e.g., CPU, memory, instruction, data).

   Using a short Python program, for example,
   ```
   x=4
   y=x+2
   print y
   ```
   , have learners act out the different phases of the cycle, mimicking the flow of data and instructions through the CPU and memory.

   Encourage students to discuss and reflect on their roles and how they contribute to the overall operation of the CPU.

7. Show a short suitable video to introduce embedded systems. There are many to choose from YouTube such as:

What is an Embedded System? | Concepts

8. Learners brainstorm examples of embedded systems.

9. Learners create a slideshow presentation under the two headings:
   - Features of an embedded system
   - Examples of an embedded system
   - Images should be inserted in the slides.

## ASSESSMENT:

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for these focal areas from Section 1 would be to give learners working in pairs or a small grouping a set of cards with steps descriptions (including a few surplus ones) and instruct them to put the cards in the correct order to describe the machine cycle of a computer. No indication that there are surplus cards should be given when delivering the task instructions.*

***NB:** The summative assessment questions below are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal areas.*

**DOK Level 1: Recall**

1. Name the four stages in the machine cycle.
2. Name the three buses that are involved the Fetch stage of the machine cycle.
3. What is the name for the set of commands that a processor can understand and execute?

**DOK Level 2: Skill/ Concept Application**

1. List the steps involved in the Fetch phase in the Fetch-Decode-Execute-Store cycle.
2. Learners to research and prepare PowerPoint slides to illustrate with examples how a typical instruction is processed through the Fetch-Decode-Execute-Store cycle.

**DOK Level 2: Skill/ Concept Application**

1. Explain the role the CPU clock plays in the machine cycle? (The clock generates regular electronic pulses that synchronise the various stages of the cycle, ensuring each step happens at the right time).
2. Explain the roles played by the CU, ALU, and registers in the machine cycle.

**DOK Level 3: Strategic Thinking**

1. Learners to research and prepare PowerPoint slides to explain how the Fetch-Decode-Execute-Store cycle functions within a computer processor, illustrating the interaction between its various stages and their impact on program execution efficiency.

Scan for solutions to some of the above questions:

**Note that at this level, the learners are not expected to name the registers involved in the FDES cycle though they may wish to do so.**

**DOK Level 4 Extended Thinking**

Investigate what happens when a processor performs a memory write operation. List the main steps involved in this operation, identifying the buses required at each step.

# SECTION 1: REVIEW

Over these four weeks, the subject covers everything from basic data patterns to program execution, ensuring a thorough understanding of Data Storage and Manipulation.

By the end of this section, the teacher should have guided learners to explore computer architecture, focusing on how data is stored and handled with a key focus on how processors and memory work together to execute programs. By the end of this session learners are expected to have a good understanding of data representation and manipulation by computers, the main components of the processors and why the machine cycle is often referred to as the heartbeat of a computer.

Teachers may have used interactive methods like "Intro-Tag" for introductions, physical hardware and online resources for demonstrations, and collaborate with teachers in the Mathematics/Physics Department to facilitate learning.

The section made use of the Depth of Knowledge (DOK) in all the weekly assessments, guiding teachers to evaluate learners' learning progress through weekly tasks. These assessments aim to check learners' understanding and help teachers identify areas where students may need further assistance or practice.

**TEACHING AND LEARNING RESOURCES**

*Here are some teachings and learning resources list, the teacher can integrate into his/her lesson.*

- Paper, pen
- Photos
- Videos
- Smartphones
- Desktop/Laptop computers
- Tablets
- Open Educational Resources (Including: YouTube, MOOCS-Udemy/ Coursera, Khan Academy, TESSA)
- Productivity tools ix. Subject-based application software.
- Old/new hardware e.g. RAM module
- Instructional Laboratories (with multimedia equipment and smartboards)
- Interactive Whiteboard (like Kahoot Whiteboard)
- Colour Pencils/Markers or Crayons
- Paper Ball (as activity ball)
- A4 Sheets/ Cardboards
- Online puzzles/ games
- Interactive Whiteboards (Like google Classroom boards/ Zoom Whiteboard or Kahoot Whiteboard)
- Word processor
- Presentation program
- Paint program

## ADDITIONAL READING

### Books


1. Brookshear, J. G. Brylow, D. (2019*). Computer Science: An Overview, Global Edition*. Pearson Education Limited.
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# SECTION 2

**STRAND: Computer Architecture and Organisation**

**Sub-Strand:** Computer Hardware and Software

**Content Standard 1.1.2.CS.1**: *Demonstrate knowledge and understanding of components of Computer Hardware and types of Software.*

**Learning Outcome 1.1.2.LO.1:** *Explain the relationships between the components of a computer and how data are transferred among the components.*
*Explain types of Software and their functions*

**Introduction and Summary of Section:**

This section requires the teacher to introduce the basics of computer hardware and software to learners. Learners are required to cover the essential hardware components of a computer like the central processing unit (CPU), RAM, secondary storage devices and input/output devices. Processing hardware other than the CPU are also studied as well as communication hardware devices. The two main categories of computer software (applications and systems) are studied in depth.

By the end of the section, learners are expected to have mastery of how hardware parts connect and work together and what role software plays in the operation and functionality of a computer system. In other words, from this block of lesson learners will gain an understanding on why hardware needs software to tell it what to do, but software also needs hardware in order to act out its directions. Computer fundamentals such as hardware and software are becoming more and more necessary in our increasingly digital world. The knowledge gained in this section will enable students to progress better in education as well as preparing them for daily tasks and careers in their future lives.

This section runs through from week 5 to week 8 to facilitate a more fuller understanding of Computer Architecture and Organisation. The breakdown of the weekly learning indicators is as follows:

**Week 5** Description of the Categories of Computer Hardware Explain the features of the hardware components of a computer (input hardware, processing hardware, output hardware, storage hardware and communication hardware)

**Week 6** LI from Week 5 *continued*

**Week 7** LI from Week 5 *continued*

**Week 8** Describe the categories of Computer-Software

**Summary of Pedagogical Exemplars**

This section makes use of pedagogies like interactive teaching approaches to introduce the learning outcome and establish prior knowledge of computer hardware and software. A combination of interactive teaching and direct instruction should be employed to deliver the section content. Learners' proficiency with using the internet, such as their experience with Google searches, and GESI principles should be considered when creating groups tasked to research task. Teachers are encouraged to actively supervise group activities and use whole-class or individual discussions to address any challenges encountered by the learner(s).

Teaching about hardware and software can be a bit theory heavy so, wherever possible, visual aids such as photographs, videos and flashcards should be used to explain focal areas and connect concepts to real-life situations. Research-based and collaborative learning should increase learner engagement as well as enhance understanding through peer teaching. Allowing pupils to handle items such as old motherboards, RAM module and CPU chips allows makes the study of hardware less theoretical. Using applications such as word processing and presentation programs will allow learners to demonstrate their understanding of the concepts studied as well as record research findings and build up a set of course notes.

Plenaries should be used by the teacher at the start or at the end of a lesson, to review and consolidate the students' learning.

**Summary of Assessment**

Teachers are to refer to the weekly tasks and assessments questions in this section as a guide for both formative and summative evaluations in the focal areas related to "Computer Architecture and Organisation". Product differentiation is again exemplified in the Key Assessments (KA) and the Depth of Knowledge (DOK) assessment method is again adapted to help teachers evaluate, measure, and diagnose how well learners are comprehending the topics covered and to identify areas where additional help or practice may be needed.

# WEEK 5

**LEARNING INDICATOR 1.1.2.LI.1:** *Explain the features of the hardware components of a computer (input hardware, processing hardware, output hardware, storage hardware and communication hardware).*

## Theme/Focal Areas:

1. **Input devices**
2. **Output devices**
3. **Storage devices**

## KEY CONCEPT NOTES

### Categories of Computer Hardware

Hardware components of a computer consist of various physical parts or devices that work together to provide the necessary functionality for computing tasks.

Hardware devices are categorised into the following:

- Input devices
- Output devices
- Processing devices
- Storage devices
- Communication devices

### Input Devices

Input devices are hardware components that allow users to input data and instructions into a computer system. They enable users to interact with the computer and provide the necessary input for executing tasks. Here is a keynote on some input devices:

1. **Keyboards:**

   A keyboard is a common input device, consisting of a set of keys that allow users to input alphanumeric characters, symbols, and commands. They are essential for typing text and providing commands to the computer.

***Figure 5.1:*** *Keyboard*

2. **Mouse:**

   Mouse is a pointing device that allows users to control the cursor on the screen. They typically have buttons and a scroll wheel, enabling users to select objects, navigate interfaces, and perform actions through mouse movements and clicks.

***Figure 5.2:*** *Mouse*

3. **Touchscreens:**

   Touchscreens enable users to directly interact with the computer by touching the display. They can detect and respond to finger gestures, allowing for intuitive input methods such as tapping, swiping, or pinching.

4. **Scanners:**

   Scanners are used to convert physical documents, images, or objects into digital formats. They capture the data optically and transfer it to the computer for storage, editing, or further processing.

***Figure 5.3:*** *Scanners*

## Output Devices

Output device displays the result of the processing of data that is entered in the computer through an input device. There are a few output devices that display output in different ways such as text, images, hard copies, and audio or video.

They bridge the gap between digital data and human perception, letting users engage with computer-generated information.

There are many types of output devices for processed data as text, images, or video.

Monitors and projectors allow users to view computer output on screens or project it onto larger surfaces.

1. **Monitors**

   There are different types of monitors, three of which as shown in Figure 5.4.


***Figure 5.4:*** *Monitors*

Some computers, such as laptops, have built-in monitors.

Monitors can be found where computers are being used. For example, they are used in educational institutions, such as schools and universities, to facilitate learning. They display educational content, multimedia presentations, interactive learning materials, etc.

**2. Projectors**

A projector is an output device that enables the user to project the output onto a big screen or wall. It can be connected to a computer and similar devices to project their output onto a screen. It uses light and lenses to produce magnified texts, images, and videos. So, it is an ideal output device to give presentations or to teach a large number of people.

Modern projects (digital projectors) come with multiple input sources such as High-Definition Multimedia Interface (HDMI) ports for newer equipment and Video Graphics Array (VGA) ports that support older devices. Some projectors are designed to support Wi-Fi and Bluetooth as well. They can be fixed onto the ceiling, placed on a stand, and more and are frequently used for classroom teaching, giving presentations, home cinemas, etc.


***Figure 5.5:*** *A projector*

**3. Plotters**

A plotter is a specialised output device used to generate high-quality, accurate, and detailed graphics. It's popular in fields like engineering, architecture, and graphic design. Unlike printers, which use ink or toner to create pictures or text on paper, plotters utilise a pen or marker to draw continuous lines on diverse media such as paper, vinyl, or film.

**Examples of Plotters**

**Pen Plotters:** Pen plotters are the most classic sort of plotter, drawing continuous lines on paper or other media using a pen or marker.

***Figure 5.6:*** *Pen Plotter*

**Electrostatic Plotters:** Electrostatic plotters use an electrostatic charge to attract toner or ink onto paper. They operate by selectively charging areas of the paper and then applying toner or ink to those charged areas, resulting in the formation of graphical output.

***Figure 5.7:*** *Electrostatic Plotter*

**4. Printers**

A printer produces hard copies/physical copies of the processed data. It enables the user to print images, text or any other information onto the paper. Users can pick from various printer types, such as inkjet and laser, to meet their printing demands. Printers enable the generation of tangible copies for record-keeping, presentations, marketing materials, and other purposes, from household to professional settings. Printers are essential for personal and commercial use due to their simplicity and adaptability.


***Figure 5.8:*** *Small Laser Printer*

Printers vary in type. size, speed, and cost. Some printers can output in A3. Some printers have photocopy and scan functions. Popular types of printers are laser printers and inkjet printers.

3D printers create three-dimensional objects by depositing layers of material (plastic, metal, or composite) based on a digital model. They are used in various industries, including manufacturing, prototyping, and healthcare.


***Figure 5.9:*** *3D printing*

**5. Sound Output devices**

These devices deliver audio output for listening or communication purposes. Speakers and headphones/earphones enable users to hear the sound - music, speech.


***Figure 5.10:*** *Examples of Sound Output Devices*

## Storage Devices

These devices are essential components of a computer system that store and retrieve data, programs, and files. They provide long-term data storage and enable users to save, access, and manage their digital information.

When looking at storage devices, there are three considerations: capacity, speed, and cost (how much to purchase per MB).

**Storage Capacity and Performance:**

One characteristic of storage devices is their capacity, which is the amount of data they can store, typically measured in gigabytes (GB) or terabytes (TB).

Performance factors include read/write speeds, access times and data transfer rates.

**Types of storage devices**

Storage devices fall into three categories: magnetic, optical and flash.

1. **Magnetic**

   Magnetic storage uses a magnetisable material. Patterns of magnetisation are then used to represent binary sequences. Magnetic storage tends to have a high capacity at low cost. Examples include magnetic tape and hard disk drives.

   *Magnetic tape* is sometimes used for backup of server computers.

   *Hard Disk Drives (HDDs)* are the most common form of magnetic storage devices used in computers. They use magnetic storage to store data on spinning disks (platters) and read/write heads to access and modify data. HDD capacities typically range from several hundred gigabytes (GB) to several terabytes (TB).

***Figure 5.11:*** *Internal HDDs*

2. **Optical**

   Optical storage works by using laser technology to read and write data a laser. Examining the reflection from the laser will determine whether there are pits on the surface of the disk representing 1s, or lands representing 0s. Examples of optical disks are CDs and DVDs. They can be used for data storage, software installation, media playback and creating backups.

   Optical disk drives are gradually being phased out in favour of faster and more versatile storage options.

***Figure 5.12:*** *Optical Disks (DVDs)*

3. **Flash**

   Flash media works by using a special type of ROM that can be overwritten. Data is retained after power is shut off. It is used in solid state drives, USB flash drives, and memory cards.

   *Solid State Drives (SSDs)*

   SDDs offer faster data access and transfer speeds compared to HDDs due to the absence of moving parts. SSDs are more resistant to physical shocks and consume less power compared to HDDs. They come in various form factors and can be internal or external/portable.


***Figure 5.13:*** *Internal Solid-State Drive (SSD)*

*USB Flash Drives*

USB flash drives, also known as thumb drives, pen drives or USB sticks, are portable storage devices that use flash memory. They connect to computers via USB ports and offer a convenient way to transfer and store data. They come in various storage capacities and are widely used for data ***backup, file transfer, and portable storage.***

***Figure 5.14:*** *Flash Drives*

*Memory Cards*

Memory cards are small, portable storage media commonly used in cameras, smartphones, tablets, and other portable devices. The data can usually be read by connecting the device with the card to the computer or removing the card from the device and inserting it into a memory card reader connected to the computer.

They provide removable and expandable storage options and use flash memory technology. Popular memory card formats include Secure Digital (SD) cards, microSD cards, CompactFlash (CF) cards, and Memory Stick.


***Figure 5.15:*** *SD Cards*

**Learning Tasks**

Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.

**Input and Output devices tasks**

1. List three input devices.
2. What category of device is a speaker?
3. Describe at least three things that you would consider when buying a new printer.
4. What category of device is a digital camera?
5. Name a device that is used to convert physical documents or images into digital format, which can then be stored or processed by a computer.

