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Name:

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Semester: Autumn 2026

ALLAMA IQBAL OPEN UNIVERSITY, ISLAMABAD

Course: Basics of Information and Communication Technology (1431) • Level: BS

Semester: Autumn 2026

Assignment No. 1 (Units 1–4) — Total Marks: 100

SOLVED ASSIGNMENT GUIDE

(For Study & Reference)

Note: This guide is prepared for study and reference purposes. Students are advised to read the relevant units of the course book, understand the concepts, and then write the assignment in their own words. Total marks of the assignment are 100; each question carries the marks shown with it.

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Question 1: Data and Information — How Data Is Processed into Useful Information and the Role of ICT (20 Marks)

Question as printed: Differentiate between data and information. Explain how data is processed to become useful information, and discuss the role of ICT in this transformation with suitable real-life examples. (20)

Introduction

Every organisation, whether it is a school, a hospital, a bank or a small shop, works with facts and figures all day long. Marks obtained by students, names and addresses of customers, temperatures recorded by a weather office and amounts deposited in bank accounts are all collected, stored and used for making decisions. Two words are used again and again in this connection: data and information. Although in ordinary conversation the two words are often used as if they meant the same thing, in computing they have clearly different meanings.

Understanding the difference between them is the very first step in understanding how computers and Information and Communication Technology (ICT) work, because the whole purpose of a computer system is to take data as input and to deliver information as output. This answer first explains the meaning of data and information, then differentiates between them point by point, then describes step by step how raw data is processed into useful information, and finally discusses, with real-life examples, how ICT has changed the speed, scale and quality of this transformation.

Meaning of Data

Data is a collection of raw, unorganised facts and figures that, by themselves, carry little or no meaning. The word data is the plural of the Latin word datum, which means something given. Data may consist of numbers, letters, words, symbols, sounds, images or signals. Examples of data are the marks "72, 45, 91, 58" written in a teacher's register, the readings "38, 39, 41" on a thermometer, a list of names and telephone numbers, the weight of parcels recorded at a post office, and the sounds and pictures captured by a camera. In this raw form, data does not answer any question directly. If a teacher is shown only the numbers 72, 45, 91 and 58, she cannot say who passed, who stood first or what the average of the class is. Data is therefore described as the raw material of computing: it is the input that a computer system receives before anything useful has been done with it. Data can be collected from many sources, such as forms filled in by people, sensors and machines, transactions at shops and banks, surveys, experiments and observations.

Meaning of Information

Information is data that has been processed, organised and presented in such a form that it becomes meaningful and useful for the person who receives it. Information answers questions such as who, what, where, when and how many, and it helps people to take decisions and actions. When the raw marks 72, 45, 91 and 58 are arranged in a result sheet showing each student's name, total, percentage, grade and position, they become information, because now the teacher, the students and the parents can understand them and act upon them. In the same way, a bank statement is information whereas the separate entries of deposits and withdrawals are data; a weather forecast is information whereas the raw temperature and pressure readings are data. Information is thus the output of a data processing system. It reduces uncertainty: before receiving information we are unsure about something, and after receiving it we are in a better position to decide. It should also be remembered that information at one level can become data at the next level. For example, the monthly sales reports of different branches (information for the branch managers) are used as data by the head office to prepare the company's annual performance report.

Difference Between Data and Information

The main differences between data and information are summarised in Table 1. In short, data is raw, unprocessed and meaningless by itself, while information is processed, organised, meaningful and useful for decision-making. Data depends on nothing, but information always depends on data, because no information can be produced without first collecting and processing data.

Table 1: Difference between data and information

Aspect	Data	Information
Meaning	Raw, unorganised facts and figures	Processed and organised data that is meaningful
Form	Numbers, letters, symbols, sounds and images in raw form	Reports, statements, charts, summaries and statements presented in context
Meaningfulness	Has little or no meaning by itself	Carries clear meaning for the receiver
Usefulness	Cannot be used directly for decisions	Directly useful for decisions and actions
Dependency	Independent; it is the starting point	Dependent; it is produced from data
Input / Output	It is the input of a computer system	It is the output of a computer system
Example	Marks: 72, 45, 91, 58 recorded in a register	Result sheet showing names, percentages, grades and positions
Volume	Usually large in quantity	Usually smaller, because it is summarised and filtered

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How Data Is Processed into Useful Information

The conversion of data into information is called data processing. It is carried out through a series of steps known as the data processing cycle, shown in Figure 1. The steps are as follows.



Figure 1: The data processing cycle — input, processing, storage, output and distribution, with feedback.

- **Collection and input.** Data is first collected from source documents such as admission forms, invoices, answer sheets or sensor readings, and then entered into the computer through input devices such as the keyboard, scanner, barcode reader or microphone. At this

stage the data is checked for obvious errors, because wrong data entered into the system will produce wrong information — a principle known as "garbage in, garbage out" (GIGO).