**Storage devices tasks**

6. List three categories of storage devices
7. Compare the following devices/media and use a table in Word to present your work. Use the internet to research your devices/ media further:

   HDDS vs SDDs, HDDs vs Magnetic Tape Drive, CDs vs DVDs, USB flash drive vs memory card

## PEDAGOGICAL EXEMPLARS

***NB:*** *These examples are only to serve as a guide to the teacher.*

1. Use the block diagram of a computer system as a means to open discussion on the LI and focal areas for this week.
2. Learners should brainstorm on input, output and storage devices (a whole class exercise).
3. Photographs of a collection of these devices labelled A, B, C, D, …. are displayed around the classroom. Each learner has to move around the classroom and write down the name of the device and its category (input, output, or storage)
4. Once activity three (3) has been discussed and corrected, in mixed-ability groups, learners should match these devices with a given list of tasks. An example of a possible task would be to transfer a Word document from a school to a home computer. A discussion may arise that several devices could be used for a task.
5. Learners working in pairs are asked to compare certain pairs of devices/media with related uses such as HDDS vs SDDs, CDs vs DVDs, Keyboards vs Mouse, and asked to present their comparisons in a suitable easy-to-read format.
6. Learners who need more clarification on computer hardware can watch this a video (by scanning QR code) before starting the next task.

7. Learners are required to complete a table template (column headings: device, typical use(s), main features, average cost, image) and then populate as much possible with no online assistance using

a set of devices set by the teacher. The teacher can differentiate by the number and complexity of devices assigned. Scan for template:

The average cost may be difficult to do at this stage.

8. *The teacher should bear in mind GESI principles, learners' digital literacy skills including proficiency at internet research, writing speed and communication clarity to form small mixed-ability groupings for the follow-on collaborative task.*

   Working in their groups and the devices assigned to the group by the teacher, the learners collectively decide on the entries to their group's table. Some of the devices assigned may differ from activity seven (7) (individual tables) but entries from activity seven (7) may be used, if applicable. The internet should be used, in particular, for image(s) and typical cost. (average cost would be difficult to calculate).

9. Task learners with designing a new gadget. They should draw diagrams and write annotations that explain what their gadget does. Their annotations should also clearly identify all input, output and storage devices/media included in their design.

   *This activity may lead to a discussion about the use of sensors for input and actuators (output devices that produces motion).*

**ASSESSMENT:**

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for these focal areas from Section 2 would be to ask learners to draw a concept map to represent their understanding of computer storage from this week's lessons.*

*The summative assessment questions below are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal areas.*

1. The teacher can organise a photo gallery hunt game for the learners to identify and list different input devices (keyboard, mouse, touchscreen, scanner), output devices (monitor, printer, touch screen) and storage devices (HDDs, SSDs, optical disk drives, USB flash drives and SD cards).

   **DOK Level 1: Recall**

   a. Learners should each be able to identify at least three input devices and output devices each.

   **DOK Level 2: Skill/ Concept Application**

   b. Learners should each be able to state and explain the functions of each of their selected devices.

**DOK Level 3: Strategic Thinking**

c. Analyse how the introduction of SSDs has changed the performance of computers compared to HDDs. Consider factors such as speed, durability, and energy consumption.

**DOK Level 4: Extended Thinking**

d. Learners should create a report on assistive technology, describing at least three assistive devices and their benefits. (Examples include a screen reader, a braille keyboard and a head mouse).

# WEEK 6

**LEARNING INDICATOR 1.1.2.LI.1 contd.:** *Explain the features of the hardware components of a computer (input hardware, processing hardware, output hardware, storage hardware and communication hardware).*

## Theme/Focal Areas:

1. **Network storage**
2. **Communication hardware**

***NB**: The second part of the storage hardware notes (network storage) and communication hardware.*

## KEY CONCEPT NOTES

Whether working on a stand-alone computer or a networked computer, storage is needed to store files for later use. A network is two or more computers that are connected, either wired or wirelessly, that can share resources such as printers, files, and software.

### Cloud Storage

Cloud storage refers to storing data on remote servers in data centres that is accessed through the internet. It offers flexible and scalable storage solutions with the convenience of accessing data from anywhere with an internet connection. The business running the cloud storage service manages backups and security. Nowadays, cloud storage is used by individuals, businesses and organisations throughout the world. Cloud storage is regularly used by users of both stand-alone and networked computers even though they will have local storage such as a hard disk and file server respectively.

Popular cloud storage services include Dropbox, Google Drive, Microsoft OneDrive and Amazon S3.

The following are two types of data centre storage systems: file storage devices and block storage devices

***1). File storage devices***

File storage devices, like network-attached storage (NAS), can store a large volume of files.

- **Network-Attached Storage (NAS)**

NAS devices are specialised storage devices connected to a network and used for centralised data storage and file sharing. Apart from their use in data centres, NAS devices are often used in homes and in small to medium sized businesses. They provide data access to multiple users or devices over a network. NAS drives are in operation 24/7, meaning the data and files can be accessed by authorised users at any time, unlike desktop hard drives, which are only in operation when their computer is on**.**

NAS devices typically contain from two to five hard or solid-state drives which gives them high-volume storage capacity. They offer capacities ranging from a few terabytes to multiple petabytes (1 petabyte (PB) is 1024 TB. NAS increases performance and reliability with features like RAID (explanation to follow).


***Figure 6.1*** *QNAP TS-464 4-Bay 16TB NAS w/ 4x4TB MG Hard Drive Bundle 19,633.48 Cedi (March 2024)*

NAS devices have a processor that provides computing intelligence and power to manage the file system. The processor reads and writes data to process and serve files, manage multiple users, and integrate with the cloud if desired. Although, not specified in the key features above, the QNAP TS-464 is powered by the Intel Celeron N5105 processor.

### *2). Block storage devices*

Block storage devices store data in blocks and provide many terabytes of data capacity. Storage area networks (SANs) are storage units that contain several internal drives (hard drives or solid-state drives) and act as large block storage systems.

- **Storage Area Networks (SANs):**

SANs are specialized high-speed networks that connect storage devices to the computer.

Apart from their use in data centres, SANs are commonly used in enterprise environments that require large-scale storage solutions and high-performance data access. SAN uses Fibre Channel and can use Ethernet.

To compare:

- A NAS is a single storage device that serves file-based data over Ethernet and is relatively inexpensive. NAS devices are easier for a home user or small business to set up.
- A SAN is a network of multiple storage devices serves block-based data over Fibre Channel and is more expensive and complex to set up and manage. A SAN is better suited for larger businesses and requires administration by IT staff.

YouTube Video:
4 mins


NAS vs SAN - Network Attached Storage vs Storage Area Network

**Data Redundancy and RAID:**

Redundant Array of Independent Disks (RAID) is a storage technology that combines multiple drives to improve performance, reliability and data redundancy. Data redundancy is when multiple copies of the same information are stored in more than one place at a time. This redundancy provides fault

tolerance which is the ability of a system to continue operating properly in the event of the failure of one or more components (in this case a disk failure).

RAID configurations provide fault tolerance and data protection by distributing data across multiple drives.

## COMMUNICATION HARDWARE DEVICES

Communication hardware devices enable the transmission and reception of data and signals between computers, devices, and networks. They facilitate communication and data transfer across various media.

1. **Network Interface Cards (NICs)**

   Network Interface Cards, also known as network adapters or network cards, enable computers to connect to networks. NICs provide the necessary hardware interface for transmitting and receiving data over wired networks. WNICs (Wireless Network Interface Cards) provide the same functionality for wireless networks. They support various networking technologies such as Ethernet, Wi-Fi, Bluetooth and cellular connectivity.

***Figure 6.2:*** *Network Interface Cards*

2. **Modems**

   Modems are devices used to modulate and demodulate digital signals into analogue signals and vice versa. Modems allow computers to communicate over analogue networks such as telephone lines. A modem is essential for internet access because it receives an analogue signal from the Internet Service Provider (ISP) and then converts it into a digital signal that work, school or home devices can understand and vice versa.

   Many modems nowadays are “all-in-one” devices that also include a router. This integrated device is sometimes called a gateway.

3. **Routers**

   Routers are networking devices that connect different networks (such as the internet and a school network) and direct data packets between them. Data packets are fundamental units of data transmitted over a network. They contain both the information being transmitted and metadata necessary for the network to deliver them to their intended destination.

Routers analyse network addresses, determine the most efficient path for data transmission, and forward packets accordingly.

You will need the features of both a modem and a router, integrated or not, in order to have an internet connection for all of the devices in a local network (for example, your home network).

***Figure 6.3:*** *Modem and Router*

**4. Switches**

Switches are devices that enable the interconnection of multiple devices within a local network. They receive and forward data packets to their intended destination based on their MAC (Media Access Control) addresses. A MAC address is a string of characters that identify a device on a network. Switches provide a dedicated connection for each device leading to enhancing network performance.

***Figure 6.4:*** *Switches*

The main difference between routers and switches is that routers connect networks while switches connect devices within a network.

**5. Hubs**

Hubs are networking devices that serve as central connection points for multiple devices within a network. They receive incoming data and broadcast it to all connected devices, making them less efficient than switches as bandwidth is shared. Only the intended network device will accept the data.

***Figure 6.5:*** *A Hub*

**6. Wireless Access Points (WAPs)**

Wireless Access Points, also known as WAPs enable wireless connectivity in local networks. They create wireless network signals that devices can connect to, allowing wireless communication and internet access.

***Figure 6.6:*** *WAPs*

**7. Repeaters and Extenders:**

Repeaters and extenders are devices used to extend the coverage area of a WiFi network. They receive and amplify signals to increase coverage and overcome signal degradation or distance limitations. however, they do it in different ways.

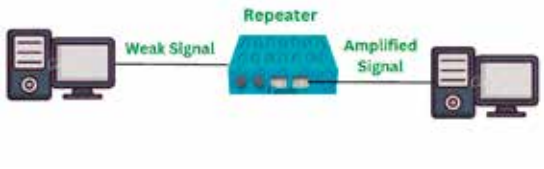


***Figure 6.7:*** *Repeater*

***Figure 6.8:*** *WiFi Extender*

**Learning Tasks**

Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.

**Computer Storage Tasks**

1. Write out and complete the following sentence:
   *C_____ storage is a mode of computer data storage in which digital data is stored on servers in off-site locations.*
2. Describe two benefits of cloud storage.
3. State a disadvantage of cloud storage.
4. What is SAN an acronym for in computing?
5. Describe one similarity and two differences between a NAS device and a SAN device.

**Communication Hardware tasks**

6. Give one advantage of a wireless network over a wired network.
7. Working in pairs or small groups, learners should name the communication hardware items shown on slides/printouts.

8. Use this image to explain the function of a modem.


9. Create three tables in a Word document, one for each of the following comparisons of pairs of communication hardware:
   - NIC and WNIC
   - Modem and Router
   - Switch and Hub

10. Use the internet to source the following:
    - a modem router combo
    - a modem
    - a router

Insert an image and the cost for each of the devices that you have found in three separate PowerPoint slides. On the fourth slide describe at least one advantage and one disadvantage of the combined device over the two separate devices.

## PEDAGOGICAL EXEMPLARS

***NB:*** *These examples are only to serve as a guide to the teacher.*

1. The teacher should introduce the week's first focal area (network storage) by conducting a whole class brainstorming session on computer storage devices/media covered to date.
2. Using words and phrases from activity one (1), volunteers from the class could create a concept map of computer storage on the board. The teacher should act two additional nodes – *Network Storage* and *Cloud Storage.* After a brief discussion on what is meant by these categories of computer storage, the class could discuss what links and any offspring nodes that they think could be added to the map. This may reveal prior learner knowledge of the first focal area.
3. Direct instruction using a presentation with images and video to explain cloud storage, NAS devices and SAN devices, as well as RAID. The video indicated on page 59 (NAS vs SAN) may be a bit too technical for some learners.
4. Learners work through some written questions on Network storage.
5. Learner should work in their teacher-selected groups to create a report on cloud storage using the headings:
   a) What is cloud storage?
   b) Examples of cloud storage services
   c) Advantages of cloud storage
   d) Disadvantages of cloud storage

6. A comparison table for NAS versus SAN could be created by learners using the column headings: cost, target users, speed, scaling potential, other.

7. An opening activity to introduce the second focal area (communication hardware) would be to brainstorm on the hardware required to set up an internet connection at home.
8. Direct instruction using a presentation with images and video to explain NICs, modems and routers.
9. A similar set of activities for other communication hardware that could be found in a LAN – brainstorming session and slides with visuals of the devices.
10. A set of names of communication hardware items on card and a set of images of the same devices are issued to the class. Working in pairs or small groups, learners should match up the name with the corresponding image.
11. Similarly, a set of communication and storage devices on card labelled A, B, C, D, …, which they should match to a set of hardware descriptions. Learners who are finding it difficult to understand should be assisted by peers or teachers for clearer explanation.
12. Learners in pairs/small groups make up a quiz, mixing questions from the two focal areas, and testing their quiz on their peers.

## ASSESSMENT

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for these focal areas from Section 2 would be a shadow test on communication hardware. Shadow tests allow learners and teachers to test whether a teacher's feedback following an assessment has been successful. A shadow test is a replica of another test (whose solutions the teacher has shared with learners) but with slightly different questions.*

*The summative assessment questions below are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal areas.*

1. The teacher can organise a photo gallery hunt game for the learners to identify and list different Communication Hardware Devices: Network Interface Cards (NICs), Modems, Routers, Switches, Hubs, Wireless Access Points (WAPs), Repeaters and extenders.

   **DOK Level 1: Recall**

   a. Learners should each be able to identify at least three communication hardware devices.

   **DOK Level 2: Skill/ Concept Application**

   b. Learners should explain the functions of each device selected in part a.

   **DOK Level 1: Recall**

   1. You need access to the internet for cloud storage.
      a. true
      b. false

   2. What does the acronym RAID stand for?

3. What does the acronym NAS stand for in computer networking?
   a. Network Attached Storage
   b. Network Allocated System
   c. Non-Accessible Storage
   d. New Age Storage

4. A modem connects a local network to the internet.
   a. true
   b. false

5. Which device helps increase Wi-Fi coverage in large buildings?
   a. Switch
   b. Repeater
   c. Router
   d. NIC

**DOK Level 2: Skill/ Concept Application**

1. Identify the primary function of a router in a office network. How does it differ from the role of a switch.

2. One advantage of RAID systems is fault tolerance.
   a. Explain what this means.
   b. State another advantage of a RAID system.

**DOK Level 3: Strategic Thinking**

1. Apart from a transmission medium, either wired or wireless, identify two other hardware components that are required to connect a computer to a LAN.

2. Evaluate the benefits of using a SAN over direct-attached storage for a large enterprise. Consider aspects such as scalability and performance.

**DOK Level 4: Extended Thinking**

1. Describe the requirements to set up a network in a small office with four workers. Include as many technical specifications as you can, with images and costs. A drawing showing a possible positioning of the hardware items within the office can also be included.

2. Use the internet to explore the difference between file data storage and block data storage. Create a diagram to illustrate each one. Find out the name of a third type of data storage and also create a diagram for it.

Scan this QR code for the solutions to some of the above questions:

# WEEK 7

**LEARNING INDICATOR 1.1.2.LI.1 contd.:** *Explain the features of the hardware components of a computer (input hardware, processing hardware, output hardware, storage hardware and communication hardware).*

## Theme/Focal Areas:

**Computer Motherboard – function and components**

***NB:*** *The motherboard ties together the hardware components listed in this LI.*

## KEY CONCEPT NOTES

Computer hardware encompasses a wide range of components that work together to form a complete computer system. Input, output, storage, communication, and some processing hardware have already been examined in this manual. Some devices may be classified in more than one category. For example, a touchscreen is both an input and an output device.

Examples of processing hardware include:

- CPU (Central Processing Unit)
- GPU (Graphic Processing Unit)
- Motherboard
- Sound Card
- NIC (Network Interface Card)

### Motherboard

A motherboard is an essential piece of hardware that is often referred to as the "heart" of a computer. It is a large circuit board that holds and connects all the essential components of a computer, allowing them to work together.

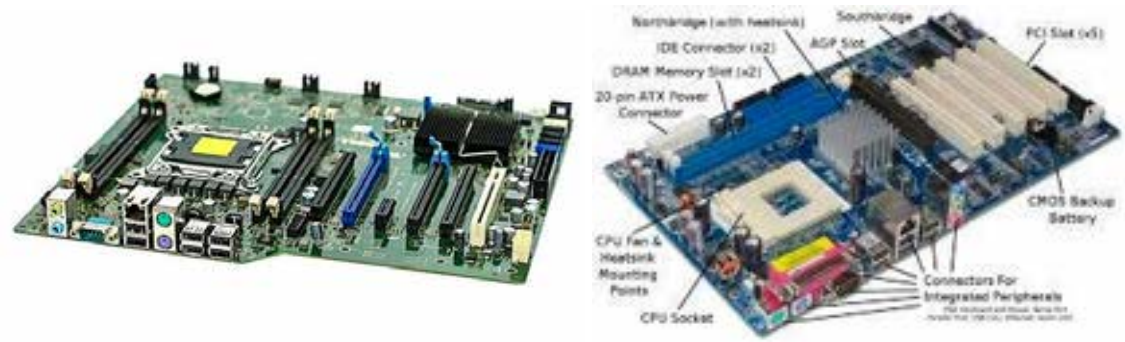


***Figure 7. 1:*** *Motherboards – empty and with components*

The motherboard's form factor is the specification of a motherboard, such as the dimensions, power supply type, location of mounting holes, and number of ports on the back panel, Different sizes of motherboards fit into different computer cases, so if building a computer, it is essential to choose a form factor that fits your chosen case.

**Motherboard Components**

**1. CPU Socket**

The CPU is installed through the CPU socket onto the motherboard. A fan is typically mounted directly on top of the CPU, dissipating heat generated by the processor's operation.

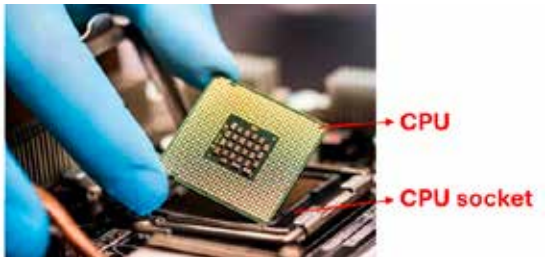


***Figure 7.2:*** *CPU installation*

The CPU (the "central" or "main" processor), often referred to as the "brain" of the computer is a complex set of electronic circuitries that runs the computer's programs.

*Specifications of a processor (CPU) include:*

- **Clock Speed:** Measured in GHz, it determines how fast the CPU can execute instructions.
- **Number of Cores:** Multicore processors can handle multiple tasks simultaneously.
- **Cache Memory:** Provides faster access to frequently used data for the CPU.

**2. RAM Slots**

RAM slots are where memory modules (RAM sticks) are inserted on the motherboard. RAM stores the program and data that the computer is currently using are stored, and more RAM means the computer can handle more tasks at once.

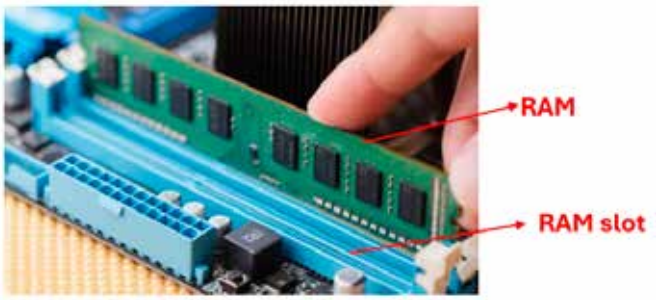


***Figure 7:3:*** *ROM and RAM slot*

RAM is a computer's short-term memory where the data and programs that the processor is currently using are stored.

*Specifications of RAM include:*

- **Capacity:** Measured in gigabytes (GB) for desktops, laptops and smartphones,
- **Speed:** Measured in MHz, it affects how fast data can be read and written to the RAM
- **Type:** here are a few different types commonly in use today: Static RAM (SRAM) Dynamic RAM (DRAM) Synchronous Dynamic RAM (SDRAM). The type used can affect the speed and power consumption.

**3. Expansion Slots**

Expansion slots are the connection points on the motherboard where you can add extra components like graphics cards, sound cards and WNICs to enhance the computer's capabilities.

4. **Chipset**

The chipset is often referred to as the “glue” of the motherboard. It is basically the electronics on the motherboard that communicate with all the connected components. It is like a traffic police officer on the motherboard. It manages data flow between the different parts, making sure everything works together smoothly.

5. **BIOS**

The BIOS (or Basic Input Output System) is software stored on a small memory chip on the motherboard that tells the computer how to start up, perform self-checks, and load the operating system. UEFI (Unified Extensible Firmware Interface) is a more modern solution doing the same job as a BIOS but works a bit differently.


***Figure 7.4:*** *photo of BIOS*

6. **Power Connectors:**

Power connectors on the motherboard provide electricity to all the components. Just like a power outlet in a wall, these connectors make sure all the parts get the power they need.

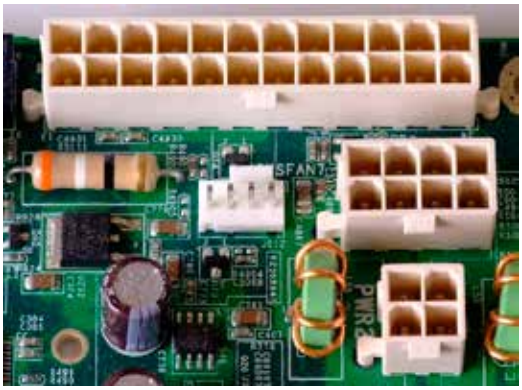


***Figure 7.5:*** *Power connectors*

7. **Storage Connectors:**

These connectors let you attach Hard Disk Drives (HDD) and Solid-State Drives (SSD) to store all your files and programs.

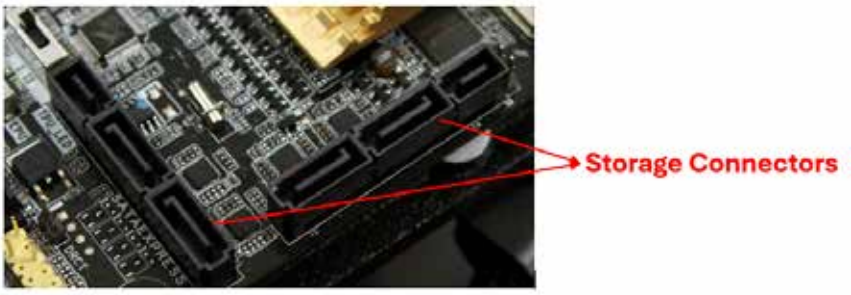


***Figure 7.6:*** *Storage Connectors*

8. **I/O Ports:**

I/O ports are like the computer's "communication points." They include USB ports, audio ports, Ethernet ports, and more, allowing you to connect various devices and peripherals. Peripherals are the electronic devices (e.g. a scanner) connected to the system unit. They expand the capabilities of the computer.


***Figure 7.7: Types of ports***

9. **Sound card**

A sound card is hardware that connects to the motherboard (via a PCIe slot) and is responsible for handling sound received via a microphone and for producing sound on a computer that can be heard through speakers or headphones Many sound cards have their own processor, a DSP (Digital Signal Processor) which handles audio-related tasks such as the calculations for analogue-to-digital and digital-to-analogue conversions, thus relieving the load on the main processor (CPU).

Alternative to a sound card, computer sound can be handled by a designated sound chip that is integrated into the motherboard.

***Figure 7.8:*** *PCIe sound card*

**10. Graphics Card**

A graphics card or video card is an add-in circuit board to the motherboard. One of its main components of this expansion board the Graphics Processing Unit (GPU) which is responsible for 3D graphics rendering and displaying images, videos, and animations on the computer monitor.


***Figure 7.9:*** *Graphics card*

Rather than a GPU being part of a separate card, sometimes GPUs are integrated, that is they are embedded in the motherboard. Some GPUs have their own memory to store graphical data separately.

**11. Onboard (or integrated) Components**

Built-in components, like a sound chip, GPU or a Wi-Fi chip, saves the computer user from having to add separate cards for these functions.

**12. Cooling System**

Motherboards need to cool the chips that would otherwise get too hot and degrade. There are two main options to safely mitigate heat from motherboard components such as the CPU: fans and heatsinks, and liquid cooling.

- Fans/Heatsinks**:** a cooling method using circulated air.
- Liquid Cooling: an alternative cooling method that uses liquid to dissipate heat

**Learning Tasks**

Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.

**Motherboard Tasks**

1. Write out and complete the following sentence:
   *Often referred to as the heart of a computer, the _____ is an essential piece of hardware that connects and powers various components, allowing them to work together.*

2. Name the components described below:
   (a) A physical connector on a computer's motherboard where you can insert memory modules.
   (b) Software stored on a small memory chip on the motherboard that the processor uses to start the computer system after it is powered on.
   (c) An external motherboard port for peripherals including keyboards, mice, external hard drives, audio equipment, and more.

3. (a) What does GPU stand for?
   (b) Describe the main function of a GPU.

4. Why might a motherboard have a heatsink?

## PEDAGOGICAL EXEMPLARS

**Motherboard Anatomy:**

1. The teacher can teach the learners using direct instruction and open class discussion about the components of the motherboard, its features and function (s) in a computer system. Ideally, circulate an old motherboard among the learners for closer examination.

2. Using online simulations, videos or photos, link learners' understanding from weeks 5 and 6 to the role of a motherboard, its various components and features.

3. Provide learners with labelled diagrams of the components of the motherboard and have them research to discuss features and importance of the components such as CPU socket, RAM slots, expansion slots, chipset, and I/O ports in their mix-ability groups.

4. Print/project or use a virtual whiteboard to give learners a motherboard image with/out labels in their mix-ability groupings. Ask the group members to collaborate to identify the various components (such as the RAM slots).

**Build a Computer**

1. Organize a hands-on activity (if possible) where learners work in small groups to assemble a computer from scratch. Provide them with a variety of components, including a motherboard, CPU, RAM, storage, graphics card (if needed), and a power supply. Guiding them through the

assembly process will allow them to gain a better understanding of the role of the motherboard in computer architecture.

2. Alternatively, the teacher can use online-simulations, videos or demonstrations to show how a desktop computer can be assembled.

3. The teacher can ask learners in their mix-ability groupings to write a narration of the assembly process after watching the demonstration video.

## ASSESSMENTS

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for these focal areas from Section 1 would be to ask learners to explain why the chipset is often referred to as the "glue" of the motherboard.*

*NB: The summative assessment questions below are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal areas.*

**DOK Level 1: Recall**

1. What is the role of a motherboard in a computer system?
2. Identify at most five components of the motherboard from the photo gallery and write the names in your exercise books. Scan the QR code for the photo gallery.
3. Name four examples of processing hardware in a computer system.

**DOK Level 2: Skills and Concepts**

1. Explain the function of the CPU socket on a motherboard.
2. Explain the importance of the number of RAM slots on a motherboard.
3. Differentiate between RAM slots and expansion slots on a motherboard.

**DOK Level 3: Strategic Thinking**

1. Compare and contrast the roles of the chipset and the CPU in a computer system.
2. Discuss how the I/O ports on a motherboard affect the connectivity of a computer system.
3. Evaluate the importance of expansion slots on a motherboard for upgrading a computer system

**DOK Level 4: Extended Thinking**

1. Imagine you are responsible for building the school team, where each player has their own unique powers and abilities. Think of the motherboard as the pitch where your team plays, and each component, like RAM, graphics cards, and other devices, as the players. Now, just like how some players work better together than others, the components of your computer need to be compatible to ensure your computer runs smoothly and efficiently.

   For example, if you put different types of RAM into the computer, it's like having players who don't get along well; they might not work together as effectively, causing your team to slow down or encounter problems. Similarly, adding too many players into a team without

considering their compatibility is like overcrowding the team with heroes, which can lead to chaos and reduce the overall efficiency of your team.

Your goal is to analyse the impact of a motherboard components' incompatibility and mixed specifications on the performance and functionality of a computer system (team).

Scan the QR code for the solutions to some of the above questions and some additional questions:

# WEEK 8

**LEARNING INDICATOR 1.1.2.LI.2:** *Describe the categories of Computer Software*

## Theme/Focal Areas:

1. **Identify the main two categories of computer software**
2. **Describe the function of application software**
3. **Describe the functions of the following system software: operating systems, device drivers, and utility software**

*The wording of LI 2 has been amended to fit with the Learning Outcome for Section 2, 1.1.2.LO.1. Categories of hardware have been covered by LI 1 in earlier weeks.*

## KEY CONCEPT NOTES

### CATEGORIES OF COMPUTER SOFTWARE

There are two main categories of computer software as shown in Figure 8.1 – Applications and System.

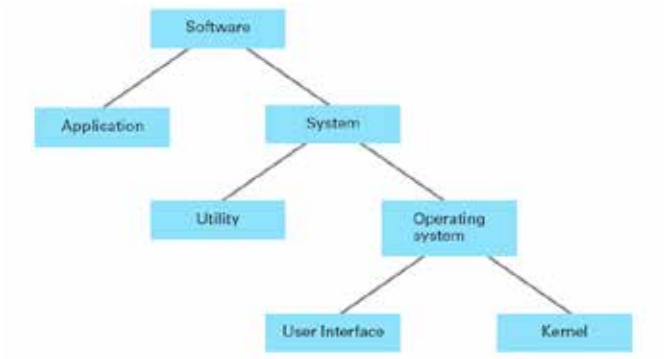


***Figure 8.1:*** *Categories of Computer Software*

### Application Software

Application software are programs designed to carry out a specific task other than one relating to the operation of the computer/device itself. Application software is tailored to fulfil particular user needs, such as productivity, communication, entertainment, education, and more. Examples of application software include a spreadsheet program, database management systems, a word processor, and games software. A computer used to maintain the inventory for a manufacturing company will run different application software from that found on a computer used by an electrical engineer for his/her work.

Application software runs on top of the systems software, an operating system and utilises system resources to execute tasks according to user instructions.

*Example of some categories of application software in more detail*

- **Productivity Software**

  Productivity software helps users create, edit, manage, and share various types of digital content, including documents, spreadsheets, presentations, and databases. Examples include Microsoft Office Suite (Word, Excel, PowerPoint), Google Workspace (Docs, Sheets, Slides), and Adobe Acrobat.