- **Processing.** The computer then works on the data. Processing includes classifying data into groups (for example, students into classes), sorting it into an order (alphabetical or numerical), calculating totals, averages and percentages, summarising long details into short reports, and comparing and merging data from different files. All these operations are performed by the processor under the control of software.
- **Storage.** Processed results, and data that will be needed again, are stored on storage devices such as a hard disk, SSD or database server, from where they can be retrieved quickly at any time. Storage protects information from being lost and makes it available for future processing.
- **Output.** The processed data is presented in a form that people can understand: printed reports and result cards, displays on a monitor, charts and graphs, or announcements through speakers.
- **Distribution.** Finally, the information is delivered to the people who need it — by hand, by post, or instantly through e-mail, websites, mobile applications and messaging services. Feedback completes the cycle: if the users find an error, the corrected data is entered again and the cycle is repeated.

A simple example makes the cycle clear. In an electricity billing system, the meter readings of thousands of houses are data. The computer calculates the units consumed and the amount payable, stores the record, prints the bill (output) and delivers it to the consumer (distribution). The bill is information: the consumer now knows exactly how much to pay and by what date.

Qualities of Useful Information

Processing alone does not guarantee that the result will be useful. Good information should be accurate (free from errors), complete (nothing important missing), timely (available when it is needed — a weather forecast received after the storm is useless), relevant (related to the decision being taken), concise (summarised, not flooded with unnecessary detail), verifiable (its source can be checked) and cost-effective (the benefit of having it should be greater than the cost of producing it). ICT helps in achieving all these qualities, as the next section shows.

Role of ICT in the Transformation of Data into Information

ICT means the technologies used to capture, process, store and communicate information — computers, software, the Internet, mobile phones, databases, sensors and communication networks. Before ICT, data processing was manual or mechanical: clerks maintained registers, calculated with pen and paper or simple calculators, and reports took days or weeks to prepare and often contained errors. ICT has transformed every step of the cycle. Computers process millions of items of data in seconds with great accuracy. Barcodes, QR codes, online forms and sensors capture data automatically at the source, reducing copying errors. Databases store huge volumes of data in an organised way and retrieve any item instantly. Software such as spreadsheets, database management systems and reporting tools classifies, sorts and summarises data and presents it as tables and colourful charts. Networks and the Internet distribute information immediately to any part of the world, and mobile phones have placed information in the pocket of every person. ICT has also made information interactive and up to date: instead of waiting for a monthly printed report, a manager can see a live dashboard that refreshes every minute.

Real-Life Examples

- **Education.** At Allama Iqbal Open University and other institutions, the marks and records of lakhs of students are data. The examination system processes them into result cards, transcripts and merit lists, which students can view online. Teachers likewise enter attendance and test marks in a learning management system, which instantly shows each student's progress to parents.
- **Banking.** Every deposit, withdrawal and transfer at an ATM or through mobile banking is data. The bank's system processes it into account statements, balance enquiries and fraud alerts — information on which customers and bank managers base their decisions.
- **Health.** A patient's temperature, blood pressure, blood test values and X-rays are data. Doctors and hospital software organise them into reports and diagnoses, which is information that guides treatment. During epidemics, health departments process data from thousands of hospitals into daily situation reports for the government.
- **Weather forecasting.** Satellites and weather stations collect raw data about temperature, pressure, humidity and wind. Supercomputers process it into forecasts and storm warnings, which farmers, pilots and the public use to plan their activities.
- **Business and e-commerce.** Online stores record every click and purchase as data. Processing reveals which products sell best, which customers may buy again and where stock is running low. This information guides purchasing, pricing and advertising decisions.

Conclusion

To conclude, data and information are two stages of the same thing: data is the raw, meaningless input, and information is the processed, meaningful output that reduces

uncertainty and supports decisions. Data becomes information through the processing cycle of input, processing, storage, output and distribution. ICT has revolutionised this transformation by making it fast, accurate, large-scale and instant, as seen in education, banking, health, weather forecasting and business. That is why it is rightly said that we live in the information age: success today belongs not to those who merely have data, but to those who can turn data into useful information at the right time.

Question 2: Basic Operations of a Computer System — Input, Processing, Output and Storage (20 Marks)

Question as printed: Explain the basic operations of a computer system (Input, Processing, Output, and Storage). Illustrate how these operations work together by describing a real-world scenario. (20)

Introduction

A computer is an electronic machine that works on data and produces useful results, but it does not perform its work in one single step. Whatever the task — typing a letter, calculating a result, withdrawing money from an ATM or playing a video — the computer carries out four basic operations again and again: input, processing, output and storage. These four operations together are known as the information processing cycle. Each operation is performed by a particular group of devices and units, and the operations are so closely linked that a weakness in any one of them affects the whole system: wrong input produces wrong output, slow processing delays the output, and without storage nothing can be remembered for future use. This answer explains each of the four operations in detail, shows how they work together, and

then illustrates the complete cycle through a real-world scenario of withdrawing cash from an Automated Teller Machine (ATM).

Overview of the Four Operations

Figure 1 shows the relationship between the four operations. Data flows from input devices to the processor; the processor works under the control of instructions (the program); results flow to output devices; and at every stage data and results can be saved into, or loaded from, storage. Table 1 summarises the function, the main devices and an example of each operation.

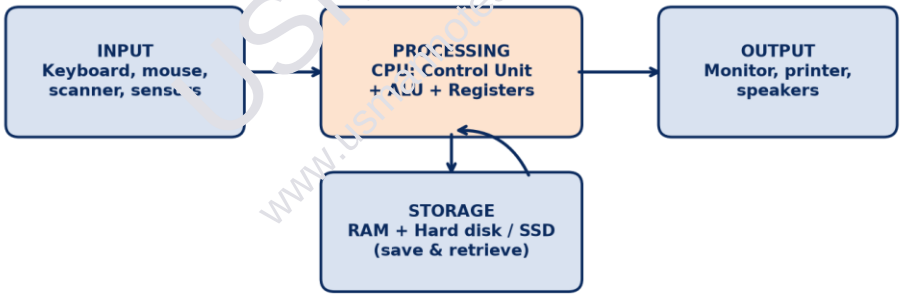


Figure 1: The four basic operations of a computer system — input, processing, output and storage.

Table 1: The four basic operations of a computer system

Operation	Function	Main Devices / Units	Example
Input	Entering data and instructions into the computer	Keyboard, mouse, scanner, microphone, camera, barcode reader	Typing marks into a spreadsheet
Processing	Performing calculations and logical operations on data	CPU: Control Unit, ALU and registers; main memory (RAM)	Calculating totals and percentages
Output	Presenting processed results to the user	Monitor, printer, speakers, projector	Displaying and printing a result card
Storage	Saving data, programs and results for future use	RAM (temporary); hard disk, SSD, USB drive, cloud	Saving the result file on the hard disk

		(permanent)	

Input Operation

Input is the operation of entering data and instructions into the computer so that it can work on them. The parts used for this purpose are called input devices. The keyboard is used to type text, numbers and commands; the mouse and touchpad are used to point, click and select items on the screen; the scanner converts printed documents and photographs into digital form; the microphone records voice and sound; the digital camera and webcam capture pictures and video; and specialised devices such as barcode readers, magnetic card readers, touch screens and sensors enter data automatically. Input devices do more than simply collect data: they convert it into binary form — combinations of 0s and 1s — because the computer can only understand and process data in this digital form. The quality of input is very important, since the computer cannot correct wrong data by itself. This is expressed in the well-known principle "garbage in, garbage out": if wrong marks are typed into a result system, the printed result will also be wrong, however powerful the computer may be.

Processing Operation

Processing is the operation in which the computer actually works on the data: it performs arithmetic calculations such as addition, subtraction and multiplication, logical comparisons such as greater than, equal to or less than, and operations such as sorting, searching, editing and summarising. This work is done by the Central Processing Unit (CPU), which is called the brain of the computer. The CPU has three main parts. The Control Unit (CU) directs and coordinates all activities: it fetches instructions from memory, decodes them, and sends signals

to the relevant parts, just as a traffic policeman controls traffic. The Arithmetic Logic Unit (ALU) performs all calculations and logical decisions. Registers are very small, very fast storage locations inside the CPU that hold the data and instructions currently being processed. During processing, data and programs are held in the main memory (RAM) so that the CPU can reach them quickly. The speed of processing is measured in millions or billions of operations per second, which is why a computer can process the results of a whole university or the accounts of a whole bank in a very short time.

Output Operation

Output is the operation of presenting the processed results — the information — to the user in a form that human beings can understand. The parts used for this purpose are output devices, and output is of two main types. Soft copy output is temporary and is seen or heard on devices such as the monitor (which displays text, pictures and videos), speakers and headphones (which produce sound). Hard copy output is permanent and is produced on paper by printers and plotters; it can be carried, filed and used where no computer is available, for example a printed result card, an electricity bill or an ATM receipt. Output devices convert the binary results inside the computer back into words, numbers, pictures and sounds. The quality of output matters greatly: a well-formatted report with headings, tables and charts conveys information far better than a confused list of numbers, so modern software pays great attention to the design of output.