- **Multimedia Software**

  Multimedia software enables users to create, edit, organise, and playback multimedia content such as audio, video, and images. Examples include media players (VLC Media Player, Windows Media Player), photo editing software (Adobe Photoshop, GIMP), and video editing tools (Adobe Premiere Pro, iMovie).

- **Educational Software:**

  Educational software is designed to support teaching and learning activities by providing interactive tutorials, simulations, quizzes, and educational games. Examples include learning management systems (Moodle, Canvas), educational apps (Khan Academy, Duolingo), and digital textbooks.

## Systems Software

Systems software is the programs that governs the computer system. It:

- controls the hardware, including any peripherals
- allows application software to run
- provides an interface for the user to interact with the computer
- maintains the system

In essence, system software acts as an intermediary between the hardware and the end-user applications, enabling the efficient execution of tasks and providing essential services for the computer system to function properly.

Examples of important systems software:

1. **Operating Systems (OS)**

   An Operating System (OS) provides the user interface, manages hardware resources, and manages the running of applications.

   In order to perform the actions requested by the computer's users, an operating system must be able to communicate with those users. The portion of an operating system that handles this communication is often called the *user interface.* Older user interfaces, called shells, communicated with users through textual messages using a keyboard and monitor screen. Nowadays, computer systems usually perform this task by means of a *Graphical User Interface* (GUI—pronounced "GOO–ee"). In GUI systems, applications run in Windows, and all objects (apps, hardware and files) are represented by icons. Application features are accessible through the use of menus. Users interact with the interface by using a mouse and on-screen pointer.

An example of a hardware resource managed by the OS is RAM. When a program is run, it is loaded into RAM. The operating system determines how much memory the program requires, and allocates enough space to hold it and its data. When the program is closed, the allocated space is freed up for use by other programs.

Multitasking means to be able to run two or more programs simultaneously. An example would be a user streaming music while entering text into a word processor. All modern operating systems have multitasking capabilities. The OS allocates system resources such as CPU time, input/output devices, and computer memory among the programs currently running.

Examples of operating systems include Microsoft Windows, macOS, Linux, Android, and iOS.


***Figure 8.2:*** *Some OS examples*

**2. Device Drivers**

A device driver is a program that controls a specific hardware device attached to a computer. Device drivers control and facilitate communication between hardware devices and the operating system. They relay requests for device access and actions from the operating system and its active applications to their respective hardware devices. They also deliver outputs or status/messages from the hardware devices to the operating system and thus to applications.

Devices such as keyboards modems, routers, speakers, and printers require device drivers to operate.

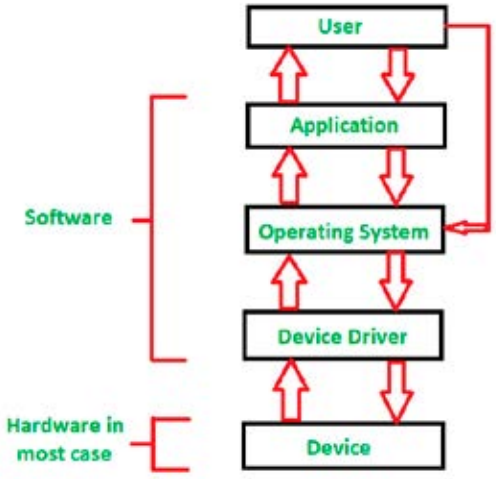


***Figure 8.3:*** *A device driver acts as a translator between a hardware device and the applications or operating systems that use it.*

### 3. Utility Software

Utility Software is system software that helps to maintain the proper and smooth functioning of a computer system. These programs assist the operating system to manage, organize, maintain, and optimise the functioning of the computer system.

A file compression program is an example of utility software. Other examples are shown in Figure 8.4.


***Figure 8:4*** *Examples of utility software*

*Comparison between utility software and operating systems*

- An OS **is a must-have software to operate a computer, while** utility software **is optional and can be added as per user convenience.**
- Utility software assists the operating system but never replaces it.
- Both are system software but their functions do not overlap.

**Learning Tasks**

Note that the teacher should differentiate the content to suit the proficiency levels of the different learners. The teacher should not expect all learners to be able to perform all the activities.

**Software Tasks**

1. What is software?
2. Name two categories of software.
3. What category of software does an operating system belong to?
4. Which of the following are operating system tasks?
   a. playing music
   b. word processing
   c. protecting computer against viruses and malware.
   d. managing the use of the computer's memory
   e. monitors and optimises the performance and health of the hard drive
   f. providing a user interface
5. List four examples of utility software.
6. Tick all examples of application software from a list of given software (including spreadsheet program, MS Word, anti-virus software, MS Windows, printer driver)
7. Create a poster that illustrates what is meant by application software. Your poster should display the names of some generic application software.

8. Write a set of 10 multiple-choice quiz questions on computer software. Test your peers with your quiz, awarding 1 mark per correct answer.
9. Working in pairs, assign each item in a list of tasks as needing either system software or application software. For example, the task to allow computers and network hardware components to interface and interact with specific devices would be assigned to systems software (device driver).

## PEDAGOGICAL EXEMPLARS

*These examples are only to serve as a guide to the teacher.*

1. Ensure that all learners know the difference between the term program and software at the beginning of a lesson.
2. Learners brainstorm on as many examples of software that they can name in 3 minutes.
3. Introduce the focal area for this week and tie with the previous weeks by having a class discussion about the statement 'hardware cannot function without the software'.
4. Using direct instruction, and slides with text, diagrams, photographs and suitable video links, go through the features of applications software, and examples.
5. Similarly, use a slideshow to through the course content on systems software.
6. Learners in their group watch a video demonstration on how a printer driver works with the operating system to print a document on one laptop but not on the other.
7. The operating system will require more time to describe and explain than the other software. Real-life analogies could be used. One possibility is in the same way a librarian manages a library, the operating system manages computer resources, like memory and CPU.
8. Teachers can list examples of utility software and their uses and also allow learners to share their experiences of using any of this software,
9. Teachers can create a pick and match bowl activity, asking learners in pairs to identify whether given software examples are system or application software.
10. Try some new interactive classroom activities. For example, hangman.

    Divide the class into two teams then select a learner to stand at the front of the class and think of a word related to the lesson (such as driver). The student must then draw spaces on the whiteboard to represent each letter in their word. The rest of the class then guesses the word, one letter at a time (allow one student from each team to guess alternatively). Incorrect guesses result in a hangman being drawn (one line or circle at a time). The first team to guess the word wins, unless the hangman is completed. The game then repeats with another student thinking of a relevant word.

## ASSESSMENTS

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects and more. Another example of a formative assessment for this focal area from Section 1 would be to ask learners to create a poster that describes utility software.*

*The summative assessment questions below are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal area*

**DOK Level 1: Recall**

1. What is the purpose of an operating system?
2. List the names of two computer operating systems.
3. List four examples of device drivers.

**DOK Level 2: Skills and Concepts**

1. Describe two functions of the operating system.
2. What is the difference between application software and utility software?
3. Explain how device drivers facilitate communication between the operating system and hardware devices. Provide an example to support your explanation.

Scan this QR code for the solutions to the some of the questions above. Note that some of the questions are different.

# Section 2: Review

In this section, the manual covered areas of computer components, hardware and software, and examined their functions. In the first three weeks of the section the focus was on the importance of the computer's hardware -input, output, processing, storage, and communication devices

In the last week, we explored different software types, such the systems software that runs the computer (in particular, the operating systems) and programs we use for specific tasks (application software).

Teachers are required to use videos, group activities, discussions and more (where applicable) to make these focal areas understandable to the learners and show them how they are used in real life.

To check learners' understanding of the focal areas in weeks 5 to 8, teachers are required to use tasks that make learners think more about how computers work and assess learners using both formative and summative methods. A checklist of the topics to be examined should be distributed in advance of end-of-section tests. This resource should be a valuable aid to learners when revising.

Teachers are advised to read more on the topics discussed and not restrict themselves to information provided in this manual only. Hardware and software trends continue to change. The latest trends (at the time of writing this manual) that are/will impact both hardware and software design include quantum computing, edge computing, Internet of Things (IoT) hardware, artificial intelligence (AI) chips, augmented reality (AR) and virtual reality (VR) equipment.

**Teaching and Learning Resources**

*Here are some proposed teaching and learning resources list, the teacher can integrate into his/her lesson.*

| | |
|---|---|
| • Photos<br>• Videos<br>• Smartphones<br>• Desktop/Laptop computers<br>• Tablets<br>• Open Educational Resources (Including: YouTube, MOOCS-Udemy/Coursera, Khan Academy, TESSA) | • Productivity tools<br>• Subject-based application software<br>• Instructional Laboratories (with multimedia equipment and smartboards)<br>• Interactive Whiteboard (like Kahoot Whiteboard)<br>• Paper Ball (as activity ball)<br>• A4 Sheets/ Cardboards<br>• Interactive Whiteboards (Like google Classroom boards/ Zoom Whiteboard or Kahoot Whiteboard)<br>• A box of old hardware components<br>• Word processor<br>• Presentation program<br>• Paint program |

## ADDITIONAL READING

### Books


1. Brookshear, J. G. Brylow, D. (2019). *Computer Science: An Overview, Global Edition*. Pearson Education Limited.
2. Chakraborty, P. (2020). *Computer Organisation and Architecture: Evolutionary Concepts, Principles, and Designs*. CRC Press.
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# SECTION 3

**STRAND:** **Computer Architecture and Organisation**

Sub-Strand: Data Communication and Network Systems

**Content Standard 1.1.3.CS.1:** *Demonstrate knowledge and understanding of network design*

**Learning Outcome 1.1.3.LO.1:** *Use skills and knowledge to identify and differentiate between the different types of Network Systems*

## INTRODUCTION AND SUMMARY OF SECTION

In this section, we will continue to explore computer architecture and organisation, but will now focus on data communication and network systems. Teachers will be required to guide learners through the basic aspects of network design and operation, aiming to impart the knowledge and skills necessary to comprehend and classify various types of networks and understand the fundamentals of how networks work. Network design and operation is a vast field with a lot of theoretical content, much too complex to cover fully at this level in four weeks. The key concepts in this field that will be explored include the four main types of area networks, network components, topologies, protocols, as well as transmission media, wired and wireless. An outline is included of a conceptual model that represents how network communications work – the OSI model.

During the delivery of this key concepts and technologies behind data communications, the importance of understanding both the theoretical and practical components of network infrastructure should be emphasised.

The breakdown of the weekly learning indicators is as follows:

**Week 9** **Explain computer networks and how they work**
*Part 1 - Advantages of a computer network over stand-alone computers, Components of a computer network*

**Week 10** **Identify at least 3 types of network systems and differentiate among these three types.**
*PANs, LANs, MANs, and WANs, and the differences between them*

**Week 11** **Explain computer networks and how they work**
*Part 2 - Client-server and P2P network architecture, Cloud networking, An introduction to the OSI model*

**Week 12** **Explain computer networks and how they work**
*Part 3 - Wireless connections, Wired connections, Comparing wireless and wired networks*

## SUMMARY OF PEDAGOGICAL EXEMPLARS

This section considers a variety of teaching and learning approaches, strategies and techniques. These include hands-on activities where learners engage in practical activities to research, explain and demonstrate. Experiential learning activities with mixed-ability and mixed gender groupings should play a prominent role. Practical sessions and project-based learning will increase learner engagement,

foster valuable collaboration and teamwork skills, and provide opportunities to practise their digital literacy skills.

Brainstorm, brain write and discuss will have a place, in particular when introducing topics or during plenary sessions. Allow the learners to engage in related hand-on activities whenever possible. Examples include learner demonstrating how to connect a smartphone to the school's Wi-Fi or a cellular network, identifying segments of physical cable when studying transmission media or actual network hardware when studying network components. Computing networking can be a very theoretical and technical subject which some learners may struggle to relate to. Suitably selected photographs, diagrams, videos, and animations in lessons will make some of the content more accessible to learners.

All learners, irrespective of their learning abilities should be encouraged to participate fully in lessons. And, of course, consideration and accommodation should be made for the different learning styles of the learners. Offer below average/approaching proficiency learners the opportunity to make oral presentations when it is deemed fit, and provide more challenging extension activities for the above average/highly proficient learners.

## SUMMARY OF ASSESSMENT

In this section, the Depth of Knowledge (DOK) framework is applied to evaluate learners' knowledge and understanding, and skill acquisition in the given focal areas of Data Communication and Network Systems. The Assessment section takes into consideration all four levels in the Revised Bloom's Taxonomy. Level 1 (Recall/Reproduction), Level 2 (Skills/Conceptual understanding), Level 3 (Strategic Thinking/ Reasoning), and Level 4 (Extended Critical Thinking and Reasoning). There are assessment suggestions that can fit to different levels of ability - learners approaching proficiency (AP), proficient (P) learners and highly proficient (HP) learners.

Apart from the traditional form of practical and written tests and assignments, assessment in this section can include many other forms. These could include demonstrations of how to do a practical task relating to a focal area (for example, how to set up a wPAN such as pairing wireless headphones to a smartphone), mind maps and concept maps, multiple choice quizzes, group projects, self-assessments, oral presentations, peer review, portfolios, debates, game-based assessments, and matching tasks.

Please note that the key assessment items in this manual are only to serve as a guide for the teacher to establish learners' understanding of the course material and pinpoint areas needing further assistance or practice. They should not in any way limit the teacher from exploring and creating his/her own questions and activities.

# WEEK 9

**LEARNING INDICATOR 1.1.3.LI.1:** *Computer Networks and how they work*

## THEME/FOCAL AREAS:

1. **Advantages of a computer network over stand-alone computers**
2. **Components of a computer network**

## KEY CONCEPT NOTES

### Introduction to Computer Networking

The need to share information and resources among different computers has led to linked computer systems, called networks, in which computers are connected so that data can be transferred from machine to machine. The two primary purposes of computer networks is to facilitate communication and share resources among connected devices. Using networks, computer users can exchange messages and share resources, such as printing capabilities, software packages, and data storage facilities.

Examples include an office network (connecting computers, printers, and a server), a cafe with free Wi-Fi (allowing customers to connect their phones to the internet), and an ATM network (connecting ATMs to a bank's network to allow customers to access their accounts from various locations).

## ADVANTAGES OF A COMPUTER NETWORK OVER STAND-ALONES

Computer networking offers numerous benefits, which have significantly transformed how we communicate, access information, and conduct business. Some of the key advantages of computer networking include:

1. **Resource Sharing:** one of the primary benefits of networking is the ability to share hardware resources (e.g. printers, scanners, storage devices) and software applications among multiple users. This reduces costs and increases efficiency as each device does not need to have dedicated resources.

2. **Data Sharing and Collaboration:** networking enables seamless sharing of data and files between users, facilitating collaboration on projects and tasks. This is particularly useful in business settings where teams need to work together on documents and presentations.

3. **Shared Internet Access:** networking allows multiple devices to share a single internet connection, making it a cost-effective and convenient way for businesses and households to provide internet access to all connected devices.

4. **Centralised Management:** in a networked environment, system administrators can manage and monitor multiple devices and users from a central location. This centralised management simplifies tasks like software updates, security configurations, and user permissions.