Storage Operation

Storage is the operation of saving data, instructions and results so that they can be used again in the future. Without storage, everything would be lost the moment the computer is switched

off, and all data would have to be entered again for every task. Storage is of two main kinds. Primary storage, mainly RAM, is temporary (volatile): it holds the data and programs currently in use and loses its contents when the power goes off. Secondary storage, such as the hard disk, SSD, USB flash drive, memory card and cloud storage, is permanent (non-volatile): it keeps files safely for months and years and has a much larger capacity. Storage works in partnership with the other three operations: data received through input is stored before and after processing, the processor loads programs and data from storage into memory, and the final output is usually saved in storage as well as being displayed or printed. Question 4 of this assignment discusses storage devices in detail.

How the Four Operations Work Together

The four operations form a continuous cycle rather than four separate jobs. A program stored on the disk is loaded into memory; the user enters data through an input device; the CPU processes the data following the program's instructions, repeatedly fetching data from storage and keeping intermediate results in memory; the results are shown through an output device and saved back into storage. The output of one task often becomes the input of another: for example, the stored result file of one semester becomes input when the final transcript is prepared. Modern computers perform this cycle billions of times per second and can even carry on several cycles for several tasks at the same time (multitasking). The scenario below shows the cycle working as one smooth whole in daily life.

Real-World Scenario: Withdrawing Cash from an ATM

Suppose a customer visits an ATM to withdraw Rs. 10,000. Input: the customer inserts the debit card — the card reader reads the account data stored on the card, which is input. The customer

then types the secret PIN on the keypad and selects "Cash Withdrawal" and the amount on the touch screen; these are further inputs. Processing: the ATM's computer, connected by network to the bank's central computer, checks the PIN, verifies that the account exists and that the balance is sufficient, and calculates the new balance after withdrawal. All these are processing operations performed by the CPU under a banking program. Storage: the bank's database is searched to retrieve the account record, and after the transaction the record is updated and permanently stored, so that the withdrawal appears in the account statement. The ATM also stores a record of the notes issued. Output: the machine counts and presents the cash, displays the remaining balance on the screen, and prints a receipt — three forms of output. If the PIN is wrong or the balance is insufficient, the output is instead a message explaining the problem, and no cash is issued. The whole cycle — input, processing, storage and output — is completed in a few seconds, and it is exactly the same cycle that takes place, on a larger scale, when a university prepares results or a railway issues thousands of tickets.

Conclusion

In conclusion, every task performed by a computer is built from four basic operations: input brings data and instructions in, processing works on the data in the CPU, output presents the results to the user, and storage saves data and results for future use. The operations are interdependent and form a continuous cycle, as the ATM example clearly shows: remove any one of them and the system stops working. Understanding this cycle is the key to understanding every computer system, from a simple calculator to the largest supercomputer.

Question 3: Analog and Digital Computers — Working Principles, Accuracy and Applications (20 Marks)

Question as printed: Compare analog and digital computers in terms of working principles, accuracy, and applications. Provide examples where each type of computer is used. (20)

Introduction

Computers can be classified in several ways — by size, by purpose and by the way they represent and process data. The classification based on the type of data handled gives two fundamental types: analog computers and digital computers. The difference between them is basic: an analog computer works with continuously varying physical quantities such as voltage, pressure, temperature and speed, whereas a digital computer works with discrete values expressed in binary digits 0 and 1. This single difference in working principle leads to further differences in accuracy, memory, speed, programmability and fields of application. In the early days of computing both types were developed side by side, but today the digital computer has become dominant, while analog devices survive in measurement instruments and as parts of hybrid systems. This answer explains the working principle of each type, compares them in detail, especially in terms of accuracy, and gives examples of where each type is used.

Analog Computers: Meaning and Working Principle

An analog computer is a machine that processes data represented by continuously changing physical quantities. The word analog comes from the idea of analogy: the machine creates a physical system that behaves like (is analogous to) the problem to be solved. For example, in an electronic analog computer, a voltage may be made proportional to speed, or a rotating shaft may represent a quantity in an equation. The computer measures the physical quantity instead

of counting numbers. There is no concept of digits or binary code in a pure analog machine; its parts — amplifiers, integrators, rotating shafts and gears — change smoothly, and the answer is read from a pointer, a dial, a graph or a meter. Familiar everyday analog devices illustrate the principle: a mercury thermometer shows temperature by the continuously rising column of mercury, a traditional speedometer shows speed by a needle moving continuously over a dial, and a slide rule gives results by the continuous position of sliding scales. Early analog computers such as differential analysers were built to solve engineering equations by modelling them mechanically or electrically.

Digital Computers: Meaning and Working Principle

A digital computer processes data in discrete, separate steps using digits — specifically the binary digits 0 and 1. Every kind of information — numbers, letters, pictures, sounds and videos — is first converted into binary code, and all operations are performed by electronic circuits that distinguish only two states: on/off, high voltage/low voltage, 1/0. Because there are only two states, the circuits are simple, reliable and exact. A digital computer works under the control of a stored program: a set of instructions loaded into memory tells the processor exactly what to do with the data. It processes input step by step, stores intermediate results in memory with complete precision, and produces output that is an exact copy of what the program specifies. All the computers in common use today — desktop and laptop PCs, tablets, smartphones, servers, supercomputers, and the computers inside washing machines, cars and ATM machines — are digital computers.

Comparison of Analog and Digital Computers

Table 1 presents a detailed comparison of the two types. The most important points — working principle and accuracy — are discussed in the paragraphs that follow the table.

Table 1: Comparison of analog and digital computers

Basis of Comparison	Analog Computer	Digital Computer
Data representation	Continuous physical quantities (voltage, pressure, rotation, length)	Discrete binary digits (0 and 1)
Working principle	Measures a quantity by analogy with a physical model	Counts and calculates using digits under a stored program
Accuracy	Limited; results are approximate (commonly up to about 99% at best, affected by component tolerances, friction, temperature and reading error)	Very high; results can be made exact to any required number of decimal places
Memory	No proper memory; cannot store results in a reusable form	Has large memory and storage; results can be saved, copied and reused exactly
Programmability	Set up for one specific problem; changing the problem means rebuilding or re-wiring the setup	General-purpose; the same machine runs countless programs — change the software, change the task
Speed behaviour	Very fast for the one continuous problem it is built for, because all parts work simultaneously	Works step by step, but modern processors perform billions of steps per second, so overall speed is extremely high
Output	Pointer readings, dials, graphs and charts; needs interpretation	Exact numbers, printed reports, screens; easy to store and transmit
Examples	Thermometer, speedometer, slide rule, seismograph, analog flight simulator, electronic analog computer for equations	PCs, laptops, smartphones, servers, digital calculators, supercomputers, ATM machines

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Working Principles Compared

The working principle of the analog computer is measurement by analogy. It builds a physical model of the problem: if an engineer wants to study how the temperature of an engine changes, an analog computer represents temperature by a voltage and the cooling effect by electrical resistance, and the changing voltage then behaves just as temperature does. All components work at the same time and continuously, so the solution appears as a smoothly drawn curve. The working principle of the digital computer is calculation by counting. It breaks every problem into small arithmetic and logical steps, represents every value exactly as a binary number, and executes the steps one after another at enormous speed under program control. The analog machine therefore resembles a measuring instrument, while the digital machine resembles an extremely fast and tireless clerk following written instructions exactly. A practical consequence is that an analog computer must be specially built or wired for each kind of problem, whereas a digital computer remains the same machine and only the program changes.

Accuracy Compared

Accuracy is the clearest difference between the two types. Analog results are always approximate. The physical quantities used — voltage, shaft rotation, mercury level — are affected by the quality of components, mechanical friction, wear, temperature changes and the limits of human reading from a dial. An accuracy of about 99 percent is usually considered good for an analog device, and repeating the same problem may give a slightly different reading each time. For many engineering and scientific purposes this approximation was acceptable in the past, but it is not acceptable for banking, accounting, examinations or space flight, where even

a tiny error is serious. Digital results, by contrast, are exact and repeatable. Because a digital computer works with digits, a calculation can be carried out to as many decimal places as required — money can be calculated to the exact paisa, and the same calculation repeated a million times gives exactly the same answer every time. Errors in a digital system arise only from wrong input data or wrong programs, not from the machine's method of working. This exactness, together with the ability to store and copy results without any loss of quality, is the main reason digital computers have taken over almost every field.

Applications and Examples

Analog computers and devices are used where a continuously changing quantity has to be measured or modelled and approximate results are sufficient. Examples include thermometers and barometers for temperature and pressure, the speedometer and fuel gauge in vehicles, seismographs that draw continuous curves of earthquakes, analog instruments in aircraft cockpits, slide rules once used by engineers, and electronic analog computers used in research laboratories to simulate systems described by differential equations, such as the behaviour of springs, circuits and control systems. Analog techniques also survive inside modern equipment: sensors first pick up continuous physical signals (sound, light, temperature) which are then converted into digital form by analog-to-digital converters.

Digital computers are used in almost every field of life because of their accuracy, memory and versatility. In education they run learning management systems and prepare exact results; in banking they maintain accounts to the last paisa; in business they handle payroll, inventory and billing; in hospitals they store patient records and process laboratory results; in communication they run the Internet, e-mail and mobile networks; in science and weather forecasting

supercomputers perform trillions of exact calculations; and at home they appear as PCs, laptops, smartphones, smart TVs and game consoles. Even a simple digital calculator — counting exact digits — is a small digital computer.