5. **Communication:** networking enables efficient communication through various means, such as email, instant messaging and VoIP (Voice over Internet Protocol). These communication tools help individuals and businesses stay connected regardless of geographic locations.

6. **Improved Efficiency:** computer networking streamlines various processes, reducing the need for manual tasks. For example, automated backups and data synchronisation across devices improve data reliability and reduce data loss risks.

7. **Remote Access:** with network connectivity, users can access resources and data remotely. This is especially valuable for employees working from home or on the go, as they can access some office resources securely from any location.

8. **Scalability:** networks can be designed to easily scale to accommodate additional devices and users as an organisation grows, without significant changes to the existing infrastructure.

9. **Cost Savings:** by sharing resources, businesses can cut down on hardware and software expenses. Additionally, networked environments can reduce paper usage through digital file sharing and electronic communication.

10. **Enhanced Security:** while security is a concern in networking, a properly configured network can implement security measures like firewalls, encryption and access controls, which improve data protection and can prevent unauthorised access.

11. **Real-Time Data Exchange:** in industries like finance and manufacturing, real-time data exchange is crucial for decision-making. Networking allows the rapid transmission of information between systems and applications.

12. **Global Connectivity:** the internet and other wide area networks (WANs) enable global connectivity, linking people, businesses and information worldwide. This has revolutionised the way we access information and conduct international business.

## COMPONENTS OF A COMPUTER NETWORK

Computer networks are composed of several key components that work together to enable communication and data exchange between devices. These components include:

1. **Hub:** this device serves as a central connection point for multiple devices in a network. It relays any signal it receives with some amplification back out to *all* the devices connected to it.

   Hubs are less common today due to their inefficiency and lack of intelligence in data transmission.

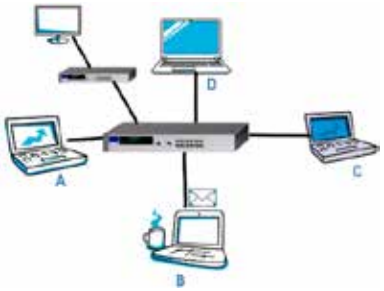


***Figure 9:1*** *A hub connected to devices*

2. **Nodes:** these are the devices connected to the network that can send, receive, and process data. Examples of nodes include computers, laptops, servers, routers, switches, smartphones, printers, and other smart devices.

***Figure 9:2*** *Network with 6 connected nodes*

3. **Network Interface Card (NIC)**: this a hardware component that allows a device to connect to the network. It is responsible for converting data from the device into a format suitable for transmission over the network, and vice versa. A WNIC (wireless NIC) enables wireless connectivity to a network.


***Figure 9:3*** *NIC*

4. **Communication Channels:** these are the physical or logical pathways through which data is transmitted between nodes. They can be wired (e.g. Ethernet cables, fibre optics) or wireless (e.g. Wi-Fi, Bluetooth).

5. **Switches**: these are devices that facilitate the connection and communication between multiple devices within a local area network (LAN). They use MAC addresses (media access control addresses) to forward data to the intended recipient. A MAC address is a 48-bit number assigned to each device connected to the network. This intelligence is illustrated in Figure 9:4.

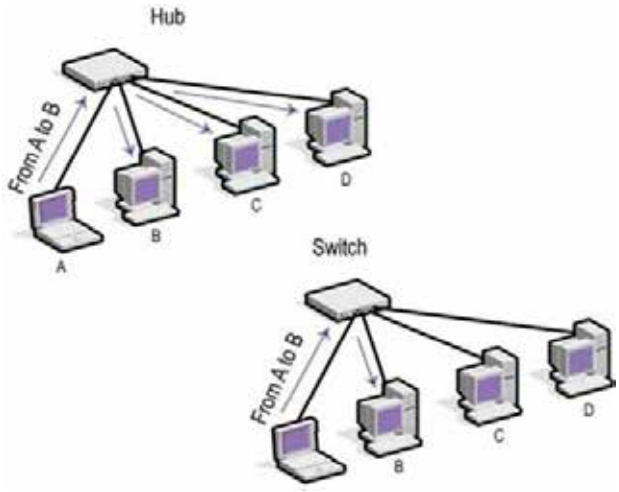


***Figure 9:4*** *A hub and switch*

6. **Routers**: these are digital devices that connect different networks and determine the best path for data to travel from the source to the destination across the internet or other networks.

7. **Modems:** these devices are used to modulate and demodulate digital signals to enable communication over analogue communication channels, such as telephone lines. Modem router combo devices combine the functionalities of routers and modems.

8. **Protocols:** these are a set of rules and conventions that govern how data is transmitted, received, and processed over the network. Examples include TCP/IP (Transmission Control Protocol/ Internet Protocol), HTTP (Hypertext Transfer Protocol), and DNS (Domain Name System).

9. **Network Operating System (NOS):** this is the software that manages and controls the network, providing services such as file sharing, network security, and network administration.

10. **Firewalls:** these are computer network security systems (hardware or software) that monitor and control incoming and outgoing network traffic, protecting the network from unauthorised access and potential threats. It will filter data by checking to see if it or its behaviour fits the profile of malicious code.

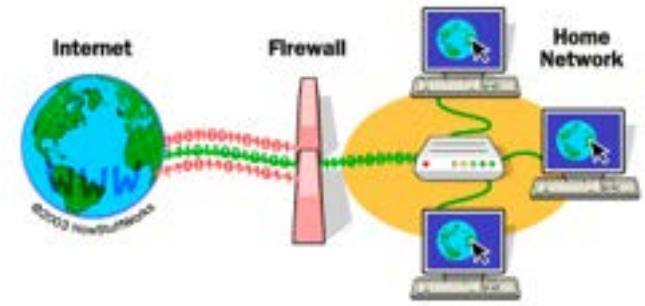


***Figure 9:5*** *A firewall is an example of a network security solution*

The main difference between a hardware firewall and a software firewall is that the hardware firewall runs on its own physical device, while a software firewall is a program installed on a computer. A common example of a software firewall is the firewall built into most operating systems like Windows and macOS.

11. **Network Cables and Connectors:** these physical cables (e.g., Ethernet cables) and connectors are used to establish wired connections between devices in a network.

12. **Wireless Access Points (WAPs):** these provide wireless connectivity to devices within a local area network, allowing them to connect to the network without the need for physical cables. Some WAPs can be wall mounted – see Figure 9:6

***Figure 9:6*** *WAP*

13. **Network Topology:** this refers to the physical or logical arrangement of nodes and communication channels in a network. Common topologies include star, bus, ring, and mesh. (Topologies will studied in Week 11)

14. **Workstation:** a term sometime used to describe a computer (usually desktop) connected to a LAN.

Each of these components play a specific role in a network, contributing to the efficiency and effectiveness of its operation. They work together to enable data sharing, resource sharing, and communication between network devices and users.

**Learning Tasks**

Here are some tasks to help learners understand the focal area in week 9. Kindly take note of differentiated learning when applying these tasks.

**Teaching and learning activities**

1. The teacher can start the lesson by having an open class discussion with what a computer network is and examples in society, including networks that are relatable to the learners. This could lead to a discussion about the advantages of using networks.
2. Present real objects or photos of the network devices to be taught and ask learners to identify the devices they know and their functions.
3. After discussion and instruction, the teacher should diagnose learners' understanding to group them appropriately.

   *Group activities:*

   **Task 1**
   - The teacher should guide the learners to collaborate to research different types of network hardware. Each group could perhaps could be given a fictional budget to source two examples of the same hardware; for example, two router/modem combo devices, each costing no more than a specified amount.
   - Every group should be given the opportunity to present their research findings to the whole class.

   **Task 2**
   - Present each group with a set of images and/or descriptions of network components.
   - The learners should work together in their groups to correctly name the device described or shown.

4. *Individual activity:*
   **Task 3**
   Create a glossary of network components on paper or using the Tables tools in Word.

## PEDAGOGICAL EXEMPLARS

*These examples are only to serve as a guide to the teacher.*

1. *Brainstorming sessions to introduce each focal area:* Once the definition of a computer network is established, the learners should brainstorm the reasons for using a computer network. This should lead nicely into the advantages of a computer network over a set of stand-alone computers, as well as an indication of each learner's current grasp of this area of computing. A brainstorm of the components that make up a computer network would also be a good way to start a study of the second focal area for this week.
2. *Direct instruction:* Teachers should use a variety of multimedia (photos, diagrams, videos, animations) to facilitate visual learning.
3. *Demonstration:* If possible, demonstrate using old or existing network hardware. Even simply plugging an ethernet cable into the back of a school computer will aid a learner's understanding of how a NIC and network cabling are linked.
4. *Group activities:* See Task 1 and 2 above for possible activities.

## ASSESSMENT

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects, and more.*

*The summative assessment questions that follow are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the two focal areas.*

**DOK Level 1: Recall/Reproduction**

1. What is a computer network?
   a. Two or more computers working at the same time
   b. Two or more computers connected together for the purpose of communicating
   c. A standalone computer
   d. A router

2. Name two resources that can be easily shared among workstations or user computers on a network.

3. State one advantage of using a local area network (LAN) over individual standalone computers.

4. Which of the following best describes a node?
   a. An Ethernet cable
   b. Any device connected to a network
   c. A type of network switch
   d. The internet

5. What is the name of the computer component that is responsible for converting data from the computer into a format suitable for transmission over the network, and vice versa?

6. HTPP is an example of which of the following?
   a. Hardware
   b. Software
   c. A protocol
   d. Multimedia

7. State a primary purpose of a computer network.

8. Complete the sentence:
   A _____ monitors and controls incoming and outgoing network traffic, protecting the network from unauthorised access and potential threats.

9. Which will create faster and more efficient networks – a hub or a switch?

10. What is the name of the software that coordinates the activities of multiple computers across a network?

**DOK Level 2: Skills and Concepts**

1. Describe one similarity and one difference between a switch and a router.

2. The office for a finance business needs five computers to perform their day-to-day work which includes the processing and printing of letters and customer bills.
   a. Give a reason why a network rather than five stand-alone computers would save the business money.
   b. Describe how using a network can save the company time.

3. Compare the main purpose of a modem to that of a router.

4. Create a slideshow with descriptions of the main functions of each of the following items of network hardware: NIC, modem, router, switch, hub, WAP.
   Include images and video links in your slideshow.

5. Explain why a large school network would need a switch.

6. Describe one advantage of a hub over a switch.

7. Discuss the possible costs incurred to set up and maintain a computer network.

8. Why do switches create faster and more efficient networks than hubs?

9. Describe two disadvantages of a computer network over a set of stand-alone computers.

**DOK Level 3: Strategic Thinking**

1. The office for a finance business needs five computers to perform their day-to-day work which includes the processing and printing of documents, and emailing customers.
   a. Give three reasons to recommend networking these computers.
   b. List the additional items of hardware that are required set up a network in the office.

2. A travel agency business has several branches in the same city.

3. Design a strategy for their network that would mitigate against data loss through malicious or accidental activity.

4. Describe a network scenario where a switch would not be required.

**DOK Level 4: Extended Thinking**

1. Will ChatGPT replace network engineers? Discuss.

2. Investigate the impact of implementing AI in computer networks.

# WEEK 10

**LEARNING INDICATOR 1.1.3.LI.2:** *Identify at least 3 Types of Network Systems*

**LEARNING INDICATOR 1.1.3.LI.3:** *Differentiate among three types of Network Systems*

## THEME/FOCAL AREAS:

1. **Types of computer area networks**
2. **Types of network topologies**
3. **Differences between different area networks**

## KEY CONCEPT NOTES

The term 'type of computer network' is generally understood to be the types of computer networks based on geographical scope, also known as area networks. However, the types of computer networks can also be classified based on other criteria, including the topology of the network.

## TYPES OF COMPUTER AREA NETWORKS

Area networks include a personal area network (PAN), a local area network (LAN), a metropolitan area network (MAN), or a wide area network (WAN).

1. **PAN** is normally used for short range communications—typically less than a few metres, such as between a wireless mouse and a PC.

2. **LAN** normally consists of a collection of computers in a single building or building complex. For example, the computers in a school or those in a manufacturing plant might be connected by a LAN. LANs provide high data transfer rates and low latency (delay in network communication), making them ideal for resource sharing and collaborative work.

3. **MAN** is a network of intermediate size, such as one spanning a campus, a region or even a city.

4. **WAN** links computers and devices over a greater distance—perhaps in neighbouring cities or on opposite sides of the world. WANs can also connect other small and medium networks like LANs and MANs – see Figure 10.1. The internet is essentially a huge international WAN.

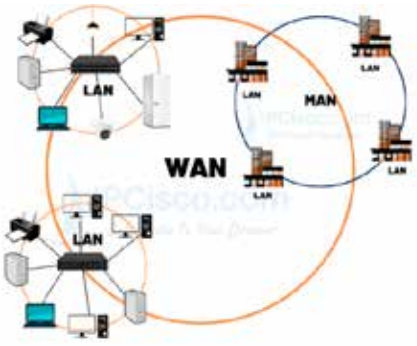


***Figure 10:1*** *A WAN*


***Figure 10:2*** *Range of area networks*

## TYPES OF NETWORK TOPOLOGIES

Network topology refers to the physical or logical arrangement of devices and connections in a computer network. There are several types of network topologies, each with its advantages and disadvantages. Here are the main types:

1. **Bus Topology:** all devices are connected to a single central cable called the 'bus'. Each device on the network can communicate directly with the others. However, if the central bus cable fails, the entire network will go down.

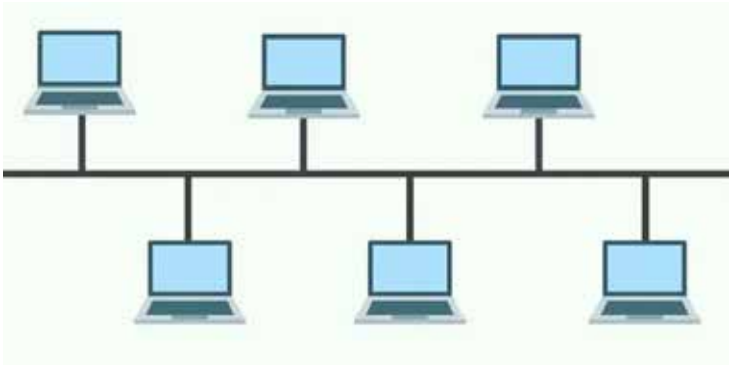

***Figure 10:3*** *Bus Topology*

2. **Star Topology:** all devices are connected to a central hub or switch. Each device has its dedicated connection to the central hub, making it easier to manage and troubleshoot individual connections. If one device fails, it does not affect the rest of the network. However, the central hub becomes a single point of failure.

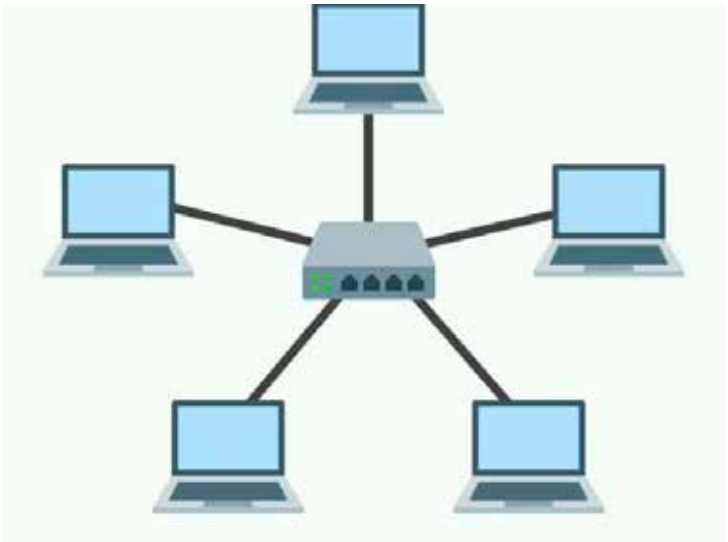

***Figure 10:4*** *Star Topology*

3. **Ring Topology:** the devices are connected in a closed loop. Each device is connected to two other devices, creating a continuous circle. Data travels around the ring from one device to the next until it reaches its destination. Ring topologies are less common due to the risk of a single connection failure disrupting the entire network.

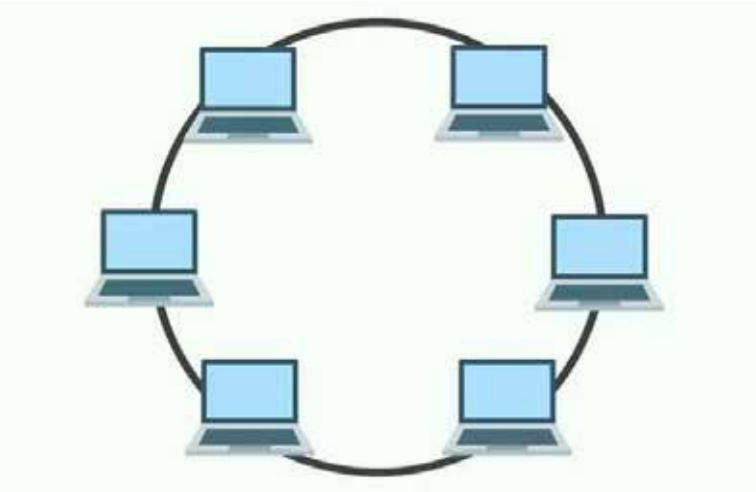

***Figure 10:5*** *Ring Topology*

4. **Mesh Topology:** every device is connected to every other device in a fully-connected mesh network. This redundancy ensures multiple paths for data to travel, providing high reliability and fault tolerance. Fault tolerance refers to the ability of a network to continue operating without interruption when one or more of its components fail. Mesh topologies are highly resilient but can be costly to implement due to the large number of connections required.

A partial mesh topology provides alternate routes from each node to some of the other nodes on the network.

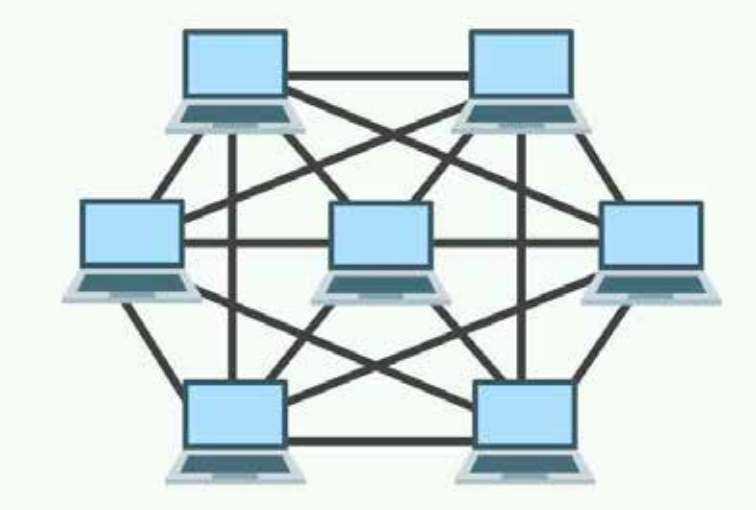

***Figure 10:6*** Mesh Topology

5. **Tree (Hierarchical) Topology**: is a combination of bus and star topologies. It has a central hub (root) connected to multiple devices in a star configuration. Each of these devices can then have additional devices connected to them, forming a hierarchical structure. Tree topologies are useful for large networks that require subnetworks and hierarchical organisation.

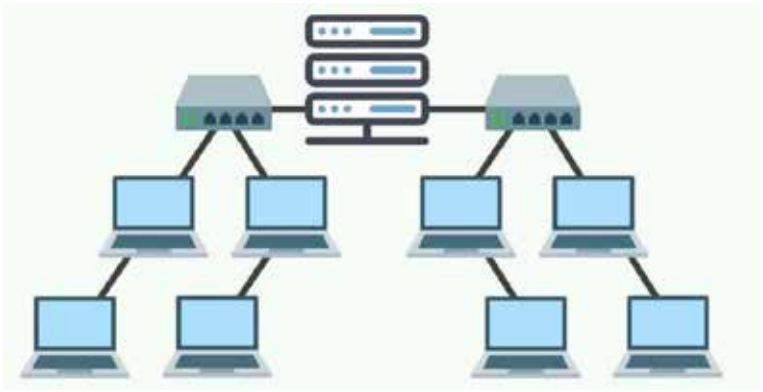

***Figure 10:7*** **Tree Topology**

6. **Hybrid Topology:** combines two or more different types of topologies. For example, an example of a hybrid topology is a ring-star, where a star network is connected through a hub to a ring network. Hybrid topologies offer flexibility and can suit complex network requirements.

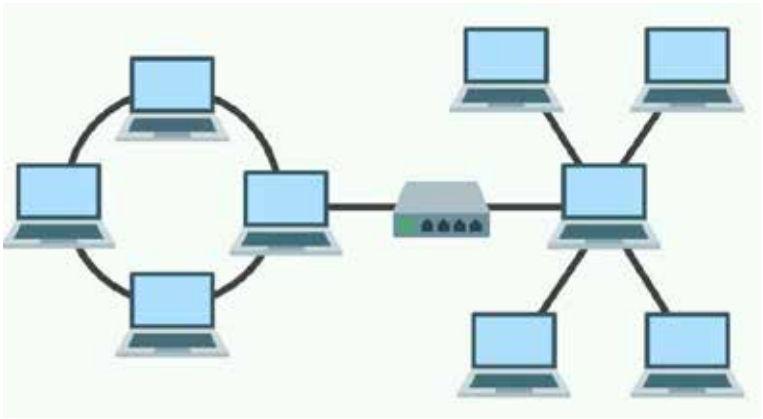

***Figure: 10:8*** Hybrid Topology

Each network topology has its strengths and weaknesses, and the choice of topology depends on factors like the size of the network, the desired level of redundancy, cost considerations, and the specific needs of the organisation or application.

Note that network redundancy refers to the process of adding additional or alternate instances of network devices, equipment, and communication channels within a network infrastructure. This is done to ensure network availability in case of a network device or path failure.

## DIFFERENCES BETWEEN DIFFERENT TYPES OF NETWORKS

These notes will only look at the differences between the three types of area networks, LANs, MANs, and WANs. Other criteria other than those given in the table below can be added when comparing these networks as we will see in later weeks. See Figure 10:2 for the range of these networks.

| Criterion | LAN | MAN | WAN |
|---|---|---|---|
| Area | A network that connects devices in a small geographic range. | A network that connects large areas than LANs such as small towns or cities. | The network covers a large areas such as a country or several countries. |
| Example | School network | University network | Internet, ATM network |
| Ownership | Private | Public or private | Public or private |
| Topology | Star, Bus, or Ring | Ring, Mesh, hybrid | Point-to-point1, Mesh |
| Transmission speed | High | Moderate | Low |
| Fault tolerance | More fault tolerance | Less fault tolerance | Less fault tolerance |
| Maintenance | Easy to maintain as has a less complex structure | More complex structure than LAN and is also more difficult to maintain. | Maintenance and the design structure are more complex compared to LAN and MAN. |
| Congestion | Less | More | More |

Point-to-point networks are used to connect two locations together via a private, dedicated line.

**Learning Task**

Here are some tasks to help learners understand the focal area in week 10. Kindly take note of differentiated learning when applying these tasks.

**Teaching and Learning Activities**

1. The teacher can guide a class discussion on what the learners remember about the lessons on computer networks to date.
2. Using visual aids (tables, diagrams, videos, and/or animations), discuss with the learners the two focal areas for this week - network types and topologies (Scan QR code for example).
3. The teacher can create matching activities from the content for learners to tie the types of networks and topologies with descriptions/diagrams.
4. Using pick-from-hat-and-explain, teachers should task learners in mixed-ability groupings to explain in their own words PAN, LAN, MAN, and WAN, and the main features of these area networks.
5. Repeat pick-from-hat-and-explain activity for the types of topologies.

6. - The class should brainstorm possible criteria to compare different types of area networks such as geographical area and ownership and then settle on the most appropriate.
   - A blank table with 5 columns should be created and these criteria listed in the first column headed 'Criterion'. The other columns should be headed PANs, LANs, MANs, and WAN.
   - Working in pairs or small groups, the learners should populate the table (see previous page for a comparison table with just three of these network types).
   - Come together and finalise a table that summarises the differences between these four area networks.

## PEDAGOGICAL EXEMPLARS

*These examples are only to serve as a guide to the teacher.*

1. Using talk for learning, teachers should have an open class discussion with the learners in the introduction process.
2. The teacher can use the visual images provided or create similar ones to assist in conveying the key concepts.
3. GESI, SEL and SEN should be considered when grouping for the Learner Tasks 4, 5, and 6.
4. Teachers should diagnose responses given during lessons and guide the learners to reflect on how they could improve on their responses.

## ASSESSMENT

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects, and more.*

*The summative assessment questions that follow are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the focal areas.*

**DOK Level 1: Recall/Reproduction**

1. Name the topology shown in Figure 10.9.

Figure: 10:9

2. What type of area network is the internet?
3. Which of the following types of network has the biggest geographical coverage?
   a. MAN
   b. WAN
   c. LAN
4. Which is easier to maintain – a LAN or a WAN?
5. What does acronym MAN stand for in computing networking?
6. Which type of network covers the smallest geographic area?

7. In local area networks where bus topology is used, each attached device is connected to a single cable.
   a. true
   b. false

8. What is a topology that combines two or more different types of topologies more commonly known as?

9. The connection between a Bluetooth earpiece and a smartphone is an example of which type of area network?

10. Name two area networks that covers a larger geographical area than LAN.

11. What type of area network is the internet?

12. The maximum range of a PAN is approximately:
   a. 1KM
   c. 50m
   d. 10m

**DOK Level 2: Skills and Concepts**

1. Describe two differences between a MAN and a WAN.

2. Create a table in Word to show the difference between a PAN and a LAN in terms of coverage area and purpose.

3. Explain the difference between bus and star topologies. Use diagrams to support your explanation.

4. What impact will a hub or switch failure have on a network with a star topology?
   a. The internet is an example of a partial mesh network. Explain what this means.
   b. Explain why the internet is not an example of a metropolitan area network.

5. Demonstrate how to do the following:
   a. Connect a smartphone to the school's Wi-Fi network
   b. Pair a smartphone to a set of wireless headphones.

**DOK Level 3: Strategic Thinking**

1. Assess the impact on network activity when adding or removing a node in a ring topology.

2. Explain why a mesh topology is considered more reliable than a ring topology.

3. Which topology provides the highest fault tolerance of all of the network topologies. Give a reason for your answer.

4. Is GCB bank (Ghana Commercial Bank ), including its 185 branch offices and ATM machines an example of a MAN or a WAN? Justify your choice of area network.

5. A network engineering firm is setting up a local area network in their office block. 50 workstations across three floor need to connect to the network and there should be the capacity to extend the number of workstations.

6. Write an evaluation of the star, bus, and ring topology as possible topologies to use. Recommend one of these topologies to the firm with reasons for your choice.

**DOK Level 4: Extended Thinking**

1. Write a short analysis on how the internet of things (IoT) is impacting networking.

2. Another type of area network is a Storage Area Network **(**SAN). Research this type of network and complete a report summarising your findings.

Scan for solutions to some of the above questions: 

# WEEK 11

**LEARNING INDICATOR 1.1.3.LI.1:** Computer Networks and How They Work

## THEME/FOCAL AREAS:

1. **Network architecture models: client-server and P2P**
2. **Cloud networks**
3. **OSI Model – an introduction**

## KEY CONCEPT NOTES

### NETWORK ARCHITECTURE

Network architecture refers to the way network devices and services are structured to serve the connectivity needs of the user devices. This includes the hardware, software, protocols, and configurations used to create and manage the network. There are several types of network architecture, each serving different purposes and catering to specific needs. Two of the most common models are client-server and peer-to-peer.

1. **Client-Server Architecture:** in this architecture, devices on the network are divided into two categories: clients and servers. Clients (e.g., computers, smartphones) request services or resources from servers (e.g., access to webpages from a web server, access to files from a file server). Servers respond to client requests, and this model allows for centralised management and resource sharing. Servers tend to be quite powerful machines. They need the processing power because many other computers connect to them. Clients do not usually store data and they have no control over the network as a whole.

   Because this model is centralised, it is more secure and easier to back up data. It is suitable for both small and large networks and to situations where many computers need access to the same information. Many schools use this model. Client-server networks are generally more stable than P3P networks but can be cost more due to the infrastructure and maintenance required.

2. **Peer-to-Peer (P2P) Architecture**: in this architecture, all devices on the network are considered equal peers, capable of both requesting and providing resources (i.e. acting as both a client and a server). There is no central server. Each device can directly communicate, request and provide services to other devices on the network, which makes it a decentralised network.

   P2P typically is used for smaller networks, often with fewer than 10 computers, or where fewer computers need access to the same data. It is less expensive and easy to set up compared to client-server networks. However, they can be less stable as the number of peers increases and may have security challenges since each node has equal authority.

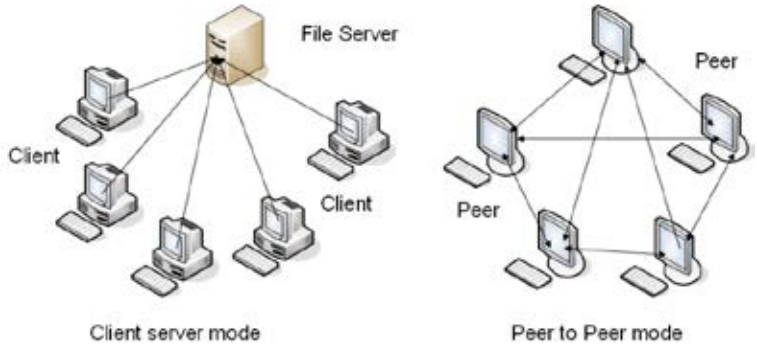


***Figure 11:1*** *Two types of computer architecture*

Note the link between network topology and network architecture. Network topology is the practical implementation of network architecture. *A network topology is the arrangement of different elements within the network, including devices like routers, switches, and computers, whereas network architecture refers to the design and structure of a computer network.*

## CLOUD NETWORKS

'The cloud' refers to servers that are accessed over the internet, and the software and databases that run on those servers. Cloud servers are located in data centres all over the world. In a cloud network, the network is on premises, but some or all resources used to manage it are in the cloud and these resources are rented from a third-party cloud provider/ cloud vendor. Cloud networking is the infrastructure that supports cloud computing, which is the delivery of various services through the internet. It involves a network of remote servers hosted on the internet to store, manage, and process data, rather than a local server or a personal computer.