Hybrid Computers: A Note

A third type, the hybrid computer, combines the features of both: it accepts continuous signals like an analog machine but processes and stores them digitally. Hybrid systems are used where the real world is analog but exact processing and recording are needed — for example in hospital intensive care units, where sensors continuously measure a patient's heart rate and blood pressure (analog) while the computer records, analyses and raises alarms digitally; in scientific laboratories; and in industrial control systems and flight simulators. Hybrid machines confirm the general pattern: analog methods are strong at sensing the continuous world, and digital methods are strong at accurate processing.

Conclusion

To conclude, analog and digital computers differ fundamentally in working principle: the analog computer measures continuous physical quantities by analogy, while the digital computer calculates with discrete binary digits under program control. Because of this difference, analog results are approximate and cannot be stored or reprogrammed easily, whereas digital results are exact, repeatable, storable and produced by a general-purpose machine. Analog devices still serve well in measurement and simulation tasks, but the digital computer — found in every office, school, hospital and home — has become the universal machine of the modern age.

Question 4: Storage Devices — Primary and Secondary Storage Compared (20 Marks)

Question as printed: Discuss the different types of storage devices, including primary and secondary storage. Compare them in terms of speed, capacity, cost and usage. (20)

Introduction

A computer would be of very little use if it forgot everything the moment a task ended or the power went off. Storage is what gives the computer a memory: it keeps data, programs and results safe so that they can be used again and again. The storage system of a computer is organised in two main levels. Primary storage (main memory) is the small, very fast memory that works directly with the processor and holds what is currently being used. Secondary storage is the large, permanent store — hard disks, SSDs, optical discs, flash drives and the cloud — where files and programs are kept for months and years. Each device in these two levels has its own speed, capacity, cost and typical usage, and computer designers combine them so that the system is fast where it matters and economical where large quantities must be kept. This answer describes the main types of storage devices and then compares them in terms of speed, capacity, cost and usage.

Primary Storage

Primary storage, also called main memory or internal memory, is directly accessible to the CPU. It consists mainly of the following types. Random Access Memory (RAM) is the computer's working memory: the programs and data currently in use are loaded into RAM from the disk, and the processor reads from and writes to it at very high speed. RAM is volatile — its contents are lost when the power is switched off. Its two common forms are DRAM, used as main

memory, and SRAM, which is faster and used in cache memory. Cache memory is a very small and extremely fast memory placed between the CPU and RAM; it stores the most frequently used data and instructions so that the processor does not have to wait for RAM. Registers, located inside the CPU itself, are the fastest and smallest storage of all, holding the instruction and data being executed at this very moment. Read Only Memory (ROM) is non-volatile memory whose contents are permanently written by the manufacturer; it stores the start-up instructions (firmware/BIOS or UEFI) that the computer needs to boot. Its variants — PROM (programmable once), EPROM (erasable by ultraviolet light) and EEPROM/flash (electrically erasable) — allow the firmware to be recorded or updated in different ways.

Secondary Storage

Secondary storage, also called external or auxiliary storage, is permanent, non-volatile storage used for keeping programs and files when they are not in immediate use. Its main types are as follows. Magnetic storage uses magnetised surfaces. The hard disk drive (HDD) — a stack of spinning magnetic platters with read/write heads — has for decades been the main store of PCs, offering large capacity at low cost; magnetic tape, though slow because data is accessed in sequence, is still used for cheap bulk backup and archiving in large organisations. Optical storage uses laser light: CD (about 700 MB), DVD (4.7 GB or more) and Blu-ray discs (25 GB or more) were widely used for distributing software, music and films and for small backups, although their use is now declining. Solid-state storage uses flash memory chips with no moving parts: the solid state drive (SSD) is now the standard main drive in modern laptops because it is many times faster and more robust than a hard disk; USB flash drives and memory cards (SD cards) provide small, portable storage for transferring files and for use in cameras and phones.

Finally, cloud storage keeps data on remote servers reached through the Internet (for example Google Drive or OneDrive), so that files are available from any device and are protected against the loss of one machine, though they depend on an Internet connection and a subscription for large amounts.

Comparison of Storage Devices

Table 1 compares the main storage devices on the four required points — speed, capacity, cost and usage — and Table 2 then summarises the general difference between primary and secondary storage as a whole.

Table 1: Comparison of main storage devices — speed, capacity, cost and usage

Device	Type	Speed	Typical Capacity	Relative Cost per GB	Typical Usage
Registers	Primary	Fastest of all	A few bytes	Highest	Holding the instruction/data being executed
Cache memory	Primary	Extremely fast	A few MB	Very high	Speeding up the CPU with frequently used data
RAM	Primary	Very fast	4 GB – 32 GB	High	Running programs and data in current use
ROM	Primary	Fast to read; not for writing	A few MB	High	Start-up firmware (BIOS/UEFI)
SSD	Secondary	Fast (no moving parts)	250 GB – 4 TB	Medium	Main drive of modern PCs and laptops
Hard disk (HDD)	Secondary	Moderate (spinning platters)	500 GB – 16 TB	Low	Bulk storage of files, backups, servers
USB flash drive / memory card	Secondary	Moderate	8 GB – 1 TB	Medium	Portable transfer; cameras and phones