A cloud network can employ a client-server architecture. In this model, the cloud acts as the server that provides resources and services, and the clients (which can be end-user devices like computers, smartphones, etc.) request and consume these services. The cloud-based delivery of services ensures that clients can access resources on-demand via the internet.

The client-server architecture in a cloud environment is designed to be easily scalable and efficient, allowing for a robust network that can handle varying workloads and provide services to a large number of clients simultaneously.

With cloud networking, an organisation can shift its network management, control, and data connectivity from on-premises to a cloud infrastructure. Cloud networking allows organisations to create complex networks using only the internet.

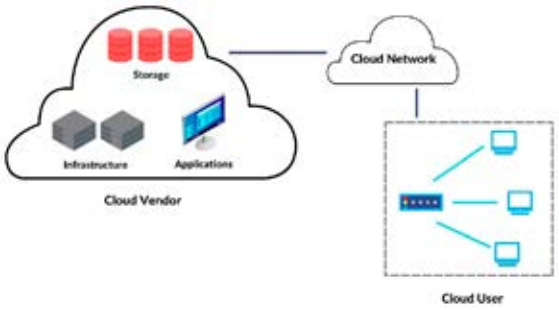


***Figure 11:2*** *Cloud networking*

## OSI MODEL - What is it?

Networking is a vast and often complex topic. The OSI model helps us better understand it. **The OSI model describes how a network functions and gives a reference framework (a set of rules) that explains the process of transmitting data between network devices**. It is essentially a blueprint for network architecture that standardises the way the nodes send data to each other.

This model makes use of what is called in networking, a layered architecture. In the OSI model, the process of communication between two devices on a network can be divided into seven distinct groups of related functions, or layers, with each layer having a specific job.

**From highest-level to lowest-level the seven levels of the OSI model are:**

**Layer 7: The Application Layer**

**Layer 6: The Presentation Layer**

**Layer 5: The Session Layer**

**Layer 4: The Transport Layer**

**Layer 3: The Network Layer**

**Layer 2: The Data Link Layer**

**Layer 1: The Physical Layer**

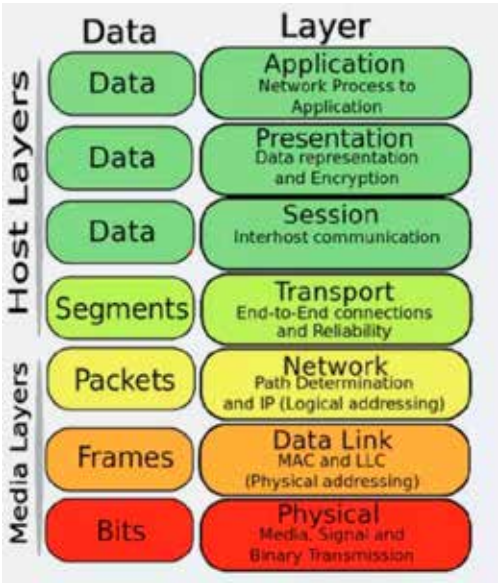


***Figure 11:3** OSI Model Layers*

**The physical layer (Layer 1) is responsible for the transmission and reception of raw data bits over a physical medium, such as wires, optical fibres, or wireless signals.**

A possible mnemonic for remembering the names of the layers (highest to lowest) is:

**A P**enguin **S**aid **T**hat **N**obody **D**rinks **P**epsi

### Why the OSI model is used?

Before the OSI model, each company has its own packet structure or data structure, which meant that peripherals of different companies were not compatible. For example, if you have a computer made by company A, then you needed to buy peripherals such as a printer from company A. So, the International Organisation for Standardisation (ISO) decided that data had to go in a particular manner from one place to another place to overcome this issue. This is where the reference model (OSI model) came into being. ISO decided that when data goes from one place to another place it has to go through the layers of the OSI model so that others can also understand it.

At this stage of the course, just an overview of the OSI model is required, as indicated by the emboldened text above.

## Learning Tasks

Here are some tasks to help learners understand the three focal areas in week 11. Kindly take note of differentiated learning when applying these tasks.

Working in small groups, the learners could work together to complete the following tasks:

**Task 1**

Present each group with a blank comparison table (between client/server and P2P) using previously discussed and agreed criteria. The groups should work together to complete the table.

**Task 2**

Assign each group a different server to research and create a short summary of the function of each server. Possible servers include file server, print server, email server, web server, database server, proxy server, DNS server, cloud server, and application server. These summaries could be collated and made available to all learners.

**Task 3**

Assign each group with one of the three focal areas to research further. Each group should present their findings in the form of a slideshow.

## PEDAGOGICAL EXEMPLARS

*These examples are only to serve as a guide to the teacher.*

### Direct instruction

1. The teacher should introduce this week's lessons with an explanation of what is meant by network architecture. Visual aids should be used to study the three focal areas with the learners. Discuss how network architecture links with network topology.

### Group Activities

2. Divide learners into small mixed-ability groups. Discuss possible criteria that could be used to compare client-server and P2P architectures, such as typical uses, security, maintenance, reliability, scalability, and cost. The groups should then complete the Learner Tasks 1 to 3 above.

3. There are many research-based projects relating to the focal areas that would also develop the learners' digital literacy, communication and presentation skills. An example of such a project would a study of the different types of cloud networking.

### Video-assisted learning (VAL)

The more able and interested learners could explore the OSI model in greater depth if interested. There are many online videos on this conceptual frame such as this YouTube video:

OSI Model Explained Simply for Beginners | Real World Examples

## ASSESSMENT

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects, and more.*

*The summative assessment questions that follow are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the three focal areas.*

**DOK Level 1: Recall/Reproduction**

1. What is the primary purpose of network architecture in computer networking?

2. Complete the sentence:
   In a LAN with a client-server architecture, the printer requests from clients are queued by the _____ server for deliver to the final destination printer.

3. When client files in a network are stored on a file server, this makes it easier to
   a. create the files
   b. rename the files
   c. backup the files

4. What is the name of a network arrangement where all of the connected computers have equal status.

5. What do IT teams need to consider as they plan to migrate to cloud network environments?
   a. The risk involved
   b. Level of performance monitoring
   c. How much the migration will cost
   d. Business requirements
   e. All of the above

6. Complete the sentence:
   The _____ _____ is a reference model that defines how applications can communicate with each other over a networking system.

7. How many different types of tasks does a single layer perform in a layered architecture network model?

8. A network manager is required to run and maintain a peer-to-peer network?
   a. true
   b. false

9. What does network layering allow?
   a. Breaking up the sending of messages into separate components and activities
   b. Standards to be put in place and simply adapted as new hardware and software is developed.
   c. The transfer of packets between nodes on a network, and between one network and another

10. Complete the sentence:
    A cloud network is easily s_____ which means it has the capability to handle increased demands and grow its capacity as the need arises.

11. What is the name of the type of architecture that divides a complex task into smaller sub parts so that the task can be solved efficiently.

**DOK Level 2: Skills and Concepts**

1. Describe the service provided by a file server in a network?

2. Compare and contrast client-server and peer-to-peer architectures. Present your work in a tabular format.

3. Draw annotated diagrams to illustrate the difference between a client-server and a peer-to-peer network.

4. Describe two methods of ensuring that access to a network is restricted and controlled.

5. Define a client-server architecture and explain the roles of clients and servers in this model.

6. Describe two advantages of a cloud network over a traditional network.

**DOK Level 3: Strategic Thinking**

1. Explain why the following differences exist between the specifications of a server and a client computer.
    a. A server has a lot more RAM
    b. A server has lots and lots more hard disk space

2. Evaluate the security implications of various network architecture designs, identifying potential vulnerabilities and recommending mitigation strategies.

3. Develop a strategy for managing trust in a peer-to-peer network.

4. Evaluate the cost efficiencies for an organisation of switching to cloud networking.

5. Explain why client-server networks are considered more secure than a peer-to-peer networks.

**DOK Level 4: Extended Thinking**

1. Research the following types of cloud networking platforms: Public, Virtual Private Cloud (VPC), Hybrid, and Multicloud.

2. Investigate what is meant by edge computing and how it is impacting computer networks. What networking problems does edge computing solve?

3. Microsoft Azure and Amazon Web Services (AWS) are the two main cloud service providers. Investigate these two vendors and summarise the services that they provide and what they charge.

4. Do some research on three main types of cloud computing services: Infrastructure-as-a-Service (IaaS), Platforms-as-a-Service (PaaS), and Software-as-a-Service (SaaS). Create a short report summarising your research findings,

# WEEK 12

**LEARNING INDICATOR 1.1.3.LI.1:** Computer Networks and How They Work

## THEME/FOCAL AREAS:

1. **Wireless data connections**
2. **Wired data connections**
3. **Comparing wired and wireless networks**

### KEY CONCEPT NOTES

Another classification of a network is wireless or wired.

## WIRELESS DATA CONNECTIONS

Instead of connecting computers to peripheral devices or to another computers through ports and connectors, wireless communications technologies are used.

Wireless media offer mobility and flexibility but they can be affected by environmental factors and have limited range and security concerns.

There are many types of wireless technologies. They differ in various ways including frequency and modulation. Some of these technologies are described below.


***Figure 12:1***
*Wireless Technologies*

### Bluetooth

Bluetooth technology uses short-range radio signals to transmit data between two Bluetooth-enabled computers or devices. In addition to computers, mobile devices and many peripheral devices, such as a mouse, keyboard, printer, or headset, and many vehicles and consumer digital devices are Bluetooth enabled. The range of a Bluetooth connection is approximately 10 meters (30 feet). However, maximum communication range will vary depending on obstacles (such as a person, metal, or wall) or the electromagnetic environment. The range may be able to be extended with additional equipment. If you have a computer that is not Bluetooth enabled, you can purchase a Bluetooth wireless port adapter that will convert an existing USB port into a Bluetooth port.

Scan this QR code for more information on *Pairing Bluetooth Devices*

### Near Field Communication (NFC)

NFC uses close-range radio signals to transmit data between two NFC-enabled devices. Examples of NFC-enabled devices include many smartwatches, most smartphones, and some digital cameras, computers, and smart televisions. Other objects, such as contactless debit and credit cards, and contactless travelcards, also use NFC technology. For successful communications, the devices either touch or are within a distance of 4 centimetres (1.6 inches) of each other.

**Infrared (IR)**

Infrared connectivity is a wireless technology that uses a beam of infrared light to transmit information. It is used for short-range or medium-range communications between two devices. IR communication is among the simplest wireless communication methods and serves as a cost-effective way of transmitting a few bits of data wirelessly. It requires direct line of sight and operates only at close range.

The wireless technologies used by Wireless Personal Area Networks (wPAN) include Bluetooth, NFC and IR.

**Wireless Fidelity (Wi-Fi)**

Wi-Fi uses radio signals that conform to certain standards. Computers and devices that have the appropriate Wi-Fi capability can communicate via radio waves with other Wi-Fi computers or devices. Most computers and mobile devices are Wi-Fi enabled, along with routers and other communications devices. The reach of your signal will be impacted by the manufacturer of the equipment that you are using, the location where your router is installed, and the obstructions that might block the signal in your home or business. Routers set to a 2.4Ghz frequency that are correctly placed should offer you coverage for about 45 metres (150 feet) indoors and about 91 metres (300 feet) outdoors.

Scan this QR code for more information on *Linking a phone to a Wi-Fi network*

The wireless technology primarily used by Wireless Local Area Networks (wLAN) is Wi-Fi.

**Cellular communication**

A cellular wireless network, often referred to as a mobile network, is a communication system that enables wireless communication via radio and microwave signals over a wide geographic area using cell towers. They enable smartphones, tablets and other digital devices to connect to the internet through the nearest cell tower.

This setup (referred to as cellular or mobile data) allows for mobility and convenience, as users can get online without being bound to a physical location (for Wi-Fi you need to be located near a router in order to get an internet connection). You just need to be within the coverage area of the cellular network to connect to the internet. It is particularly useful for those who travel or work remotely.

The first commercial cellular network, the 1G generation, was launched in Japan in 1979. 5G or the fifth-generation technology standard for cellular networks, began deployment worldwide in 2019. 5G has a number of advantages over 4G, including wider bandwidth resulting in faster speeds and greater capacity.

**Satellite Communication**

Satellite communication involves transmitting data signals to and from satellites in space. It is commonly used for long-distance communication in remote areas and for global connectivity.

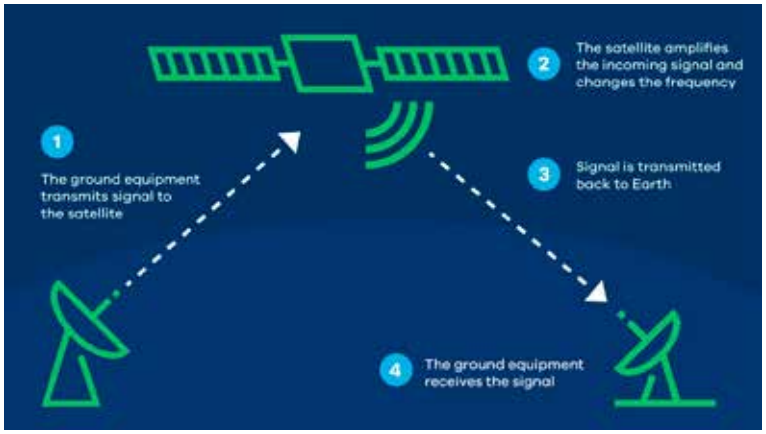


***Figure 12:2*** *Satellite Communication*

Wireless Metropolitan Area Networks (wMAN) use various wireless technologies, the most common being WiMAX and LTE (not covered at this level).

Wireless Wide Area Networks (wMAN) use various wireless technologies, including cellular networks and satellite.

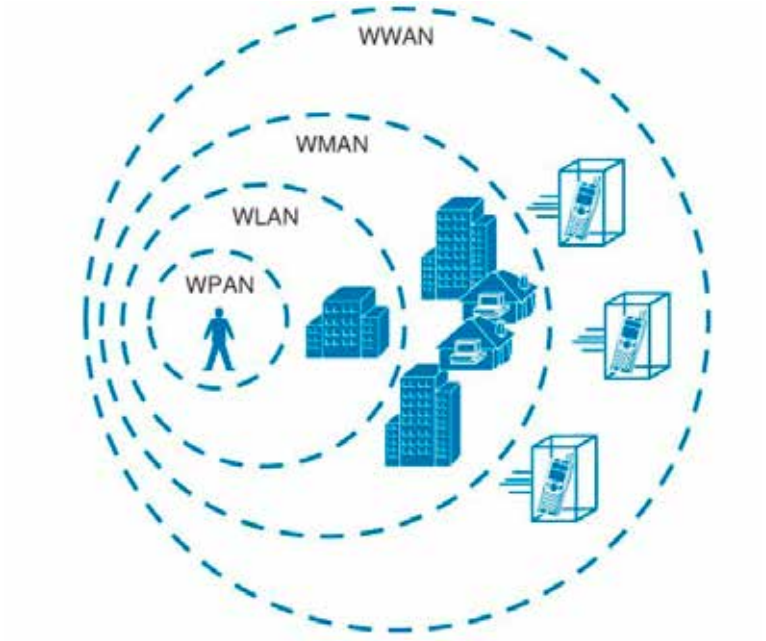


***Figure 12:3*** *Wireless Networks*

## WIRED CONNECTIONS - TYPES OF NETWORK TRANSMISSION MEDIA

Network transmission media, also known as network cables or communication channels, are used to transfer data between devices in a computer network. There are several types of network transmission media, each with its advantages and limitations. The main types are described below.

There are also a number of different wired computing technologies, one of the most common being Ethernet. Ethernet can be considered a network protocol that controls how data is transmitted over cables. An Ethernet cable (Layer 1 Physical layer of the OSI model) plugs into a network interface card (NIC) which handles the Layer 2 Data Link layer functionality. Effectively, Layer 2 is responsible for putting 1's and 0's on the cable, and pulling 1's and 0's from the cable.

Ethernet cables are commonly used in LANs, MANs and WANs. The original 10BASE5 Ethernet used a thick coaxial cable. More modern Ethernet variants use twisted pair and fibre optic cables.

### 1. Twisted Pair Cable

A twisted pair cable is a widely used cable for transmitting data and information over certain distances. A twisted pair cable consists of two separate insulated copper wires that are twisted together within a wrapping shield and run parallel with each other. This helps to reduce the crosstalk or electromagnetic induction between the pair of wires. They come in categories like Cat5e, Cat6, and Cat7. Cat6 cables are commonly used for high-speed Ethernet data transmissions in modern networks with a data rate of 10Gbps. Cat7 cables with a data rate of up to 100Gbps are more suited to data centres than residential applications.

There are two types of twisted pair cabling: UTP and STP.

I. **Unshielded Twisted Pair (UTP): c**ommonly used in LANs, UTP cables have twisted pairs of copper wires and come in categories like Cat5e and Cat6. UTP cables are small in diameter but unprotected against electrical interference.


***Figure 12:4*** *UTP cable*

II. **Shielded Twisted Pair (STP)**: this is a type of twisted pair cable that contains an extra wrapping foil or copper braid jacket to protect the cable from defects like cuts, losing bandwidth, noise, and signal to the interference. It is a cable that is usually used underground and is more costly than UTP. It supports higher data transmission rates across a long distance.


***Figure 12:5*** *STP cable*

## 2. Coaxial Cable

This is a type of copper cable specially built with a metal shield and other components engineered to block signal interference. It consists of a copper conductor surrounded by insulation, a braided metallic shield, and an outer jacket. These cables were commonly used for older Ethernet networks (e.g. 10Base2 and 10Base5). Coaxial cables have good bandwidth and resistance to interference but are bulky and less flexible compared to twisted pair cables.

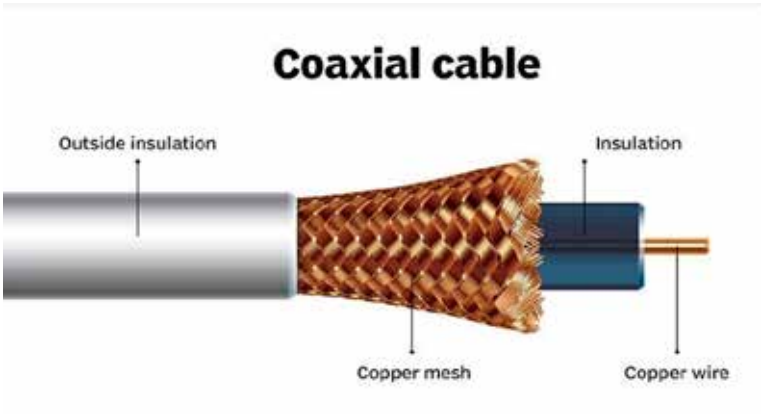


***Figure 12:5*** *Coaxial cable*

A common use of coaxial cable in networking today is for connecting a cable modem to an Internet Service Provider (ISP), and for cable broadband internet. They are also used in automobiles, aircraft, military and medical equipment, as well as connecting satellite dishes, radio and television antennas to their respective receivers.

## 3. Fibre Optic Cable

Fibre optic cables use strands of glass or plastic to transmit data as pulses of light. They offer high bandwidth, long-distance transmission capabilities, and immunity to electromagnetic interference. Fibre optic cables are commonly used in high-speed networks, telecommunications, and data centres.

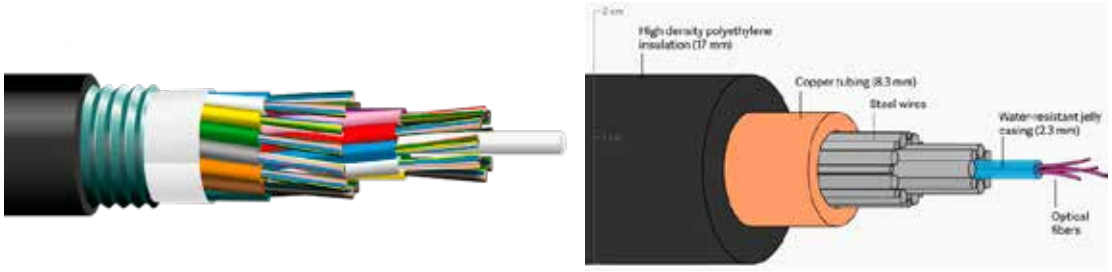


***Figure 12:6*** *Fibre-optic cable*

**Comparing different network cabling**

| Characteristics | Twisted pair cable | Co-axial cable | Optical fibre cable |
|---|---|---|---|
| Signal transmission | Takes place in the electrical form over the metallic conducting wires. | Takes place in the electrical form over the inner conductor of the cable. | Takes place in an optical form over glass fibre |
| Installation and Implementation | Simple and easy | Relatively difficult | Difficult |
| Cost | Very low | Moderate | Expensive |
| Diameter | Larger than optical fibre cable. | Larger than optical fibre cable. | Small diameter |
| Bandwidth | Low bandwidth. | Moderately high bandwidth. | A very high bandwidth. |
| Electromagnetic interference (EMI) | UTP susceptible to external interference | EMI is reduced due to shielding. | EMI is not present. |
| Attenuation[1] | Very high | Low | Very low |
| Noise immunity[2] | Low noise immunity. | Higher noise immunity. | The highest noise immunity. |
| Repeater[3] Spacing | Repeater spacing is 2-10 km. | Repeater spacing is 1-10 km. | Repeater spacing is 10-100 km. |

[1]Attenuation is the reduction in the strength of a signal.
[2]Noise immunity is the ability to perform its functions when interference (noise) is present.
[3]A repeater on a network is a node that amplifies incoming signals and rebroadcasts them.

### 4. Power Line Communication (PLC)

Power Line Communication uses a building's existing electrical system as the transmission medium and regular wall outlets as connecting points. It is commonly used to extend a wired Ethernet network into another room. You can form a Powerline network wherever there are power outlets, eliminating the need for expensive and complicated Ethernet cables.

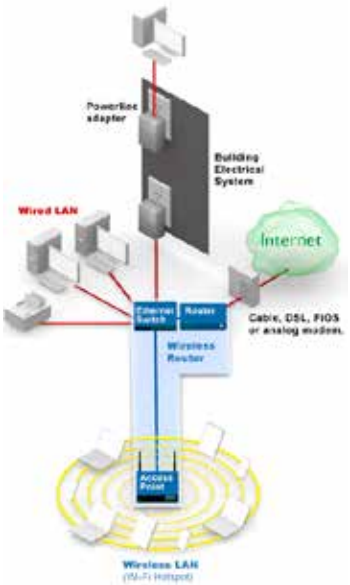


*Figure 12:7*

**Advantages of PLC**

1. Easy to set up: no cabling required, just plug and go
2. Large Reach: PLC can enable communication with hard-to-reach nodes by cable or where Wi-Fi signals might be weak or compromised
3. Low implementation cost: installation of new wires not required.

**Disadvantages of PLC**

1. Lower speed – the maximum speed is generally lower than Ethernet.
2. Can be impacted by electrical interference, for example such as from tumble dryers or microwaves
3. Powerline adaptors must be plugged into a wall and, usually do not work when plugged into extension cords. This means that users will have fewer electrical outlets available for other uses.

**Conclusion**

Each type of cable has its own unique features and is used for different purposes. Twisted-pair cable is the most common and cheapest option, Co-axial cable has a higher bandwidth and is used for high-speed connections, and optical fibre cable is immune to electromagnetic interference and has a very high bandwidth. The choice of cable depends on factors such as data transfer speed requirements, distance, cost, environment, and the type of network being deployed.

## WIRED NETWORKS VERSUS WIRELESS NETWORKS

| | **Wired networks** | **Wireless networks** |
|---|---|---|
| **Cost** | Installation costs can be expensive | Cheaper to set up, devices can connect if in the range of a wireless access point |
| **Installation** | Installation requires technical knowledge and space to install cables | Installation is quick and simple as most wireless devices will connect automatically<br>A solution for outdoor locations that are impossible for cabling. |
| **Maximum transmission speed** | Up to 10 Gbps for Ethernet (Cat6) | Up to 50 megabits per second |
| **Maximum distance for reliable communication** | Up to 100 metres for Ethernet.<br>40 to 100 kilometres for fibre optic (single mode) | Up to 50 metres |
| **Security of connection** | More secure as a physical connection is required to intercept data | Less secure as wireless signal cannot be contained within a building and no physical connection is needed to intercept data |

**Learning Tasks**

Here are some tasks to help learners understand the three focal areas in week 12. Kindly take note of differentiated learning when applying these tasks.

Working in small groups, the learners could work together to complete the following tasks:

**Task 1**

- Each group is assigned a wired transmission medium to research further.
- Working together, the members of each group should demonstrate how their assigned transmission medium works, using videos, models, or diagrams.
- Each group should then create a presentation outlining their medium's characteristics, advantages, disadvantages, and common use cases.

**Task 2**

- Each group is assign to research two network transmission media from UTP, STP, coaxial, fibre optic, and should create a comparison table between the two media, on paper or in Word.

**Task 3**

- Same as Task 1 except for wireless technologies.

**Task 4**

- Give each group a list of network features/advantages. The group members should work together to label each feature/ advantage as belonging to wired, wireless or both .

**Task 5**

- Each group should create a glossary for network transmission technologies.

**Task 6**

- Each group should create a concept map on the content of this section with the title 'Computer networks'.

**Task 7**

- Each group should create a quiz to test each other of the section content (on paper or using an online tool such as Quizlet). Then test the quiz on the learners from the other groups.

## PEDAGOGICAL EXEMPLARS

*These examples are only to serve as a guide to the teacher.*

1. Teachers can employ mixed-ability grouping for collaborative learning and practical engagement.
2. Incorporate research to engage learners and provide more in-depth knowledge.
3. Guide learners through the research and preparation of documents and presentations.
4. Encourage all learners to write reflective summaries on the content taught to enhance their writing and communication skills. These summaries can highlight gaps or difficulties in understanding.

## ASSESSMENT

*Teachers should assess learners during the learning process. Marks can be assigned to presentations, contributions during work, research projects, and more.*

*The summative assessment questions that follow are only to serve as a guide for the teacher when creating questions to measure learners' comprehension of the three focal areas*

**DOK Level 1: Recall/Reproduction**

1. Which of the following is a disadvantage of using a wireless connection?
   a. Can connect when out of doors
   b. Limited connection range
   c. Users unable to share files

2. Bluetooth is limited in range and transmission speed.
   a. true
   b. false

3. State two type of wireless technologies that are used in wireless private area networks (vPANs).

4. Which of the following transmission media has the highest bandwidth?
   a. Coaxial cable
   b. Twisted wire cable
   c. Fibre optic cable

5. State one advantage and one disadvantage of a wired network over a wireless network.

6. What activity and wireless technology is indicated in the image shown in Figure 12:8.

Figure 12:8

7. What does the acronym UTP stand for in computer networking?

8. Complete the sentence:
   One way to connect your desktop computer to the internet is to connect one end of an Ethernet cable to your _____, and the other to your computer.

9. State the name of the primary wireless technology used by wLANs.

10. Where would you find the Ethernet port on a laptop?

11. Study Figure 12:9. A cellular network uses these to enable mobile communication and provide internet access on digital devices such as smart phones. What are they?

12. What is main benefit of shielded twisted-pair cable over unshielded twisted-pair cable?

Figure 12:9

13. Which of the following cable types does NOT use copper wires?
    a. UTP
    b. STP
    c. Fibre optic
    d. Coaxial

14. Radio waves, microwaves and infrared waves are all types of what?

15. Twisted pair cables are a cost-effective option for communication and networking.
    a. true
    b. false

**DOK Level 2: Skills and Concepts**

1. Describe two advantages and one disadvantage of coaxial cabling over twisted wire cabling.

2. Why is coaxial cabling good for usage in situations where signals must be sent over great distances, such as cable TV networks?

3. Correctly label a set of diagrams of various network transmission media.

4. Briefly define the following data transmission media: twisted pair cables, coaxial cables, fibre optic cables, and wireless communication.

5. Compare and contrast the physical properties, transmission characteristics, and applications of different types of data transmission media.

6. Analyse at least three factors that influence the choice of transmission medium in a given networking scenarios.

7. Identify the type of Ethernet cable shown in Figure 12:10. Justify your answer.

**Figure 12:10**

**DOK Level 3: Strategic Thinking**

1. Evaluate the relative advantages and disadvantages of a given data transmission medium in terms of its suitability for specific network architectures, such as LANs, WANs, and MANs.

2. Investigate edge computing and how it reduce latency and bandwidth usage in data communications.

# Section 3 Review

This section of the manual focused on data communication and network systems. In the four weeks from week 9 to week 12, teachers were required to guide learners through the fundamentals of network design and architecture, and to explore different types of networks.

Computer networks have played a significant role in the enormous changes to the way we live and work in recent decades. Most learners will not be considering a future career in networking but to have an understanding of network systems and data communications with related skills will be very valuable in this digital age to all learners.

Teachers are required to use discussions, visual aids, group practical activities, and the powerful research tool that is the internet to make the focal areas more accessible to the learners. Some learners may find parts of this section quite abstract so hands-on activities and real-life exemplars should be included in lessons, wherever possible.

The Depth of Knowledge (DOK) framework was again adopted to serve as the evaluation tool to assess learners' understanding of the focal areas, and to identify areas requiring further emphasis and learners requiring additional support.

Teachers are advised to read more on data communications and network systems, and not restrict themselves to information provided in this manual only.

**Teaching and Learning Resources**

*Here are some teaching and learning resources that a teacher may wish to integrate into his/her lessons:*

| | |
|---|---|
| • Visual aids - photos. videos, etc.<br>• Desktops or laptops<br>• Smartphones or tablets<br>• Open Educational Resources (Including: YouTube, MOOCS-Udemy/ coursera, Khan Academy, TESSA)<br>• Subject-based application software<br>• Old or new relevant hardware components, including network cabling | • Instructional Laboratories (with multimedia equipment and smartboards)<br>• A4 Sheets/ Cardboards<br>• Colouring pens/pencils<br>• Interactive Whiteboards (Like google Classroom boards/ Zoom Whiteboard or Kahoot Whiteboard)<br>• Word processor<br>• Presentation program |

## ADDITIONAL READING

### Books


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