CD / DVD / Blu-ray	Secondary	Slow to moderate	700 MB – 25 GB	Low	Distributing media/software; small archives
Magnetic tape	Secondary	Very slow (sequential access)	Several TB per cartridge	Lowest	Bulk backup and long-term archiving
Cloud storage	Secondary (online)	Depends on Internet speed	From GBs to unlimited (subscription)	Subscription-based	Anywhere access, sharing and backup

Table 2: Primary storage versus secondary storage

Feature	Primary Storage	Secondary Storage
Volatility	RAM is volatile (lost on power off); ROM is non-volatile	Non-volatile; data remains safe when power is off
Speed	Extremely fast; works directly with the CPU	Slower than primary storage (SSD narrows the gap)
Capacity	Small (MBs to a few GBs)	Very large (GBs to many TBs)
Cost per unit	Expensive per GB	Cheap per GB
CPU access	Directly accessed by the CPU	Data must first be loaded into primary storage
Usage	Holding programs and data currently being processed	Permanent keeping of programs, files and backups

Discussion: Speed, Capacity, Cost and Usage

The comparison reveals a clear pattern, known as the memory hierarchy: as we move from registers and cache down to tape and cloud archives, speed decreases but capacity increases and cost per gigabyte falls. No single device is best in everything. Registers and cache are the fastest but are far too small and expensive to hold a user's files; a hard disk is cheap and spacious but thousands of times slower than RAM. Computer systems therefore use all levels together: the processor works with cache and RAM for speed, while the bulk of programs and

data lives on an SSD or hard disk and is loaded into RAM only when needed. Usage follows from these qualities. Primary storage is used for whatever is active at the moment — the operating system, the open application and the document being edited. Secondary storage is used for permanent keeping: installed software, documents, photographs, databases and backups. Portability decides further choices: a USB drive or memory card is chosen for carrying files, optical discs for distribution, tape for organisational archives, and the cloud when the same files must be reached from many places and protected against theft or disk failure. A practical buying decision illustrates the balance: a student may choose a laptop with 8–16 GB of RAM (enough for smooth working), a 512 GB SSD (fast and sufficient for study files), and free cloud storage for backup — speed where it is felt every second, capacity where it is needed, and cost kept within budget.

Conclusion

In conclusion, storage devices form a hierarchy from the tiny, fastest primary memories — registers, cache, RAM and ROM — to the large, permanent secondary devices — SSDs, hard disks, optical discs, flash drives, tape and cloud storage. Primary storage offers speed at high cost and small capacity for current work; secondary storage offers permanence and large capacity at low cost for keeping data. A well-designed computer system combines both, and choosing the right device for each purpose — by speed, capacity, cost and usage — is an essential part of using ICT effectively.

Question 5: Users and Software in a Computer System — System Software and Application Software (20 Marks)

Question as printed: Explain the concept of users and software in a computer system. Differentiate between system software and application software, and discuss their roles in the effective functioning of a computer system. (20)

Introduction

A computer system is much more than the machine sitting on the desk. In its complete sense, a computer system consists of hardware (the physical equipment), software (the programs), data, procedures and the users — the people who operate the system and for whom it works. The finest hardware is useless by itself: hardware cannot start on its own, cannot decide what to do, and cannot serve any human purpose until software instructs it and users direct it. Users and software are therefore two sides of the same reality — software is written by people, for people, and users can get useful work from the hardware only through software. This answer explains the concept of users and the types of users, explains what software is, differentiates carefully between system software and application software, and discusses the role of each in the effective functioning of a computer system.

The Concept of Users

Users are the people who interact with a computer system to get their work done. They are sometimes called the "liveware" or "peopleware" of the system, and they are its most important component, because the whole system exists to serve them. Users differ greatly in knowledge and in the work they do, and they are commonly classified as follows. End users are the ordinary people who use application programs for their own tasks — a student writing an

assignment, an accountant preparing a balance sheet, a doctor viewing a patient's report, or a customer using mobile banking. They need not know how the computer works internally; they only need to use the application correctly. Programmers (developers) are the specialists who write software — both system and application programs — using programming languages. System analysts study an organisation's problems and design new computerised systems to solve them, acting as a bridge between end users and programmers. System administrators and operators manage the day-to-day running of systems: they install software, create user accounts, take backups, watch performance and keep the system secure. Data entry operators feed large volumes of data into the system accurately. In modern practice the same person may play several roles — a student is an end user of a word processor but may also write small programs — yet the classification is useful because each type of user needs different rights, training and tools. A well-designed system serves all of them: it gives end users simple screens, programmers powerful tools, and administrators proper controls, and it protects each user's data from the others through accounts and passwords.

The Concept of Software

Software is the set of instructions — programs — written in a language the computer can execute, together with their associated data and documentation, that tells the hardware what to do and how to do it. Unlike hardware, software cannot be touched; it is stored electronically on disks and in memory. Hardware and software depend completely on each other: hardware without software is a lifeless box, and software without hardware has nothing to run on. Software is broadly divided into two main categories: system software, which manages the computer itself, and application software, which performs tasks for the user. A third term often

heard, utility software, refers to small helper programs and is generally treated as part of system software.

System Software

System software is the software designed to operate and control the computer hardware and to provide a platform on which application software can run. Its best-known component is the operating system (OS) — such as Windows, Linux, macOS, Android and iOS — which is the first program loaded when the computer starts and which manages everything: it runs programs, allocates memory and processor time, controls input and output devices, manages files and folders, provides the user interface, and enforces security through user accounts and passwords. System software also includes utility programs that maintain the system, such as antivirus software, disk cleanup and backup tools, file compression programs and disk defragmenters; device drivers, which are small programs that let the operating system communicate with a specific device such as a printer or graphics card; and language translators — assemblers, compilers and interpreters — which convert programs written by programmers into the machine language (binary code) that the processor can execute. System software is generally supplied by the computer or software company, runs in the background, and is essential: without it, the computer cannot even start.

Application Software

Application software (often simply called apps) consists of programs designed to perform specific tasks for the user — the actual jobs for which the computer was bought. It is of two main kinds. General-purpose (packaged) application software is made for common tasks needed by many users: word processors (MS Word) for documents, spreadsheets (MS Excel) for

calculations and accounts, presentation software (MS PowerPoint), database software (MS Access), web browsers (Chrome, Firefox), e-mail and messaging programs, media players, photo editors, and educational and entertainment software including games. Customised (tailor-made) application software is written for the special needs of one organisation — for example, a university's admission and examination system, a bank's core banking software, a hospital management system, a railway reservation system, or a school fee system. Application software cannot run on bare hardware: it always runs on top of the operating system, which provides it with memory, files, printing and display services.

Difference Between System Software and Application Software

Table 1: Difference between system software and application software

Basis	System Software	Application Software
Purpose	To manage and control the computer hardware and provide a working platform	To perform specific tasks for the user
Examples	Operating systems (Windows, Linux, Android), utilities, device drivers, compilers	MS Word, MS Excel, browsers, games, banking and examination software
Necessity	Essential — the computer cannot work without it (especially the OS)	Optional — installed only if the user needs that task
When it runs	Starts when the computer is switched on and runs continuously in the background	Runs only when the user starts it, and stops when the task ends
User interaction	Little direct interaction; works mostly behind the scenes	Direct and continuous interaction with the user
Dependence	Independent; runs the hardware directly	Depends on system software; cannot run without an operating system
Who provides it	Usually supplied with the computer or by system software companies	Bought, downloaded or specially developed for the user/organisation
Level of language	Written in low-level languages close to	Written in high-level languages close to

	the machine	human tasks

Roles in the Effective Functioning of a Computer System

The two categories of software, together with the users, work as layers of one team. At the bottom is the hardware. Directly above it, system software — above all the operating system — takes charge of the hardware, hides its complexity, and offers simple services: saving a file, printing a page, showing a window. Application software sits on top of the operating system and uses those services to do the user's real work: when a student presses "Print" in MS Word, Word does not control the printer itself; it requests the operating system, which uses the printer driver to produce the hard copy. The user stands at the top, giving commands and data through the application and receiving results. This division of labour is what makes the system effective. The operating system ensures fair and efficient use of resources — several programs share the CPU, memory and printer without interfering with one another; it provides consistency, so all applications open, save and print in familiar ways; and it provides safety, through accounts, passwords, antivirus support and backups, so one user or one faulty program cannot destroy the whole system's data. Application software, for its part, turns a general machine into a useful tool for each profession — the same computer serves the writer, the accountant, the teacher and the engineer simply by running different applications. Finally, users complete the system: they supply the data, choose the right software, interpret the output and take the decisions. Effective functioning therefore requires all three: responsible users, reliable system software, and suitable application software. If any layer fails — an untrained user, a crashed operating system, or a wrong application for the task — the whole system's effectiveness falls, however good the hardware may be.

Conclusion

To conclude, users are the people — end users, programmers, analysts, administrators and operators — for whom the computer system exists and who direct it at every stage. Software is the set of programs that brings the hardware to life. System software, headed by the operating system, manages the machine itself, while application software performs the user's specific tasks on the platform the system software provides. Neither hardware, nor software, nor users can achieve anything alone; the effective functioning of a computer system is the result of all of them working together in their proper roles.

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